CATALYSIS IN CANADA
3rd Edition

The Catalysis Division, 1971-2020

Alan Sanger‡, Jacques Monnier, and Josephine Hill

on behalf of

The Catalysis Division,
The Chemical Institute of Canada

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Josephine Hill	Jacques Monnier	Alan R. Sanger
Calgary	Ottawa	Deceased

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This book is dedicated with respect to the builders of a catalysis organization for Canada: the Canadian Committee on Catalysis, the founders of The Catalysis Division of The Chemical Institute of Canada, and those today who continue the drive to promote catalysis and its applications for Canada.

SPONSOR

Financial support from the Canadian Catalysis Foundation for the production of the 3rd Edition is gratefully acknowledged.

PREFACE TO THE 3rd EDITION

This edition builds on the work done by Alan Sanger to create the original Catalysis in Canada book that covered the years 1971-1996. I still have the copy that I received when I joined the Catalysis Division upon my return to Canada in 1999. Jacques Monnier worked with Alan to update the second edition to include information up to 2005. In this third edition, the information has been further updated and several new sections added. This book provides a history of the Catalysis Division, is an archive of our work, and most importantly recognizes all of the people who have done the work. Sadly, many of the founders of our Division are no longer with us but, fortunately, many people are building on their efforts to keep catalysis research strong in Canada.

When embarking on this project, I wanted to reflect the collaborative and truly national effort in catalysis - I asked for help and received enthusiastic inputs from many researchers (identified under each Chapter heading). I received additional help from Bob Hayes with the publishing, printing, and Library and Archives Canada Cataloguing, from Graeme Norval with obtaining information from senior members of our community, and editorial advice from Bob, Graeme, Natalia Semagina and Kevin J. Smith. Thank you to everyone for your contributions to this tome. I apologize if I have overlooked anyone and if there are errors or omissions in the text.

Alan, and then Jacques, did a tremendous amount of work to assemble the information on which this edition builds, and so they have been included as authors. I thank Jacques for passing on files and information, as well as reviewing several versions. I have reorganized the book slightly putting the organizations first, followed by information on the awards and the award winners. The new sections include student support, national research centres, in memoriam, a bibliometric review of the types of catalysis research in Canada, and future directions for catalysis in Canada.

This year (2020) has been very unusual with the COVID pandemic. Research labs and workplaces shut down in March to minimize the spread of the disease. All events, including conferences, were either canceled or held virtually; teaching moved to an online format; people worked from home. The Canadian Government and the Natural Science and Engineering Council (NSERC) have provided financial support, while organizations such as the Chemical Institute of Canada (CIC) and most universities have provided online workshops. As labs open up, extensive disinfection protocols have become part of the daily routine, while work is done in shifts and meetings are held through Zoom or Teams to maintain physical distance, and everyone wears a mask in public places.

In this same time, the Black Lives Matter movement has been front and centre after multiple occurrences of racial violence in the United States of America. Organizations have made statements against racism and pledged to make system wide changes (which are long overdue). To quote Natalia, “we are still in the midst of unknown” - time will tell what the consequences of these events will be and how we will react as a society. Optimistically, I hope that we learn to do things differently and more inclusively.

On the title page of the original book, Alan included:

~ a celebratory overview ~

Indeed we have much to celebrate for our achievements in Catalysis in Canada!

Josephine M. Hill, Calgary, 2020

PREFACE TO THE 2nd EDITION

The impact of the 1st Edition was such that The Catalysis Division of The Chemical Institute of Canada decided that the 2nd Edition should be prepared after The Catalysis Division served as hosts for the 17th Meeting of the North American Catalysis Society, Toronto, 2001. We agreed to serve as editors, compilers and writers. We received all the help for which we asked from our colleagues in the catalysis community. In particular, Michael Wilson and Graeme Norval provided generously from their resources of knowledge of the affairs of The Catalysis Division and the activities it continues to support so vigorously, and Bryce McGarvey assisted greatly with the revisions.

The preparation of this edition has allowed us to correct some errors of fact that were made in the 1st Edition. We apologize for the errors. In particular, we apologize to Ron Mann, a stalwart in development of catalysis in Canada, whose name was inadvertently omitted twice from the recognition of those who have served us so well. We hope that no similar omissions or errors have made it into this 2nd Edition.

Jacques Monnier, Ottawa, 2006

Alan R. Sanger, Edmonton, 2006

PREFACE TO THE 1st EDITION

In 1994 I was approached by representatives of The Catalysis Division of The Chemical Institute of Canada to either write or to oversee the writing of a history of the Division, to celebrate its silver anniversary in 1996. I volunteered to attempt the task. Respected and knowledgeable colleagues in turn volunteered to provide assistance, by contributing from their singular or collective wisdom, by proofreading, and by searching their several and various memory banks. In particular, I.G. Dalla Lana and M. Ternan offered me the use of their earlier retrospective of events leading to the formation of the Division. A structure for the anniversary volume was proposed and accepted, and a plan of action was then made to address each issue and component of the volume. A number of corporate bodies were approached for financial support to enable the printing and distribution of the volume. I am pleased to be able to acknowledge the generous commitments which were made by the organizations listed opposite.

I have designed this volume around the efforts of the members of The Catalysis Division. The strength and importance of a professional organization such as the Division is directly related to those of its members. Several of the outstanding efforts in catalysis in Canada have been recognized since the 1960s through The Catalysis Award. The winners of this award are each noteworthy in their own right, and as a body they are representative of the depth and breadth of catalysis in Canada. For each winner of this award a descriptive overview of his career and achievements has been composed by one or more persons knowledgeable of the winner and his areas of work. For each of these descriptions I have made amendments only for style and integration with the other sections of the volume.

Other members who have contributed strongly to the Canadian catalysis community are those who have dedicated their time and efforts on the executive of the Division and in the

organization of meetings. I have taken pains to include the names of all who have served so constructively as members of the executive of the Division. If I have inadvertently omitted any name, I apologize. The success of an international, national or local meeting depends upon the hard work and skills of several volunteers. There have been so many successfully organized catalysis meetings over the past 25 years that it would require reams of paper to name every volunteer. I have therefore chosen to name only the chairpersons of the organizing committees and the program organizers for such meetings. To those valuable colleagues whom I have not listed, please accept both my thanks for your efforts and my regrets at the necessary brevity of the listings.

As with any effort made entirely by volunteers, the realities of life, especially pressing commitments to clients, employers, and students, caused minor to severe amendments to the schedule! It is to the credit of the contributors to this volume that the work was completed at all, that it was achieved in reasonable time, and that the effort made by each colleague constitutes an interesting and valuable contribution.

Special thanks are due to the following colleagues. Marten Ternan and Ivo Dalla Lana recounted events leading to the origins of the Division, and their input forms the basis of Chapter 1. The description of the Ninth International Congress on Catalysis is based on the reports of that event by Harry Habgood (Co-Chair), John Moffat (Secretary) and Yoshi Amenomiya (Program Sub-committee Chair). John Moffat also confirmed my data on the origins of the Canadian Catalysis Foundation. The accounts of the achievements by the winners of The Canadian Catalysis Award were written by or based upon data provided by the following persons, in alphabetical order: Elm Alyea, Yoshi Amenomiya, Ted Calverley, Richard Fiederov, Ed Furimsky, Jan Galuszka, Brian James, Jerry Kriz, Jacques Monnier, Don Singleton, Kevin Smith, Mike Wilson, and myself. My thanks go to all the contributors, without whom this volume would not have been possible. The manuscript was typed by Diane Reckhow, without whose magnificent efforts this project could not have been completed.

This volume is in celebration of the silver anniversary of a special professional organization. The Catalysis Division is strong today because of the efforts in the past. The stars who will be recognized tomorrow are among the unsung heroes of today. In 2021 we can celebrate their achievements!

Alan R. Sanger, Edmonton, 1996

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1 THE ORIGINS OF THE CATALYSIS DIVISION

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Graeme Norval (3rd Edition)

Although The Catalysis Division has formally existed since June 7, 1971, its origins date back to the early 1960s. It should be of interest to the membership of the Catalysis Division to learn how those in the Canadian scientific community interested in chemical catalysis came together and eventually formed The Catalysis Division. Some of the past Division Chairs have dug into the files and fading memories of Division stalwarts, and reconstructed this chronological account. Apologies are made for errors of omission, inaccuracy, or failure to recognize contributions from deserving but unknown members of the catalysis community in Canada.

Scientists in Canada, particularly in the field of physical chemistry and certainly members of the Physical Chemistry Division of The Chemical Institute of Canada (CIC), were involved in surface chemistry and heterogeneous catalysis throughout the 20th century. Similarly, members of the Inorganic Chemistry Division and the Organic Chemistry Division were interested in the design and applications of homogeneous catalysts for an extended period. However, it was only in the early 1960s that an informal group (history refers to them as the "Canadian Committee on Catalysis") attempted to organize distinct technical sessions at the annual conferences of the CIC. The first such program appeared in June 1965, when sessions containing catalysis technical papers were organized. The persons active in the original Committee and participants in the 1965 program included, in alphabetical order, C. Amberg, Y. Amenomiya, B.E. Conway, R.J. Cvetanovic, H.W. Habgood, K.E. Hayes and M.J. Phillips.

Under the auspices of the Physical Chemistry Division of The Chemical Institute of Canada, a much more ambitious program was organized by R.B. Anderson at McMaster University in June 1967, and this was called the Second Canadian Symposium on Catalysis. It was the first conference fully dedicated to chemical catalysis and kinetics. Thirty four papers were presented and participants from Canada, U.S.A. and several other countries met together in the student residences in Hamilton, Ontario.

The momentum from this Hamilton program led to planning of further stimulating events, which will be summarized in the following pages. Drs. H.W. Habgood and I.G. Dalla Lana approached the Physical Chemistry Division and the Canadian Society for Chemical Engineering, respectively, to sponsor jointly the proposed third Canadian Symposium on Catalysis during the October 1969 Chemical Engineering Conference to be held in Edmonton, Alberta. The intent was to bring together the catalytic chemists and the chemical engineers, in this one intellectual interface where both chemists and chemical engineers still move freely. The success of this Third Symposium, in broadening interest in catalysis in Canada and, more importantly, financially, resulted in a re-examination of the loosely organized "Canadian Committee" with the objective of perhaps stabilizing the structure by forming a "society".

This group of scientists and engineers with a common interest in catalysis was an early precursor of The Catalysis Division, and was formally labelled the "Canadian Committee on Catalysis", and in 1969, their executive was H.W. Habgood (Chair), C.H. Amberg (Vice-Chair), E.L. Tollefson (Secretary-Treasurer), J.R.B. Boocock, R.J. Cvetanovic, and B.E. Conway. The 1969 activities of the Committee addressed the following documented objectives:

1. To promote and encourage growth and development of science of catalysis in Canada.
2. To establish and maintain close contact between Canadian chemists and chemical engineers interested in catalysis.
3. To assume responsibility for organizing symposia and technical sessions.

4. To maintain contact and/or Canadian representation with international catalysis organizations.

This Committee was affiliated with the Physical Chemistry Subject Division of the CIC. In 1969, a meeting of the Committee was held to discuss the organizational structure necessary to attain representation as a member organization of The Catalysis Society, the international society providing both a forum and organization for workers in all aspects of catalysis. To this end it was proposed that a Catalysis Division of CIC be formed. After the 1969 Edmonton meeting, the Physical Chemistry Division and the CSChE both agreed to permit the fledgling Catalysis Division to retain the money provided for working capital in organizing the Edmonton Symposium. In previous years these monies had been returned to the Physical Chemistry Division from conference revenues, whereas in 1969 they provided the "seed capitalization" for the proposed Division. In 1970, the formal machinery started, whereby the CIC Council was approached to approve formation of the proposed Catalysis Subject Division. The persons who served on the Canadian Committee on Catalysis are shown in Table 1.1.

The founding meeting of The Catalysis Division was held on June 7, 1971 in Halifax, N.S. during the 4th Canadian Symposium on Catalysis, chaired by R.J. Cvetanovic, in the absence of the initially appointed Chair, H.W. Habgood. The following is a partial list of those persons who attended the founding meeting.

C.H. Amberg	R.J. Cvetanovic	J.H. Rolston
Y. Amenomiya	M.J. Dignam	D.M. Ruthven
R.B. Anderson	O.M. Fuller	G. Strathdee
J.R.B. Boocock	K.E. Hayes	M. Ternan
H.C. Chen	R.R. Hudgins	E.L. Tollefson
B.E. Conway	S. Kaliaguine	K.P. Wagstaff

Professor R.B. Anderson was elected as the first Chair of The Catalysis Division. The other officers of the first and subsequent executives are listed in Chapter 2, and the present Constitution and By-Laws of The Catalysis Division are in Appendix 1.

In the first few years The Catalysis Division sponsored symposia, and members participated vigorously in the programs of both the CIC and CSChE. The value of The Catalysis Division as a common forum for chemists and chemical engineers became established. Early in the 20th century the two disciplines were more strongly related, as the distinction between chemistry and chemical engineering diminished. For example, physical chemists such as E.H. Boomer established reputations for catalysis work in what would today be considered chemical engineering. By the time K.J. Laidler and J.C. Polanyi became renowned for their work on kinetics and mechanisms of molecular processes they were perceived as chemists. Similarly, for several decades Canadian researchers with a background in inorganic chemistry have made innovations and resolved issues related to both heterogeneous and homogeneous catalysis (*e.g.* see the topical overview by B.R. James, "Inorganic Catalysis", in *Chemistry in Canada*, **30**(11), 13, December 1978). Examples include J. Halpern, J. Harrod, B. James, D. Ruthven, B. Conway, and others too numerous to list.

The economic and intellectual impact of catalysis work in Canada in the period before the establishment of The Catalysis Division had not had a specific award by which excellence in the field could be recognized. To rectify this deficiency, The Catalysis Award was established by The Catalysis Division in 1977. The recipients of the award are listed in Chapter 9. After formation of The Catalysis Division, most of the symposia and catalysis sessions from 1972 to 1976 were held at CIC and CSChE meetings, as detailed in Chapter 5. In 1980, the 7th Canadian Symposium on Catalysis was held independently in Edmonton, and Canadian Symposia have been held more or less regularly in alternate (even-numbered) years since that time.

Table 1.1 The Canadian Committee on Catalysis.

Time Period	Chair	Vice-Chair	Secretary	Members at Large
The Initial Committee, August 1965	R.J. Cvetanovic[1,2]			H.W. Habgood C.H. Amberg[2] B.E. Conway
Prior to November 1967	R.J. Cvetanovic			H.W. Habgood C.H. Amberg B.E. Conway D.S. Alexander[3] E. Tollefson
Approximately March 1969	H.W. Habgood	C.H. Amberg	E.L. Tollefson	R.J. Cvetanovic[4,5] B.E. Conway J.R. Boocock
Approximately October 1969	H.W. Habgood[6]	C.H. Amberg	E.L. Tollefson	R.J. Cvetanovic B.E. Conway J.R. Boocock D.M. Ruthven R.B. Anderson

[1] R.J. Cvetanovic (CIC Councillor) was delegated by the executive of the Physical Chemistry Division at the 1965 CIC meeting to form a Canadian Committee on Catalysis.
[2] R.J. Cvetanovic and C.H. Amberg were the first two Canadian delegates appointed to the International Congress on Catalysis.
[3] D.S. Alexander resigned prior to March 1969.
[4] In March 1969 R.J. Cvetanovic (as outgoing Chair) appointed I.G. Dalla Lana and H.W. Habgood to nominate two additional members. They were added to the Committee in October 1969.
[5] R.J. Cvetanovic was asked to attend (as an observer) a meeting of the Board of Directors of The Catalysis Society held in Atlantic City in conjunction with the First North American Meeting of The Catalysis Society, February 20-22, 1969.
[6] The Committee Meeting October 22, 1969 at the Macdonald Hotel in Edmonton approved a motion "that the executive of the Canadian Committee on Catalysis make application to the Board of Directors of the CIC to form a separate subject division within the bylaws of the CIC".

One of the reasons for forming The Catalysis Division was to be a part of The Catalysis Society (later known as the North American Catalysis Society, NACS). The Catalysis Society holds its North American meetings in odd-numbered alternate years. To avoid conflict, the Canadian Symposia on Catalysis are held in even-numbered alternate years. In addition, The Catalysis Society has sponsored the Ciapetta lecturer, who has usually given one or more presentations in Canada. Initially a lecture was given at one location in Canada each year, then two locations, and in 1981 the Ciapetta lecture was given at three Canadian locations. As of 2004, the Ciapetta lecturer has been invited to give a presentation at the Canadian Symposium on Catalysis. A description of The Catalysis Society is presented in Chapter 4.

In addition there have been several single-day catalysis meetings held at various locations. A local catalysis discussion group (not sponsored by The Catalysis Division) was formed primarily from people in the Montréal-Chalk River-Ottawa-Kingston area. The first one-day meeting was organized by A.H. Hardin at the Energy Research Laboratories in Ottawa on May 14, 1976. Meetings continued once or twice a year up to the early 90's.

Members of The Catalysis Division have participated in each of the International Congresses on Catalysis (ICC). At the 1980 International Congress, Y. Amenomiya and R.B. Anderson presented a letter signed by the Chair, B.W. Wojciechowski, indicating The Catalysis Division's interest in inviting the Congress to Canada in 1988.

At the 1984 meeting in Berlin, Canada was awarded the ICC. Canada hosted the 9th ICC in Calgary in 1988, as described in Chapter 7. This was truly a Canadian effort, with local and national efforts in the organization of the event. A post-congress symposium was also held in Québec City, on the use of organometallic complexes in heterogeneous catalysis.

In 2001 The Catalysis Division hosted the 17th North American Meeting of the Catalysis Society, in Toronto. The organizing committee was co-chaired by J. Moffat and M. Ternan. The entire Canadian catalysis community contributed strongly to the organization of this major and successful meeting, as described in Chapter 6.

Since its formation in 1971, The Catalysis Division has grown to the point where its members are involved in a number of activities. These include local one-day meetings, the biennial F.G. Ciapetta lecture, biennial Canadian Symposia on Catalysis and biennial North American meetings of The Catalysis Society. The organization is now mature, and functioning well.

The Catalysis Division and its sibling organization, the Canadian Catalysis Foundation, are each active in support and sponsorship of organization and attendance at meetings related to catalysis throughout Canada and abroad. Examples include not only the meetings of NACS and the ICC, but also major international events such as the Sixth International Symposium on Homogeneous Catalysis, Vancouver, 1988 chaired by B. James, and the International Zeolite Symposia, Québec City, chaired by S. Kaliaguine. Other meetings containing sponsored sessions on catalysis include the annual Canadian Society for Chemical Engineering Conference and the annual Canadian Society for Chemistry conference and exhibition

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2 EXECUTIVES OF THE CATALYSIS DIVISION

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Josephine Hill, Graeme Norval, Hui Wang (3rd Edition)

The main roles of Chair, Vice-chair, Secretary/Treasurer and Members at large have remained constant over the years. Other roles have evolved over time. As such the information has been divided into multiple tables as given below.

Table 2.1 Executives of The Catalysis Division of The CIC, 1971-83.

Year	Chair	Vice-Chair	Secretary-Treasurer	ICC Rep	Director, The Catalysis Soc.	Chemistry in Canada Rep	CIC Councilor	Members at Large
1971-72	R.B. Anderson	E.L. Tollefson	J.R. Boocock	R.J. Cvetanovic	R.J. Cvetanovic			B.E. Conway I.G. Dalla Lana N.J. Gaspar K.E. Hayes S. Kaliaguine D.M. Ruthven
1972-73	E.L. Tollefson	C.H. Amberg	J.R. Boocock	C.H. Amberg R.J. Cvetanovic	H.W. Habgood	B.E. Conway	R.J. Cvetanovic	I.G. Dalla Lana O.M. Fuller N.J. Gaspar K.E. Hayes S. Kaliaguine P.L. Silveston
1973-74	C.H. Amberg	S. Kaliaguine	J.R. Boocock	R.B. Anderson H.W. Habgood	H.W. Habgood	B.E. Conway	R.J. Cvetanovic	Y. Amenomiya I.G. Dalla Lana O.M. Fuller K.E. Hayes A. Lawson P.L. Silveston
1974-75	S. Kaliaguine	J.R. Boocock	I.G. Dalla Lana	R.B. Anderson H.W. Habgood	H.W. Habgood	B.E. Conway	E.L. Tollefson	Y. Amenomiya O.M. Fuller A. Lawson B.I. Parsons D.M. Ruthven P.L. Silveston
1975-76	J.R. Boocock	I.G. Dalla Lana	Y. Amenomiya	R.B. Anderson H.W. Habgood	H.W. Habgood	B.E. Conway	E.L. Tollefson	R.R. Hudgins A. Lawson P. Norton B.I. Parsons D.M. Ruthven
1976-77	I.G. Dalla Lana	A. Lawson	Y. Amenomiya	R.B. Anderson H.W. Habgood	C.H. Amberg	B.E. Conway	E.L. Tollefson	E. Chornet R.R. Hudgins B.I. Parsons R.A. Ross D.M. Ruthven F.R. Smith
1977-78	A. Lawson	Y. Amenomiya	M. Ternan	R.B. Anderson H.W. Habgood	C.H. Amberg	S.E. Wanke	J.R. Boocock	E. Chornet P.C. Flynn R.R. Hudgins R.A. Ross N.H. Sagert F.R. Smith
1978-79	Y. Amenomiya	B.W. Wojciechowski	M. Ternan	R.B. Anderson H.W. Habgood	C.H. Amberg	S.E. Wanke	J.R. Boocock	E. Chornet P.C. Flynn K.E. Hayes A.E. Pope R.A. Ross N.H. Sagert

1979-80	B.W. Wojciechowski	R.A. Ross	M. Ternan	R.B. Anderson Y. Amenomiya	C.H. Amberg	S.E. Wanke	J.R. Boocock	P.C. Flynn K.E. Hayes M.J. Phillips A.E. Pope N.H. Sagert F.R. Smith
1980-81	R.A. Ross	M. Ternan	J.B. Moffat	R.B. Anderson Y. Amenomiya	I.G. Dalla Lana	S. Kaliaguine	A. Harrison	K.E. Hayes B.R. James M.J. Phillips A.E. Pope F.R. Smith S.E. Wanke
1981-82	M. Ternan	E. Chornet	J.B. Moffat	Y. Amenomiya B.W. Wojciechowski	I.G. Dalla Lana	S. Kaliaguine	R.A. Ross	O.M. Fuller B.R. James M.J. Phillips A.R. Sanger F.R. Smith S.E. Wanke
1982-83	E. Chornet	M.J. Phillips	J.B. Moffat	Y. Amenomiya B.W. Wojciechowski	I.G. Dalla Lana	S. Kaliaguine	R.A. Ross	R.B. Anderson O.M. Fuller Z.M. George B.R. James R.F. Mann A.R. Sanger S.E. Wanke

Table 2.2 Executives of The Catalysis Division of The CIC, 1983-86.

Year	Chair	Vice-Chair	Secretary-Treasurer	ICC Rep	NACS Director	Division Councilor	Members at Large	Canadian Chemical News
1983-84	M.J. Phillips	J.B. Moffat	J.F. Kriz	Y. Amenomiya B.W. Wojciechowski	I.G. Dalla Lana	R.A. Ross	R.B. Anderson O.M. Fuller Z.M. George B.R. James R.F. Mann J.H. Rolston A.R. Sanger	S. Kaliaguine
1984-86	J.B. Moffat	B.R. James	J.F. Kriz	Y. Amenomiya B.W. Wojciechowski	I.G. Dalla Lana	K.A.R. Mitchell	N.N. Bakhski J. Feimer Z.M. George D.E. Laycock R.F. Mann J.H. Rolston A.R. Sanger	S. Kaliaguine

Table 2.3 Executives of The Catalysis Division of The CIC, 1986-2006.

Year	Chair	Vice-Chair	Secretary-Treasurer	ICC/IACS Rep	NACS Director	Board Rep	Members at Large	Canadian Chemical News
1986-88	J.F. Kriz	A.R. Sanger	D.E. Laycock	Y. Amenomiya B.W. Wojciechowski	A.R. Sanger	K.A.R. Mitchell (CSC) S. Kaliaguine (CSChE)	N.N. Bakhshi J.R. Brown J. Feimer J.H. Rolston E.C. Sanford	S. Kaliaguine
1988-90	A.R. Sanger	D.E. Laycock	M. Goddard	M. Ternan B.W. Wojciechowski	D.E. Laycock	J.B. Moffat S. Kaliaguine (CSChE)	P.M. Boorman J.R. Brown M. Goddard A. Krzywicki J.H. Rolston E.C. Sanford	S. Kaliaguine
1990-92	D.E. Laycock	M. Goddard	E.C. Sanford	M. Ternan B.W. Wojciechowski	M. Goddard	J. Davies (CSC) V. Galatone (CSChE)	P.M. Boorman J.R. Brown A. Krzywicki A. Sayari K.J. Smith	D. Laycock[1]
1992-94	M. Goddard	E.C. Sanford	M.F. Wilson	M. Ternan B.W. Wojciechowski	E.C. Sanford	J. Davies (CSC) V. Galatone (CSChE)	U. Achia J.R. Brown A. Krzywicki R.A. McFarlane J. Monnier A. Sayari	K.J. Smith[1]
1994-96	E.C. Sanford	M.F. Wilson	K.J. Smith	J.B. Moffat B.W. Wojciechowski	M.F. Wilson	A.L. Arduini (CSC) M Goddard (CSChE)	J.R. Brown A. Krzywicki R.A. McFarlane C.A. Mims J. Monnier G. Norval	A. Sayari[1]
1996-98	M.F. Wilson	K.J. Smith	G. Norval	J.B. Moffat B.W. Wojciechowski	K.J. Smith	K. Griffiths (CSC) J. Lundy (CSChE)	R. Kydd A.L. Arduini R.A. McFarlane J. Monnier C.A. Mims	A. Sayari[1] J. Monnier[1]
1998-2000	K.J. Smith	G. Norval	A. Sayari	J.B. Moffat B.W. Wojciechowski	G. Norval	K. Griffiths (CSC) J. Lundy (CSChE)	R. Kydd F.T.T. Ng C. Fairbridge A.J. Dalai C.A. Mims	J. Monnier[1,3]
2000-02	G. Norval	C.A. Mims	J. Monnier	J.B. Moffat B.W. Wojciechowski	C. Mims	C. Crudden (CSC) J. Lundy (CSChE)	R. Kydd F.T.T. Ng C. Fairbridge K.T. Chuang B. McGarvey	A.K. Dalai[1,3]
2002-04	C.A. Mims	J. Monnier	M. Poirier	K.J. Smith B.W. Wojciechowski	J. Monnier	C. Crudden (CSC) J. Lundy (CSChE)	K.T. Chuang C. Fairbridge B. McGarvey F.T.T. Ng J.Kirchnerova B. Peppley	A.K. Dalai[1,3]
2004-06	J. Monnier	B. McGarvey	F.T.T. Ng	J. Monnier F.T.T. Ng	J. Monnier	C. Crudden (CSC) J. Lundy (CSChE)	K.T. Chuang J.Kirchnerova F. Larachi J.M. Hill	A.K. Dalai[1,3]

[1] Also Editor, Catalysis Division Newsletter.

[2] International Association of Catalysis Societies (IACS) since 1996

[3] Since 1998, Allan Palmer, Associate Editor of the Catalysis Division Newsletter, prepared the *Bulletin de la Division de Catalyse* (French version)

Table 2.4 Executives of the Catalysis Division of The CIC from 2006-2022.

Year	Chair	Vice-Chair	Secretary/ Treasurer	Members at Large	IACS Representative
2006-08	B McGarvey	FTT Ng	A Dalai	S Brown JM Hill[1] J Kirchnerova F Larachi[2] A Nelson B Peppley	J Monnier FTT Ng
2008-10	FTT Ng	A Dalai	W Epling	S Brown JM Hill[1] J Kirchnerova F Larachi[2] G Patience Y Zheng	J Monnier FTT Ng
2010-12	A Dalai	W Epling	RT Baker	JM Hill[1] S Kaliaguine[2] S Brown Kl Karan A Nelson G Patience N Semagina Y Zheng	J Monnier FTT Ng
2012-14	G Rempel	RT Baker	J Hill	H Wang[1] S Kaliaguine[2] Y Zheng[3] G Patience N Semagina Z Chen C Siewe	J Monnier FTT Ng
2014-16	JM Hill	RT Baker	Y Zheng	C Chin S Kaliaguine N Semagina C Siewe H Wang	JM Hill G Rempel
2016-18	RT Baker	Y Zheng	N Semagina	C Chin H Wang N Braidy R Scott C Xu X Zhang	Y Zheng C Chin
2018-20	Y Zheng	N Semagina	H Wang	E Baranova N Braidy R Scott J Soltan C Xu X Zhang	Y Zheng C Chin
2020-22	N Semegina	H Wang	C Chin	M Alyani E Baranova S Bergens J Kopyscinski D Simakov J Soltan	N Semagina

[1] Newsletter Editor
[2] Associate Editor of Newsletter
[3] Webmaster

3 CANADIAN CATALYSIS FOUNDATION

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Bryce McGarvey (3rd Edition)

The 9th International Congress on Catalysis (9ICC, see Chapter 7) that was held in Calgary in 1988 was very successful from both scientific and financial perspectives. After the completion of the conference, several forward-looking members of the Canadian catalysis community decided to use the excess funds to establish a not-for-profit foundation. The intent was to have the foundation available to support the catalysis community and to foster and develop catalysis in Canada. The key proponents of establishing a foundation undertook many extensive discussions and worked out a tentative plan between the end of the 9ICC (1988) and 1990. The end result was a proposal to establish the Canadian Catalysis Foundation (CCF).

The objects and by-laws governing the Foundation were registered in 1990 (Appendix 2), and the Foundation was incorporated by Letters Patent issued by Consumer and Corporate Affairs Canada, on March 19, 1990. At the inaugural general meeting that was held on June 29, 1990, H.W. Habgood was confirmed as President, with the support of a vigorous and proactive group of catalysis professionals as officers and members of the Board of Directors. The officers and members of the Board of Directors since that date are listed in Table 3.1.

Objectives

The purposes for which the CCF was established each address the advancement and knowledge of catalysis in Canada. These objects were specified in the letters patent, and include:

- sponsoring catalysis lectures and lecture tours within Canada
- giving prizes and awards in recognition of Canadian catalysis achievements
- holding and supporting lectures, symposia, exhibitions, meetings, classes and conferences on catalysis
- supporting graduate student travel to selected conferences and symposia
- related issues concerning funding

Since 2000, in excess of $200,000 has been provided by the CCF to support lectureships and student travel to conferences. It is not an objective of the CCF to sponsor catalysis research or applications, and no funds are made available for such purposes. Grants are made by the Board of Directors of CCF based on the grant proposals received from the Catalysis Division.

Lecture Tour Sponsorship

The objectives were initially addressed through the sponsorship of the Canadian Catalysis Lectureship Award (Chapter 10), the Cross-Canada Lecture Tour (Chapter 11), awards to students to travel to catalysis meetings (Chapter 8), seed money or direct support of catalysis meetings, and similar events. Since that time, the lectureship awards have evolved. In 2016, the Cross-Canada Lecture Tour was renamed the Robert B. Anderson Award. The Canadian Catalysis Lectureship Award and the Robert B. Anderson Award recipients are selected through a nomination and evaluation process that is administered by the Catalysis Division. Financial

support from the CCF is intended to cover the cost of travel to universities and research facilities across Canada and/or to the bi-annual symposia, as well as an honorarium for the recipients.

Graduate Student Travel Support

A key objective of the CCF has been to support graduate student travel to selected conferences and symposia. Support is provided for students enrolled in Canadian university graduate programs to travel to the Canadian Symposium on Catalysis (Chapter 5) and the North American Meeting of the Catalysis Society (NAM, Chapter 6). More recently, some limited support has been provided for travel to the International Congress on Catalysis (ICC, Chapter 7). The overall support budget is determined by the Board of Directors, and managed by the Grants Committee in conjunction with the Catalysis Division. More details on the Student Support are provided in Chapter 8.

Membership

When the CCF was created, the intention was that the membership would be relatively small, and would comprise senior and experienced people in the catalysis community. The majority of the members are persons who have served as directors of the CCF, or as Chairs of the Catalysis Division of CIC. It is typical that the chair and vice-chair of the Catalysis Division are *ex officio* directors of the CCF, and that the secretary/treasurer of the Catalysis Division is an *ex officio* member. It is recognized that new directors of CCF may be appointed from outside the membership of CCF. Members who have served on the Board of Directors of CCF, or who served as Chair of the Catalysis Division of CIC before 1990, automatically become life members of CCF.

Supporting Canadian Catalysis Conferences

An ongoing objective of the CCF has been to provide seed money and financial support to organizing committees of Canadian Symposia on Catalysis, as well as travel support to graduate students from Canadian Universities to attend these symposia. The support is provided following requests from the conference organizers and is intended to lessen the financial burden of the commitments that must be made during the early stages of organization and venue booking.

Table 3.1 Executive and Board of Directors of the Canadian Catalysis Foundation.

Year	President	Vice President(s)	Treasurer	Secretary	Board Members
1990 -91	H.W. Habgood[7]	J.B. Moffat[4] B.W. Wojciechowski[3,5]	B.W. Wojciechowski[3,5]	D.E. Hill[1]	M. Goddard[2,3,5] D.E. Laycock[2,4,6,7] E.C. Sanford[2] A.R. Sanger[2,6]
1991 -92	J.B. Moffat	A.R. Sanger[4,6] B.W. Wojciechowski[3,5]	B.W. Wojciechowski[3,5]	D.E. Hill[1]	Y. Amenomiya[6,7] M. Goddard[2,3] D.E. Laycock[2,4,7] E.C. Sanford[2]
1992 -93	J.B. Moffat[5]	A.R. Sanger[4] B.W. Wojciechowski[3,5]	B.W. Wojciechowski[3,5]	D.E. Hill[1]	Y. Amenomiya[6,7] M. Goddard[2,3,6] D.E. Laycock E.C. Sanford[2,4,7]
1993 -94	J.B. Moffat[7]	Y. Amenomiya A.R. Sanger[4] B.W. Wojciechowski[3,5]	B.W. Wojciechowski[3,5]	D.E. Hill[1]	M. Goddard[2,6] D.E. Laycock[3,5,7] E.C. Sanford[2,4,6]
1994 -95	J.B. Moffat	Y. Amenomiya A.R. Sanger[4] B.W. Wojciechowski[3,5]	B.W. Wojciechowski[3,5]	D.E. Hill[1]	D.E. Laycock[3,5,7] E.C. Sanford[2,4,6] M.F. Wilson[2,6]
1995 -96	Y. Amenomiya	A.R. Sanger[4]	B.W. Wojciechowski[3,5]	D.E. Hill[1]	D.E. Laycock[3,5] J.B. Moffat[4,7] E.C. Sanford[2] M.F. Wilson[2,6,7]
1996 -97	Y. Amenomiya	D.E. Laycock[3,5]	B.W. Wojciechowski[3,5]	D.E. Hill[1]	J. Moffat[4] S. Kaliaguine[4] M. Wilson[2,4] K.J. Smith[2,6] A. Sanger[7] J. Kriz[7]

1997 -98	Y. Amenomiya	M. Wilson4 D.E. Laycock[3,5]	D.E. Laycock[3,5]	D. E. Hill[1]	J. Moffat[3,4,5] S. Kaliaguine[4] B.W. Wojciechowski [6] K.J. Smith[6] A. Sanger[7] J. Kriz[7]
1998 -99	Y. Amenomiya	J. Kriz[7] D.E. Laycock[3,5]	D.E. Laycock[3,5]	D. E. Hill[1]	J. Moffat[3,5,7] S. Kaliaguine[4,6] M. Wilson[4] K.J. Smith[2,6] G. Norval[2,4] B.W. Wojciechowski
1999 - 2000	D.E. Laycock[3,5,7]	J. Kriz[7] M. Wilson[4]	D.E. Laycock[3,5,7]	D. E. Hill[1]	G. Norval[2,3,4,5] S. Kaliaguine[4,6] K.J. Smith[2,6]
2000 -01	D.E. Laycock[3,5,7]	J. Kriz[7] M. Wilson[3,4,5]	D.E. Laycock[3,5,7]	D. E. Hill[1]	G. Norval[2,4,6] K.J. Smith[4,6] C. Mims[2,6]
2001 -02	J. Kriz[7]	K.J. Smith[4,7]	M. Wilson[3,5]	D. E. Hill[1]	G. Norval[2,3,4,5,6] C. Mims[2,6]
2002 -03	K.J. Smith[7]	J. Kriz[3,5,7]	G. Norval[3,4,5]	D. E. Hill[1]	J. Monnier[2,4,6] C.Mims[2,6]
2003 -04	K.J. Smith[7]	J. Kriz[3,5,7]	G. Norval[3,4,5,7]	D. E. Hill[1]	J. Monnier[2,4,6] C.Mims[2,3,5,6]
2004 -05	C. Mims[4]	J. Monnier[2,3,5,6,7]	G. Norval[3,4,5,7]	D. E. Hill[1]	G.B. McGarvey[2,6]
2005 -06	C. Mims[4,7]	G. Norval[3,6]	J. Monnier[2,3,5]	D. E. Hill[1]	G.B. McGarvey[2,4,6,7]
2006 -07	C. Mims[4]	G.B. McGarvey[3,5,7]	J. Monnier[3,5,7]	D. E. Hill[1]	F.T. Ng[2,4,6]
2007 -08	C. Mims[4]	G.B. McGarvey[3,7]	J. Monnier[3,7]	D. E. Hill[1]	F.T. Ng[2,4,6] G. Norval[6]
2008 -09	G.B. McGarvey[3,7]	F.T. Ng[4,6]	J. Monnier[3,7]	G. Norval[6]	A. Dalai[2,4,6] W. Epling[2]
2009 -10	J. Monnier[3,7]	F.T. Ng[4,6]	G.B. McGarvey[3,7]	G. Norval[6]	A. Dalai[2,4,6] W. Epling[2]

2010 -11	F.T. Ng[4,6,7]	A. Dalai[4,6]	G.B. McGarvey[3,7]	G. Norval[6]	W. Epling[2,3] A. Sanger[6]
2011 -12	F.T. Ng[4,6,7]	A. Dalai[4,6]	G.B. McGarvey[3,7]	G. Norval[6]	W. Epling[2,3] A. Sanger[6]
2012 -13	A. Dalai[4,6,7]	F.T. Ng[4,6,7]	G. Rempel[3]	G. Norval[6]	K.J. Smith[3,6] R.T. Baker[2]
2013 -14	A. Dalai[4,6,7]	F.T. Ng[4,6,7]	G.B. McGarvey[3]	G. Norval[6]	K.J. Smith[3,6] R.T. Baker[2,4] G. Rempel[2]
2014 -15	K.J. Smith[3,6,7]	G. Rempel	G.B. McGarvey[3]	G. Norval[6]	J.M. Hill[2,4] R.T. Baker[2,4] A. Dalai[4,6,7]
2015 -16	K.J. Smith[3,6,7]	G. Rempel	G.B. McGarvey[3]	G. Norval[6]	J.M. Hill[2,4] R.T. Baker[2,4] A.Dalai[4,6,7]
2016 -17	K.J. Smith[3,6,7]	G. Rempel	G.B. McGarvey[3]	G. Norval[6]	J.M. Hill[2,4,6] R.T. Baker[2,4,7] Y. Zheng[2,4]
2017 -18	K.J. Smith[3,6,7]	G. Rempel	G.B. McGarvey[3]	G. Norval[6]	J.M. Hill[2,4,6] R.T. Baker[2,4,7] Y. Zheng[2,4]
2018 -19	K.J. Smith[3,6,7]	J.M. Hill[6,7]	G.B. McGarvey[3]	G. Norval[6]	R.T. Baker[2,4,7] Y. Zheng[2,4] N. Semagina[2,4]
2019 -20	J.M. Hill[6,7]	R.T. Baker[6,7]	G.B. McGarvey[3]	G. Norval[6]	K.J. Smith[7] Y. Zheng[2,4] N. Semagina[2,3,4]
2020 -21	J.M. Hill[6,7]	R.T. Baker[6,7]	N. Semagina[2,3]	G. Norval[6]	C. Chin[4] Y. Zheng[4] H. Wang[2,6] G.B. McGarvey[3]

[1] David E. Hill, Q.C., is a retired lawyer formerly with Holmested and Sutton, Toronto
[2] Ex-officio, on behalf of the Catalysis Division of CIC
[3] Finance Committee
[4] Grants Committee
[5] Investment Committee
[6] Audit Committee
[7] Nominating Committee

4 THE NORTH AMERICAN CATALYSIS SOCIETY

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Natalia Semagina and Cathy Chin (3rd Edition)

The Catalysis Division of CIC is affiliated with The North American Catalysis Society (NACS), founded officially in 1956 in Philadelphia. The society was previously known by its chosen name as The Catalysis Society, as there were no other organizations of similar name at the time it was founded. NACS is comprised of affiliated clubs and societies throughout the United States, Mexico and Canada, and is in turn affiliated with the International Association of Catalysis Societies, who coordinates the organization of International Congress on Catalysis. The NACS by-laws are given in Appendix 3 (reprinted with permission from NACS).

In 1969, Dr. R.J. Cvetanovic was invited to attend as an observer at the meeting of the Board of Directors of The Catalysis Society. In 1970-71, the fledgling Catalysis Division of CIC officially became a member club of The Catalysis Society, and Dr. Cvetanovic was the director representing the Division.

According to the by-laws of the Catalysis Division, the Division Vice-Chair serves on the NACS Board of Directors as a representative from Canada. The board meetings occur annually. Each primary member of The Catalysis Division is registered as a member of NACS. Dues are paid by the Division annually.

NACS holds meetings on catalysis (North American Catalysis Society Meeting, denoted as NAM) in each odd-numbered year. Each affiliated club or society also holds its regular meetings, and subject groups organize symposia at the national meetings of the American Chemical Society, annual meetings of the American Institute of Chemical Engineers (AIChE), and the Pacifichem series of international meetings. Consequently, a wide range of pertinent meetings is available to catalysis professionals through the Division and its sibling organizations within the Society.

Awards

NACS is responsible for the administration of six key awards, in addition to the Kokes award and clubs awards: the Michel Boudart Award for the Advancement of Catalysis, the Paul H. Emmett Award in Fundamental Catalysis, the Eugene J. Houdry Award in Applied Catalysis, the Robert Burwell Lectureship in Catalysis, the F.G. Ciapetta Lectureship in Catalysis, and the NACS Award for Distinguished Service in the Advancement of Catalysis. Catalysis researchers from Canada are eligible to be nominated for the awards, subject to the specific award eligibility criteria. The details of each award, including the nominating procedure and list of recipients, are available at the NACS website *http://www.nacatsoc.org*. The abbreviated terms of reference of the awards are presented in the following pages.

The recipients of the Lectureship awards are traditionally invited to Canadian Symposia on Catalysis (CSC) as a part of their lectureship tour. As such, Jingguang Chen (recipient of the 2017 Robert Burwell Lectureship award) presented a plenary lecture "Converting CO_2 via thermocatalysis and electrocatalysis" at the 25th CSC (Saskatoon, 2018); Paul Barger (recipient

of the 2014 F.G. Ciapetta Lectureship award) presented a plenary lecture "UOP advanced MTO technology – integration of methanol-to-olefins and olefin cracking process" at the 23rd CSC (Edmonton, 2014); Johannes A. Lercher (recipient of the 2011 Robert Burwell Lectureship award) presented a plenary lecture "Hydrocarbon sorption, transport, and catalytic transformation in confined space" at the 22nd CSC (Quebec, 2012); Jeffrey T. Miller (recipient of the 2010 F.G. Ciapetta Lectureship award) presented a plenary lecture "XAFS spectroscopy in catalysis research: application to Au catalysts".

Abbreviated Terms of Reference of the NACS Awards

Adapted from http://www.nacatsoc.org (with permission from NACS) where more detailed information can be found

Michel Boudart Award for the Advancement of Catalysis recognizes and encourages individual contributions to the elucidation of the mechanism and active sites involved in catalytic phenomena and to the development of new methods or concepts that advance the understanding and/or practice of heterogeneous catalysis. The Award selection process emphasizes accomplishments and contributions published within the five preceding years. Candidates may be nominated without any restriction of national origin, thus reflecting the international scope of the career and contributions of Michel Boudart. The Award is sponsored by the Haldor Topsøe Company, and is administered jointly by the North American Catalysis Society and the European Federation of Catalysis Societies. The Award is presented biennially in odd numbered years.

The Robert Burwell Lectureship in Catalysis is given in recognition of substantial contributions to one or more areas in the field of catalysis with emphasis on discovery and understanding of catalytic phenomena, catalytic reaction mechanisms and identification and description of catalytic sites and species. The Awardee is selected on the basis of his/her contributions to the catalytic literature and the current timeliness of these research contributions. The recipient may be invited to (1) visit and lecture to each of the affiliated Clubs/Societies with which mutually satisfactory arrangements can be made and (2) prepare a review paper(s) for publication covering these lectures. Selection is made without regard for age, sex, nationality or affiliation. The Lectureship is sponsored by Johnson Matthey and administered by NACS. It is awarded biennially in odd-numbered years.

The F. G. Ciapetta Lectureship in Catalysis is given in recognition of substantial contributions to one or more areas in the field of catalysis with emphasis on industrially significant catalysts and catalytic processes and the discovery of new catalytic reactions and systems of potential industrial importance. The awardee is selected on the basis of his/her contributions to the catalytic literature and the current timeliness of these research contributions. The recipient may be invited to visit and lecture to each of the affiliated Clubs/Societies with which mutually satisfactory arrangements can be made. Selection of the awardee is made without regard to age, sex, nationality, or affiliation. The F. G. Ciapetta Lectureship in Catalysis (prior to 1973 The National Lectureship) is sponsored by the W.R. Grace & Co. and The North American Catalysis Society. It is awarded biennially in even numbered years.

The Paul H. Emmett Award in Fundamental Catalysis recognizes and encourages individual contributions in the field of catalysis with emphasis on discovery and understanding of catalytic phenomena, proposal of catalytic reaction mechanisms and identification of and description of catalytic sites and species. Selection is made without regard for sex, nationality or affiliation. The award winner must not have turned 46 on April 1st of the award year, thus nomination documents should indicate the age and birth date of the nominee. The Paul H. Emmett Award in Fundamental Catalysis is sponsored by the W.R. Grace & Co. It is awarded biennially in odd numbered years.

The Eugene J. Houdry Award in Applied Catalysis recognizes and encourages individual contributions in the field of catalysis with emphasis on the development of new and improved catalysts and processes representing outstanding advances in their useful application. Selection is made without regard for age, sex, nationality or affiliation. The Award is sponsored by Clariant. It is awarded biennially in odd numbered years.

The NACS Award for Distinguished Service in the Advancement of Catalysis recognizes an individual who advanced catalytic chemistry or engineering by significant service to the catalysis community in addition to technical accomplishments. A nominee must have demonstrated extensive contributions to the advancement of catalysis during their career. Service activities recognized by the award may include roles such as teaching, mentoring, writing, editing, and leadership of meetings or organizations. An awardee must have made these contributions to the benefit of the North American catalysis community. The Award is jointly sponsored by ExxonMobil Research and Engineering and Clariant. It is awarded biennially in even numbered years.

Canadian Awarded 2004 Ciapetta Lectureship in Catalysis
Photo: Courtesy of Douglas Stephan



The 2004 Ciapetta Lectureship in Catalysis was awarded to Professor Douglas Stephan of the Department of Chemistry and Biochemistry, University of Windsor, Windsor, Ontario. Professor Stephan presented his award address to the Canadian Division at the 18th Canadian Catalysis Symposium in Montreal, in May 2004.

Dr. Stephan received his PhD in Inorganic Chemistry from the University of Western Ontario. He undertook a NATO Postdoctoral Fellowship at Harvard University before moving to the University of Windsor where he has spent his career doing research. His research group has been active for over 20 years in studying the fundamental organometallic chemistry of early transition metals. He has received many distinctions and honors for his accumulated accomplishments during the course of his studies, but it was his recent success in developing a novel set of catalysts for polymerizing ethylene that have earned Doug Stephan many accolades both in industrial circles and among his academic peers. This

development is expected to have a major impact on the Canadian petrochemicals industry, which is a significant part of Canadian manufacturing capability.

Stephan's innovative approach to ancillary ligand design quickly led to dramatic findings of new patentable catalysts that were highly active under industrial conditions. NOVA Chemicals' goal of developing new single site catalyst technologies was significantly advanced with the discoveries of potential new catalyst compounds from the Stephan laboratories. In collaboration with a team of chemists and engineers at NOVA Chemicals, Stephan's team worked to explore and develop these new catalyst families towards commercialization. Stephan and his group have continued to study the structure-reactivity relationship of these single-site catalysts. In addition, his group has discovered and studied a number of unusual deactivation pathways that these new catalysts exhibit allowing optimization of process conditions.

More recently, Stephan's group has been studying modified systems that exhibit living catalyst behaviour and their use in the formation of co- and block polymers. His new efforts are focused on developing new co-catalysts as well as strategies to design late transition metal catalysts.

Student Support

As a local club of the NACS, the Catalysis Division of CIC receives support for graduate and postgraduates students affiliated with Canadian Universities. The NACS provides competitive Kokes awards to participate in the biennual NAM meetings, as well as annual grants ("Local student club award") to support student involvement in the local catalysis events. The detailed information on the student support can be found in Chapter 8.

5 CANADIAN SYMPOSIUM ON CATALYSIS

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Nicolas Abatzoglou and Charles Xu (3rd Edition)

This series of Canadian Symposium on Catalysis (CSC) meetings are even older than The Catalysis Division, having first been held as a component of the 1965 annual conference of CIC, in Montréal. The symposia enable chemists, engineers and professionals in related disciplines to meet at a common forum, to present papers, and to discuss issues within their common interest in catalysis.

Since the inaugural meeting, the symposia have grown in both size and scope, as illustrated in Figure 5.1 for the numbers of contributed papers and contributors' nations. At the 1965 meeting there were two invited papers and 15 contributed papers, and the authors came from three countries (Canada, USA, and one other country). At the 1996-2004 meetings there were typically approximately four invited speakers and well over 50 diverse contributed papers, and at the 2006-2018 meetings, the numbers of invited speakers and contributed papers increased to 10-20 and 80-160, respectively. Speakers came from multiple parts of the world including Canada, the United States, South America, Europe, Asia, and Australia. The topics presented covered all aspects of catalysis: from exploratory to applied chemistry and engineering; from disclosure of new methods and materials to insights into the use of known systems; from microscopic examinations to macroscopic applications; from creation of products to energy and protection of the environment.

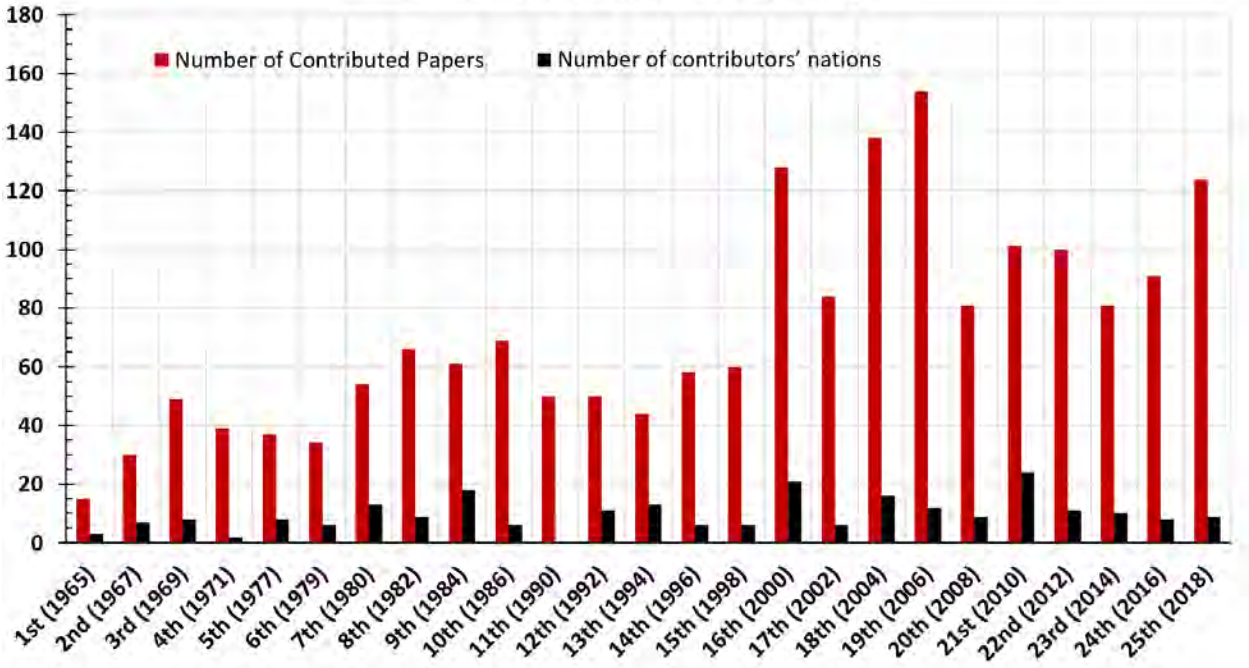


Figure 5.1 The number of contributed papers and nations represented in the past CSC meetings.

The Evolutionary Sequence

In 1965 the "Canadian Committee on Catalysis" was an informal group. It was decided to hold sessions dedicated to catalysis at a national meeting. At that time catalysis issues within CIC fell largely within the aegis of the Physical Chemistry Division. Thus, the meeting that the Committee organized was held within the 1965 annual meeting of the CIC, in Montréal. This meeting later became recognized as the inaugural Canadian Symposium on Catalysis (CSC).

Following the success of the first meeting it was decided to hold an independent conference fully dedicated to catalysis and kinetics. Two years later the 2nd CSC was held in Hamilton. The number of invited speakers and contributions greatly increased from those at the first symposium, and the meeting had a higher level of international participation, which proved the potential for a stand-alone format. Subsequently the symposia have been held in western Canada, the Maritimes, Ontario and Québec commonly in every 2 years. The criteria for selection of a location have included local interest and efforts in catalysis, strengths of the local organizers, attractiveness of the site and facilities, and the need to address the needs of the whole Canadian catalysis community.

The symposia have largely been very successful in both technical and financial terms. When meetings were held in conjunction with either CIC or CSChE, the financial arrangements had necessarily been directed principally towards the objectives of those organizations. Each stand-alone meeting has received good support from industry, local institutions, and (since 1990) the Canadian Catalysis Foundation. Indeed, The Catalysis Division now draws no funds from CIC or CSChE to support these meetings.

An outline of the symposia is shown in Table 5.1. For each the site, date, principal organizers, and extent of the program are given. Strong organizational support from both the local catalysis community and the national organization are constant features of these meetings. The evolution of the Canadian Symposium on Catalysis will be seen, from a limited size, local forum for Canadians to a national meeting of a growing size with strong international participation.

Table 5.1 A brief summary of Canadian Symposia on Catalysis.

No - Year	City	Organizing committee	Invited speakers	Presentations	Countries Represented	Publication	Remarks
1 - 1965	Montréal	C. Amberg; Y. Amenomiya; B.E. Conway; R.J. Cvetanovic; H.W. Habgood; Others.	R.B. Burwell and B.E. Conway	15	3	N.A	In conjunction with the CIC annual meeting
2 - 1967	Hamilton	R.B. Anderson (Chair)	G.C. Bond, F.G. Ciapetta, M. Cohen, W.K. Hall, and H. Marsh	30	7	N.A.	
3 - 1969	Edmonton	H.W. Habgood and I.G. Dalla Lana	V. Haensel, H. Kubota, P.W. Selwood, J.M. Smith, and J. Wei	49	8	N.A.	In conjunction with the CSChE annual meeting
4 - 1971	Halifax	T.J. Gray	R.B. Anderson (Catalysis Award lecture)	39	2	N.A.	In conjunction with the CIC annual meeting
5 - 1977	Calgary	I.G. Dalla Lana and E.L. Tollefson	M.A. Vannice	37	8	A volume of preprints of papers	In conjunction with the CSChE annual meeting
6 - 1979	Ottawa	Y. Amenomiya (Chair); C.H. Amberg and J.F. Kelly (Program Chairs).	H.W. Habgood and G.A. Somorjai	34	6	A volume of preprints of paper	
7 - 1980	Edmonton	A.R. Sanger (Chair); S.E. Wanke, S.K. Chakrabartty and S. Prakash (Program Chairs)	W.K. Hall and C.N. Satterfield	54	13	A volume of preprints of papers	In conjunction with the CSChE annual meeting
8 - 1982	Waterloo	R.R. Hudgins (Chair); P.L. Silveston (Vice Chair)	D. Barthomeuf, B.C. Gates, J. Haber, J.D. McIntyre, and J. Rabo	66 (57 oral, 9 posters)	9	A volume of preprints of papers	
9 - 1984	Québec	S. Kaliaguine (Chair); A. Adnot, E. Chornet, H. De Lasa, Z.M. George and P.C. Roberge (Program Committee)	R.B. Anderson, R.A. Armstrong and J.P. Hobson, R.L. Burwell, Jr., E.G. Derouane, K. Klier, A. Nielson, J.M. Smith, and J.G. Speight	61	18	A volume of preprints, and a volume of full papers: “Catalysis on the Energy Scene”, ed. S. Kaliaguine and A. Mahay, Studies in Surface Science and Catalysis, vol. 19, Elsevier, Amsterdam (1984)	
10 - 1986	Kingston	R.F. Mann (Chair); J. Downie (Program Chair)	C.H. Bartholomew, I.B. Dicker, H.W. Habgood (Catalysis Award lecture), A. Kiennemann, R.J. McKinney, J.M. Stencel, and H. Topsøe	69	6	A volume of preprints	
11 - 1988	Calgary						Hosting the 9th ICC in Calgary
12 - 1990	Halifax	M. Wilson, F. Kriz, J. Monnier, and J.R. Brown	B.C. Gates, M. Wilson, B.R. James (Catalysis Award lecture), and G. Rempel	50	N.A.	A volume of preprints	In conjunction with the CIC CSChE joint annual meetings

13 - 1992	Banff	A.R. Sanger (Chair); E.C. Sanford, K.T. Chuang, A. Krzywicki and K.J. Smith (Program Committee); R.E. Hayes (Fundraising)	R. Chianelli, R. Grubbs, E.L. Tollefson, and B.W. Wojciechowski (Catalysis Award lecture)	50	11	A volume of abstracts and a volume of full papers as "Progress in Catalysis", ed. K.J. Smith and E.C. Sanford, Studies in Surface Science and Catalysis, vol. 73, Elsevier, Amsterdam (1992).	
14 - 1994	Sarnia	D.J. Laycock (Chair); J.B. Moffat, I. Cody, J. Hsu, C.A. Mims, and F. Ng (Program Committee).	M.M. Bhasin, B.H. Davis, M. Daage, J.M. Garces, and K.C. Taylor	44 (30 oral, 14 posters)	13	A volume of abstracts	
15 - 1996	Whistler	K.J. Smith (Chair); A.R. Sanger, B.R. James, A. Krzywicki, and E.C. Sanford (Program Committee).	J.N. Armor, K.T. Chuang, M. Ternan (Catalysis Award lecture), and T.T. Tsotsis.	58	6+	A volume of abstracts	
16 - 1998	Québec	S. Kaliaguine (Chair); L. Benneviot (Technical Co-Chair), S. Giasson (Technical Co-Chair), F. Béland, C. Danumah, and G.Y. Xu	R.J. Farrauto, G. Rempel, R. Sheldon, D.W. Goodman and S. Kaliaguine (Catalysis Award lecture).	60	6+	A volume of abstracts	
17 - 2000	Banff	R.A. Kydd (Chair); Abdel Sayari	J.R. Grace, E. Iglesia, J.C. Stevens, J. Weitkamp, S.L. Scott, T. Ziegler and G. Rempel (Catalysis Award lecture)	128 (54 oral, 74 posters)	21	A volume of abstracts	
18 - 2002	Vancouver	Bob Hayes (Chair)	T. Kreuzer, R. Farrauto, S. Wanke, C. Crudden, and Michael C. Baird (Catalysis Award lecture).	84 (66 oral, 18 posters)	6+	A volume of abstracts	In conjunction with the CSChE annual meeting
19 - 2004	Montreal	Jitka Kirchnerova (Chair); Jacques Monnier (Program Co-chair), Faiçal Larachi (Program Co-chair), Dimitrios Berk, Philip Jessop, Peter McBreen, Michel Poirier, Marten Ternan, and Davit Zargarian	**Plenary Lectures (4):** Gabor A. Somorjai, Tobin J. Marks, Douglas W. Stephan (Ciapetta Lecture) and Colin A. Fyfe (Catalysis Award Lecture); **Keynote Lectures (13).**	138 (94 oral, 44 posters)	16	A volume of abstracts, and A special issue of "Topics in Catalysis" (J. Kirchnerova, F. Larachi, R. Le Van Mao and D. Zargarian, guest editors)	
20 - 2006	Saskatoon	Ajay K. Dalai (Chair); Craig Fairbridge	**Plenary Lectures (4):** Burtron Davis, Leo E.	154 (105 oral, 49 posters)	12	A volume of abstracts	

		(Program Chair); Hui Wang (Treasurer); Deena Ferdous (Web site); Stephen Foley (Facilities); Raphael Idem (Publication); Doug Soveran (Fund Raising); Jeff Cutler (Tour)	Manzer, Roel Prins, Stephen Brown (Catalysis Award Lecture); **Keynote Lectures (15)**.			
21 - 2008	Kingston	Brant A. Peppley (Chair); John Amphlett (Program Co-chair); Michael Baird (Program Co-chair); Kunal Karan (Treasurer), Chris Thurgood Royal	**Plenary Lectures (5):** Manfred Bochmann, Fred Wagner, Tom Ziegler, Robert Farrauto, Flora T.T Ng (Catalysis Award Lecture); **Keynote Lectures (2):** Thomas Jaramillo, Philip Jessop	81 (64 oral, 17 posters)	9	A volume of abstracts
22 - 2010	Banff	Josephine Hill (Chair); Kevin Smith (Program Chair); Natalia Semagina (Treasurer); Kenneth Boateng (Registration); Ying Zheng (Website Coordinator); Alan Nelson (Advertising); Cécile Siewe (Fundraising and Industry Liaison)	**Plenary Lectures (4):** Carl Mesters, Enrique Iglesia, Jeffrey T. Miller, (Ciapetta Lecturer), Stan Brown (Catalysis Medal Awardee); **Keynote Lectures (6):** Olaf Deutschmann, Tom Baker, Robbie Burch, Younan Xia, Charles H. F. Peden, Stu L. Soled	101 (56 oral, 45 posters)	24	A volume of abstracts
23 - 2012	Quebec City	Serge Kaliaguine (Chair); R. Tom Baker (Program Chair), Bendaoud Nohair (Treasurer), Guoying Xu (Secretary), Ying Zheng (V), Hugo St-Laurent and Serge Kaliaguine (Fund Raising)	**Plenary Lectures (5):** Can Li, Johannes Lercher, James Dumesic, Ferdi Schüth, Charles Mims (Catalysis Medal Awardee); **Keynote Lectures (5):** Cathleen Crudden, Wan Ying, Frédéric Jaouen, Mario Pagliaro, Gabriele Centi	100 (50 oral, 50 posters)	11	A volume of abstracts
24 - 2014	Edmonton	Natalia Semagina (Chair); Robert E. Hayes (Program Chair), Josephine Hill, Robert Scott and Cathy Chin	**Plenary Lectures (4):** Krijn de Jong, Robbie Burch, Paul Barger (Ciapetta Lecture), Warren Piers (Catalysis Award Lecture); **Keynote Lectures (6):**	81 (50 oral, 31 posters)	10	A volume of abstracts

			Susannah L. Scott, Yuriy Román, Zhenrong Zhang, Edward M. Calverley, Bert D. Chandler, Richard G. Finke			
25 - 2016	Ottawa	R. Tom Baker (Chair); Elena Baranova (Program Co-Chair); Javier Giorgi (Program Co-Chair); Flora Marguerite; Janette Champ	**Plenary Lectures (3):** Johannes Lercher (R.B. Anderson Award Lecture); Cathleen Crudden; Plamen Atanassov; **Keynote Lectures (7):** Viola Birss; Matthew Neurock; Mark Lautens; Curtis Berlinguette; Svetlana Schauermann; Jules Thibault; Peter McBreen	91 (61 oral, 30 posters)	8	A volume of abstracts
26 - 2018	Saskatoon	Hui Wang (Chair); Robert Scott (Program Co-Chair); Ajay Dalai (Program Co-Chair, Fund Raising & Exhibition Coordinator); Yongfeng Hu (Venue, Event & Program Coordinator); Lifeng Zhang (Communication & Student Event Coordinator, Treasurer); Amira Abdelrasoul (Poster Session Coordinator)	**Plenary Lectures (3):** Bert Weckhuysen (R.B. Anderson Award Lecture); Jingguang Chen (2017 North American Catalysis Society Robert Burwell Lectureship Winner Lecture); Cathleen Crudden (Catalysis Award Lecture); **Keynote Lectures (14)**	124 (94 oral, 30 posters)	9	A volume of abstracts

6 THE NORTH AMERICAN MEETING (NAM)

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Ajay Dalai and Ying Zheng (3rd Edition)

The North American Meetings, abbreviated as NAM, are biennial conferences organized by the North American Catalysis Society (NACS) in even-numbered years. The Catalysis Division holds the Canadian Symposium on Catalysis in the alternate, odd-numbered years. The first NAM was held at Atlantic City in 1969. A rotation between the NACS clubs to host NAM was established. The Division organized the 4th NAM in 1975 and the 17th NAM in 2001, both meetings were held in Toronto, and is scheduled to host the 30th NAM in 2027. The list of previous NAM and future locations for NAM are available on the NACS website (nacatsoc.org/resources/nam/).

The 17th Meeting of the North American Catalysis Society, Toronto, 2001

Approximately four years prior to the opening of the 17th North American Meeting of the Catalysis Society (abbreviated as 17 NACS or NACS2001), a group of scientists and engineers was assembled from the Canadian catalysis community to start organizing this important meeting. Each agreed to serve on the organizing committee for NACS2001. The effort made by each member of the committee was enormous. The work was performed with skill and energy. The results were excellent. This report has been constructed from reports for each subject area provided by the committees responsible.

Co-chairs: **John B. Moffat,** University of Waterloo, and
Martin Ternan, CANMAR Eng Inc, Ottawa, Ontario
Secretary: **Alan R. Sanger,** Alvesan Enterprises Inc., Edmonton, Alberta
Finances: **Graeme Norval,** PCI Chemicals Canada Inc., Mississauga, Ontario

Expenses

We focused on expense items first to allow the committee to determine what the registration fee must be. The Toronto meeting was set for a break-even at roughly 750 total registrants, based on a $CAD at 70¢ US. In fact, the $US surged in Q1 2001, which pushed our break-even number lower. Also, the conference received a significant amount of donations after the registration cost had been set. Consequently, the Toronto meeting had a significant surplus, even with the extra expenses that we included. We estimated registration first to estimate the number of registrants in the various categories, and to vary the registration fees to balance the expenses. The total number of anticipated registrants was used to estimate the food cost on the expense side of the spreadsheet.

Support

Industrial support was a huge success. The NACS provided $10,000 US as support for Kokes students. In addition The NSF and NIST provided support to cover student travel to the conference. The total student subsidy was roughly $90,000 CAD, with $45,000 CAD provided

by NACS and NSF/NIST, and the balance provided by the conference. The hotel contract provided a room credit to the conference of 1 room night per 50 room-nights sold. The low registration scenario had students staying at the hotel in order to fill the block, and avoid the penalty. Once the room block was cleared, it became clear that the students should stay at the University.

Cash Flow

The largest concern for the Toronto meeting was cash flow. The Canadian Division did not have much money to seed the conference. As a consequence, several actions were initiated.

1) The first was the donation of services by the National Centre for Upgrading Technology (NCUT) – which donated the website and web service costs. All of these costs would have been payable prior to registrations arriving. This donation helped enormously.
2) Donations were solicited in advance, and were received in 1998, 1999 and 2000.

Surplus

The meeting turned a surplus that was substantially greater than expected. One year before the conference, the breakeven registration was 800. Two months prior to the conference, using 900 delegates, the estimated surplus was $85,000. The final accounting surplus was $230,000. This surplus is equivalent to ~100 USD per registrant which is a significant over estimate of the registration fees.

Fund Raising: Andrzej Krzywicki, NOVA Research & Technology, Calgary, Alberta

The Financial Committee was established in 1997. The Committee established a target of $ 100,000 CAD in donations. The Committee developed a list of target companies in Canada and the US. After the meeting in Toronto both lists were shared with the organizing Committees of 18th NACS and ICC meetings. Due to the general economic situation, and M&A activities in the chemical industry the meeting timing was inconvenient, and the list of the target companies changed very quickly. Organizational changes, internal moves, lay-offs and early retirements characterized the soliciting period for the 17th NACS meeting. Several key contact people from industry changed their jobs or duties causing cancellations of earlier promised support. The exploration of Mexican sources by F. Beltran ended without any success.

Publications and Publicity: Craig Fairbridge, NCUT, Devon, Alberta

Originally, we included publications, publicity and exhibits together but we quickly decided to keep exhibits separate since it would be a lot of work on its own (see below). By December 1998, we started to make some plans for email address, website, logo, circulars and letterhead. A decision was taken to keep the publications and website similar to the previous NACS meetings.

One NACS2001 email address was chosen in 1998 so that any and all electronic communications went through this one address with an individual from our committee responsible for checking the email on a regular basis.

The first circular was designed and printed in the second quarter of 1999 and approximately 2,200 were mailed out in the third quarter. The second circular (call for papers) was designed and printed in the first quarter of 2000 and approximately 3,900 were mailed in the second quarter. We printed 3,000 first circulars and 4,500 second circulars. This second circular was also designed in French and Spanish. Although we had 3,700 names in our database, we had only

about 500 email addresses. The third circular was the registration package. It was designed and mailed out in the first quarter of 2001. There were costs associated with the printing and mailing of this registration package.

The website was initiated in the second quarter of 1999. We chose to build and maintain our website rather that contract to a website design company. The site was simple and continuously updated. We tried to give Official Sponsors some prominence by placing their company logos and links on our homepage. We also listed Exhibitors on the site with links to their websites. Our meeting management company offered an electronic registration site so that we simply provided a link from our website. Our preliminary program schedule was placed on the website in March/April 2001 with links to each abstract.

Our printer required material for the book of abstracts by mid-April to guarantee June 1 delivery. The Program Schedule was difficult to design. There were usually 10 presentations per day for each of 7 sessions so we compromised on two pages for each day and we included author names only in the plenary and keynote presentations. We added a brief description of each exhibitor to this Program Schedule.

Program: Kevin Smith, University of British Columbia

Theme:

The theme of the 17th North American Catalysis Society Meeting was 2001: Horizons of Catalysis. This theme focuses attention on catalysis research that is clearly linked to the needs of the 21st century. Each day begins with a plenary presentation. The Houdry Award Lecture was given by Leo E. Manzer on Monday and the Emmett Award Lecture was given by Donna G. Blackmond on Wednesday.

Session organizers:

The success of a conference is in large measure attributable to the quality of the technical sessions. In turn, the quality of the technical program is a direct consequence of a large and diligent effort by the organizers of the sessions.

Number of parallel sessions:

It was recognized early in the organization of the program that there would be a large number of submissions. A decision was made, after intense review of all options, to increase the number of parallel oral sessions when compared with earlier NACS meetings. Inevitably, this led to some conflicts when attendees found themselves choosing between two concurrent sessions. However, the incidence of such conflicts was relatively small, because great care was taken in scheduling sessions that would be likely to attract a similar group of attendees.

Having seven parallel oral sessions and a non-conflicting set of poster sessions allowed allocation of the vast majority of papers to the type of session preferred by the presenter(s), and allowed considerable flexibility in scheduling.

Abstracts:

Abstracts for all oral and poster presentations were reviewed. Papers were then assigned to oral or poster components of the program, and sessions were designed to maximize interest, convenience and relevance to specific themes. The abstracts were then compiled into printed volumes for distribution to all attendees. Copies of the volumes were circulated with the registration packages, and additional copies were available for sale at the registration desk.

Table 6.1 17th Meeting of the North American Catalysis Society: Session Organizers.

Session	Organizer(s)
Environmental:	K. Chuang, University of Alberta
Preparation and Characterization:	A. Dalai, University of Saskatchewan, and J. Adjaye, Syncrude Canada Ltd.
Acid Catalysis and Zeolites:	A. Kuperman, Chevron
Catalyst Deactivation and Reaction Engineering:	E.M. (Ted) Calverley, Dow Chemical
Natural Gas Conversion:	J. Galuszka, Natural Resources Canada, CETC, and K. Smith, University of British Columbia
Heterogeneous Organic Synthesis and Fine Chemicals:	K. Smith, University of British Columbia
Hydroprocessing:	J. Kriz, Ensyn Technologies Inc.
Fundamentals:	C.A. Mims, University of Toronto
Homogeneous and Polymerization Catalysis:	C. Crudden, University of New Brunswick
Combinatorial Methods:	G. Koermer, Engelhard, and A. Moini, Engelhard
Innovations in Mo catalysis:	C. Hallada, Climax Molybdenum, A.W. Armour, Climax Molybdenum, and P.C.H. Mitchell, University of Reading
Fuel Cells:	B. Peppley, Royal Military College
Membranes:	J. Galuszka, Natural Resources Canada, CETC
Novel Catalytic Processes:	D. Laycock, Dow Chemical Canada Inc. NA Polyurethanes Flexibles Group, and J. Monnier, Natural Resources Canada, CETC
General:	K. Smith, University of British Columbia
Posters:	A. Dalai, University of Saskatoon

Local Events and Registration: **Charles Mims, Jane Phillips,** both University of Toronto
Meeting Management: **R. Dewar (MMS),** Burlington, Ontario
Kokes Fund and Related Issues: **Elmer Alyea,** University of Guelph

Hiring a meeting management company:

We hired Ron Dewar, Meeting Management Services of Burlington, Ontario, to help with registration and local arrangements. The involvement of a meeting management company was deemed essential to the Local Arrangements Committee. One factor in this decision was the limited number of "locals" in Toronto to mount the effort required. Resources such as donated secretarial help at universities have all but dried up and the local industrial base is small. The demands of everyone's "day job" leaves little extra time for such an endeavour. A more important reason, however, was the efficiency gained by bringing onto the committee experts who knows the business instead of training ourselves in skills never to be used again. In our situation, a group of amateurs would have required enormous amounts of time and yet produced

a lower quality meeting for the delegates. The question of hiring a company and how they should be used was a substantial one, as it requires the firm commitment of cash at an early date.

It was most important to find a good quality company who understood the needs of our group. Ron Dewar and Meeting Management Services (MMS) was the first choice of the local arrangements committee.

Registration

Fees:

The registration fees were decided 1 year out. They were based on a conference budget that included the "final" version of the events program. The "breakeven" paid registration was set at 700. It is good to have the early registration deadline on the same day the conference delegate room block lapses at the hotel (1 month out in our case).

Registration Process:

MMS provided web-based registration. A printable registration form was also available on the conference web-site and was also circulated in preconference publicity mailings for fax or regular mail registration. 47% of the delegates registered over the internet for NACS2001.

It was important to ask on the registration form for all the useful information you can use. The registration process was the only time that contact with the delegate was guaranteed. The registration form had a connection to all the other tasks (local arrangements, program, etc.) and the design of the registration form should involve input from everyone.

MMS prepared envelopes with each pre-registered delegate's materials (badge, receipt, event tickets) were pre-prepared and combined with delegate bags that have been pre-stuffed with the technical program and other items on the Saturday before the conference. On-site registrations were handled at a separate line. The final numbers exceeded our optimistic model and are summarized in Table 6.2.

Hotel (Contract, Accommodations, Events):

The site was selected and the hotel contract negotiated in 1995 by Y. Amenomiya, J.Moffat and M. Ternan. The meeting space (except for a charge for exhibits) was provided free of charge if the room block was filled, and an increasing fraction of the meeting room rental costs were to be applied for increasing shortfalls in the room block. We filled the room block for all nights almost exactly on the day that the block reservation lapsed (2 May, 2001). A block of rooms at Victoria College at the University of Toronto was booked for students, primarily for Kokes awardees. The rate was $45 CAD /night and included a hot breakfast, although taking advantage of the breakfast precluded attending the plenaries. This block was also sold out.

Table 6.2 17th Meeting of the North American Catalysis Society: Registration Breakdown.

a. Registration by categories		b. Breakdown of attendees by country (866 total, excludes companions, exhibitors).		
Revenue-generating	Number		**Percentages**	
Full registrations	645	**North America**	**74.4**	
One - day registrations	27	USA		60.9
Student (non-Kokes)	90	CANADA		8.5
Retired	19	MEXICO		5.0
Companions	58	**South America**	**2.1**	
Non-revenue registrations		ARGENTINA		0.3
Kokes Students	85	BRAZIL		1.0
Exhibitors	80	CHILE		0.2
Total	1004	COLOMBIA		0.1
		VENEZUELA		0.5
		Europe + FSU	**16.1**	
c. Breakdown of attendees by sector (866 total, excluding exhibitors, companions)		DENMARK		0.8
Registrants participating in technical program	**%**	FINLAND		0.3
Academic (non-students)	28	FRANCE		3.3
Students	19	GERMANY		2.6
Industry (non-exhibits)	44	HUNGARY		0.4
Government	9	IRELAND		0.1
Media	0.2	ITALY		1.6
		BELGIUM		0.3
		NETHERLANDS		1.7
		POLAND		0.7
		PORTUGAL		0.2
		RUSSIA		0.4
		SPAIN		0.4
		SWEDEN		0.5
		SWITZERLAND		0.2
		UK		2.1
		UKRAINE		0.2
		Middle East - Africa	**0.6**	
		ISRAEL		0.1
		KUWAIT		0.1
		SAUDI ARABIA		0.2
		TUNISIA		0.1
		UNITED ARAB EMIRATES		0.1
		Asia	**6.7**	
		TAIWAN		0.3
		CHINA		0.6
		INDIA		0.2
		JAPAN		3.0
		KOREA		2.5
		Pacifica	**0.1**	
		NEW ZEALAND		0.1

Events

Dinner cruise:

Two boats were booked over a year in advance. The meal contracts on the boat were signed 1 month out. The delegate numbers and stronger-than- anticipated subscription to the cruise made it necessary to add another boat and band at the last minute (Sunday). All three boats were full, and more crowded than the optimum.

Banquet:

Although 670 people attended the banquet, we ended up with a substantial number (60 or so) of unfilled places because of no-shows. Most meeting managers and events organizers have formulae to calculate numbers, but the tendency is to err on the high side, since even a handful of people with no place at dinner will make a greater impact than 50 empty seats.

Companions Program:

We decided to provide a companions room with food and beverages, a local phone line, and knowledgeable people, including Ms. Carolyn Box, to help the companions sort out their options and arrangements on an individual basis. We counted on the local tour machinery and their contact through the hotel to accommodate the companions wishes, without putting conference funds at risk by reserving buses, etc. This room was heavily used.

Volunteers:

"Volunteers" were recruited from University of Toronto students for help with registration (6 from Sunday noon through Monday morning), delegate bag stuffing at the hotel (8 for 3 h Saturday before the meeting), and help during the technical program (7 or 8 per day). This staffing was adequate, except we should have had help more coverage with posters set-up at odd hours (evenings and early morning). One student was given overall responsibility as a "lieutenant" and monitor, and served in the speaker-ready room when not overseeing the operations. We decided to use local students, and give the Kokes students a break, because it allowed us to pre-train and pre-acquaint the volunteers with their tasks before the meeting started. The volunteers were paid an hourly wage of $15 CDN /h and the room monitors given a lunch voucher.

Exhibits: Peter Byrne, Snap-tite, Inc., Toronto, Ontario

No. of companies solicited:	Approximately 70, (depends on counting duplicates)
No. of companies who attended:	29
No. of sold booths:	31

NACS 2001 provided only space. The exhibitors purchased everything else directly from suppliers. Exhibitors want conference attendees to be in the exhibit space as often as possible. Ideally the exhibits should be as close to the meeting rooms as possible. Services like coffee should be located to facilitate traffic through the exhibit area. Locating exhibits remotely is particularly undesirable. Arranging of these services and poster presentations to enhance exhibit attendance is critical as it may affect attendance at the following conference.

Advisor: Bohdan Wojciechowski, Naples, Florida 34110

7 THE INTERNATIONAL CONGRESS ON CATALYSIS

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Ajay Dalai and Ying Zheng (3rd Edition)

Every four years since 1956, the international catalysis community has held an International Congress on Catalysis (ICC). At these meetings a large number of prominent established catalysis professionals and emerging talents from many nations meet. Papers on every facet of catalysis are presented, and several issues related to catalysis are discussed. For each meeting to date a diligent and hard-working organizing committee has created a program with outstanding invited speakers and contributed papers. The difficulty in designing the program has always been selection of the most appropriate papers for presentation, from the many quality submissions made. A number of papers submitted by Canadian authors have been selected for presentation at each Congress.

The Council of the ICC comprises members representing each fully accredited member nation, and observers from other participating nations [It is now called the International Association of Catalysis Societies (IACS)]. Canada is entitled to two members of the Council of ICC. The holders of this office are listed among the Executives of The Catalysis Division in Chapter 2. The Constitution of the International Association of Catalysis Societies is given in Appendix 4 and at http://www.iacs-icc.org/ConstitutIACS_04.pdf.

The selection of the site for an ICC is competitive. The Council receives submissions from representatives of the prospective host nations, and these are assessed on the basis of site, facilities, transportation and other logistical considerations, and the scientific and organizational strength of the host catalysis community. The sites selected are shown in Table 7.1. In 1982 Calgary was selected by the Canadian catalysis community as the most appropriate venue for an ICC. At the ICC held in Berlin in 1984 Canada was selected to host the 9th ICC, in 1988. A description of that meeting follows.

THE NINTH INTERNATIONAL CONGRESS ON CATALYSIS, CALGARY, 1988

When Canada was awarded the Ninth International Congress on Catalysis (9ICC), it fell to a group of hard-working, dedicated and very effective volunteers to organize this, the most prestigious of catalysis meetings. Bob Anderson and Harry Habgood were selected as Co-Chairs for the organizing committee. A strong team of local talents from Calgary undertook organization of components related to the site and events, and the national catalysis community created teams to address each of the other components. A superb job was performed by the organizing committee in enabling and arranging the technical and supporting components. The program committee undertook the arduous task of selecting and programming oral and poster presentations, selecting and organizing session chairs from the international community, and ensuring that the technical content of 9ICC was lively and worthwhile. The meeting was an outstanding success.

The quality of the work by the organizing committee is well characterized in the report to the Council of the International Congress on Catalysis by the Co-Chair, Harry Habgood as given below and followed by the list of the volunteers on the organizing committee, who deserved such high commendation.

Table 7.1. Locations for the International Congress on Catalysis.

Number	Year	Location
1	1956	Philadelphia, USA
2	1960	Paris, France
3	1964	Amsterdam, The Netherlands
4	1968	Moscow, USSR
5	1972	Miami, USA
6	1976	London, UK
7	1980	Tokyo, Japan
8	1984	Berlin, Germany
9	1988	Calgary, Canada
10	1992	Budapest, Hungary
11	1996	Baltimore, USA
12	2000	Granada, Spain
13	2004	Paris, France
14	2008	Seoul, Korea
15	2012	Munich, Germany
16	2016	Beijing, China
17	2020	San Diego, USA (canceled due to COVID-19)

Ninth International Congress on Catalysis
Report from Chair of the Organizing Committee

The committee was originally established with two co-chairs, Professor R.B. Anderson and Dr. H.W. Habgood. Unfortunately Dr. Anderson passed away a few months before the Congress; his loss was keenly felt but more in an emotional and psychological way than in any great amount of added work for the remaining co-chair or other committee members.

On our appointment by the executive of The Catalysis Division of The Chemical Institute of Canada we were told that we would not have to assume any great share of the work of the committee. In fact, the two vice-chairs, Dr. R.A. Ross and Professor I.G. Dalla Lana, were not given specific assignments initially so that they would be available to help out or take over from the chairs if necessary. It turned out that the vice-chairs took on some specific responsibilities and the co-chairs participated fully. We both were able to attend most of the committee meetings but our duties were indeed light - largely because of the efficiency and dedication of the secretary, Professor J.B. Moffat. We had numerous consultations with him by telephone and he was very willing to poll members of the committee about particular points that came up between meetings.

There were a few letters that we felt should be written by one of the chairs - *e.g.* the request to NSERC for funds for their invited plenary lecturers - but generally we

encouraged the committee members to write their own letters to solicit funds, invite speakers, negotiate the details of events, etc.

At the meeting itself there were a number of formal duties for the committee chair: presiding at the official opening which we scheduled during the Sunday evening reception; presiding at the first plenary lecture; presiding at the Symposium banquet; and, as chair of one of the final sessions, formally closing the Symposium (vice-chair Dalla Lana did the same thing for the other final session).

The life of the committee is of the order of six years. An important function of the chair is to provide a continuing focus for the members and to encourage them to keep up their interest and commitment. Bob Anderson and I have attempted to do this - with the high calibre of the committee members, particularly the secretary, this has not been difficult.

H.W. Habgood (April 4, 1989)

Organizing Committee, Ninth International Congress on Catalysis, Calgary, 1988

CHAIRS: Professor R.B. Anderson (McMaster University) (deceased October 24, 1987)
Dr. H.W. Habgood (Technical University of Nova Scotia)

VICE-CHAIRS: Professor I.G. Dalla Lana (University of Alberta)
Dr. R.A. Ross (Domtar Inc.)

Committee: Dr. A.R. Sanger (Alberta Research Council) - Post Congress Symposia

Exhibition: Professor K.T. Chuang (University of Alberta)
Dr. P.D. Clark (University of Calgary)
Mr. R.A. Cullen (Southern Alberta Institute of Technology)
Dr. A.Z. Krzywicki (NOVA HUSKY Research Corporation Ltd.)

PROGRAM:

Chair: Dr. Y. Amenomiya (National Research Council of Canada and University of Ottawa)

Committee:

Dr. J.R. Brown (Energy, Mines and Resources Canada)
Professor I.G. Dalla Lana (University of Alberta)
Dr. C. Fairbridge (Energy, Mines and Resources Canada)
Dr. J. Galuszka (Energy, Mines and Resources Canada)
Dr. Z.M. George (Alberta Research Council)
Dr. J.F. Kriz (Energy, Mines and Resources Canada)
Professor B.A. Morrow (University of Ottawa)
Dr. K.W. Oliver (National Research Council Canada)
Dr. A.R. Sanger (Alberta Research Council)
Dr. B.M. Sankey (Esso Petroleum Canada)

FINANCE:

Treasurer and Chair: Professor B.W. Wojciechowski (Queen's University)

Committee:

Dr. F. Hanson (University of Utah - USA)
Mr. T.H.G. Michael (retired from The Chemical Institute of Canada)
Dr. R.A. Ross (Domtar Inc.)
Dr. E.C. Sanford (Syncrude Research)

SECRETARY: Professor J.B. Moffat (University of Waterloo)

Committee:

Ms. Lisa Dowsett (University of Waterloo)
Ms. Gloria Rau (University of Waterloo)

LOCAL ARRANGEMENTS:

Chair: Professor E.L. Tollefson (University of Calgary)

Committee:

Dr. F.W. Bachelor (University of Calgary) - Social Events
Professor A. Badakhshan (University of Calgary) - Congress Site Arrangements
Dr. F. Berruti (University of Calgary)
Professor P.M. Boorman (University of Calgary) - Registration and Finance
Dr. P.D. Clark (University of Calgary) - Sports Tours and Equipment Exhibition
Mr. R.A. Cullen (Southern Alberta Institute of Technology) - Equipment Exhibition
Dr. E.S. Hall (University of Calgary) - Social Tours
Dr. M.A. Hastaoglu (University of Calgary) - Secretary
Dr. J.R. Hawkins (ESSO Resources) - Industrial Tours
Dr. A.Z. Krzywicki (NOVA HUSKY Research Corp. Ltd.) - Equipment Exhibition
Professor R.A. Kydd (University of Calgary) - Registration and Finance
Professor M.F. Mohtadi (University of Durham - South Africa) - Protocol
Dr. E.C. Sanford (Syncrude Research) - Industrial Tours
Professor T. Sorensen (University of Calgary) - Transportation

PUBLICATIONS AND ADVERTISING:

Chair: Dr. M. Ternan (Energy, Mines and Resources Canada)

Committee:

Dr. J. Monnier (Energy, Mines and Resources Canada) - Advertising
Professor B.A. Morrow (University of Ottawa) - Graphics
Dr. M.J. Phillips (University of Toronto) - Publications

Appended to the Co-Chair's report were reports from the Secretary, John Moffat, and the Chair of the Program Subcommittee, Yoshi Amenomiya. The following descriptions have been abstracted from these reports.

Program

Responsibilities

The responsibilities of the Program Subcommittee were to:

1. Establish a form of paper presentation.
2. Establish a method for selecting papers and implement the selection.
3. Select the fields and topics for plenary lectures and recommend a list of lecturers to the Organizing Committee.
4. Select Co-Chairpersons and Assistant Chairpersons for the oral sessions.
5. Arrange a program for technical sessions.
6. Make arrangements for session rooms at the conference site and run the sessions.

To carry out the above responsibilities in conjunction with the schedules set up by the Organizing Committee, a timetable was set as internal milestones for the Subcommittee.

Summary

The initial selection of the contributed papers was based on an extended 2-page abstract. A total of 657 abstracts from 43 countries was received. Each abstract was vigorously reviewed and evaluated by at least two reviewers from a panel of 63 international catalysis experts. The reviewers were asked to rate the abstracts in two categories: the scientific quality of the research and the merit of the paper for presentation at the International Congress. Finally, a special meeting of the Program Subcommittee, including Bob Anderson, one of the Co-Chairs, was held, and a total of 264 abstracts was selected based on the reviewers' evaluation.

After a long discussion at the meetings of the Organizing Committee, a total of five plenary lecturers was selected.

The Program Subcommittee selected a total of 36 prominent catalysis workers from the world as Co-Chairpersons of the oral sessions. Also a total of 18 Canadian scientists and engineers were asked to serve as Assistant Chairpersons. Finally, the Subcommittee selected five Chairpersons to chair the plenary lectures.

After receiving the full manuscripts of the selected papers, the Subcommittees of Publications and Advertising and of Program accepted a total of 255 papers for presentation. These papers were contributed from 32 countries. The finalized program of technical sessions consisted of:

1. 5 plenary lectures.
2. 90 oral papers presented in 18 sessions.
3. 165 poster papers presented in 4 poster sessions.

The acceptance rate (No. of papers accepted / No. of abstracts submitted) at recent Congresses was 37% at Tokyo (1980), 45% at Berlin (1984) and 40% at Calgary (1988).

The proceedings of the 9ICC were published as five volumes. In the first four volumes the oral and poster presentations were grouped by category, as follows:

Catalysis: Theory to Practice:
Proceedings of the 9th International Congress on Catalysis
ed. M.J. Phillips and M. Ternan, The Chemical Institute of Canada, Ottawa (1988).

Volume 1. Hydroprocessing, Zeolites and Catalytic Processes
Volume 2. C1 Chemistry
Volume 3. Characterization and Metal Catalysts
Volume 4. Oxide Catalysts and Catalyst Development

It was decided to encourage the participants to presubmit questions and comments using a discussion form. A copy of each submitted form was delivered to the speakers at the Speakers' Breakfast. Although this formula was also used for the poster sessions, it was particularly useful to save the limited time of discussion at the oral sessions. The questions and the written replies were published in "**Volume 5.** Plenary Lectures and Discussion" in the above series of proceedings.

The scientific program was very good, and the sessions were run smoothly without any serious incidents. The catalysis community owes this to all people who cooperated, namely the reviewers, the Co-Chairpersons, the Assistant Chairpersons, and the Program Subcommittee

members. The organizers were particularly thankful to the local members for their devotion in arranging and running sessions.

The 9ICC attendees truly represented the international catalysis community, both in terms of nations represented (Table 7.3) and the nature of the laboratories and plants in which work is conducted (Table 7.2).

Post-Congress Symposium

An additional effort was made by the Québec members of the Canadian catalysis community. A post-congress symposium was organized by P. McBreen, P.C. Roberge, and S. Kaliaguine. Over 80 attendees were attracted to the meeting on use of organometallic complexes in heterogeneous catalysis.

Table 7.2 9ICC Calgary, 1988: Breakdown of Registrations by Employment Sector.

Employment Sector	Number of Registrants
Government	41
Industry	388
Universities	419
Cancellations & unspecified affiliations	18
TOTAL	866

Table 7.3 9ICC Calgary, 1988: Breakdown of Registrations by Nation.

Country	Total Regular Participants	Total Students	Total Participants
Algeria	1		1
Argentina	3		3
Australia	15		15
Austria	2		2
Belgium	8		8
Bulgaria	3		3
Canada	73	6	79
Czechoslovakia	1		1
Denmark	4		4
Fed. Rep. Germany	31	2	33
German Dem. Rep.	4		4
Finland	6	2	8
France	45	2	47
Hungary	7		7
India	4		4
Ireland	2		2
Italy	38		38
Japan	97	6	103
Korea	2		2
Kuwait	2		2
Mexico, D.F.	1		1
Netherlands	37	8	45
New Zealand	1		1
Norway	8		8
Poland	2		2
Portugal	2		2
P.R. China	14	1	15
R.O. China	8		8
Romania	3		3
Scotland	2		2
South Africa	3	1	4
Spain	5		5
Sweden	8		8
Switzerland	13	1	14
United Kingdom	23	2	25
USSR	19		19
USA	293	16	309
Venezuela	3		3
Yugoslavia	1		1
Blanks include cancellations & those without addresses	18	3	21
TOTALS	814	52	866

8 STUDENT SUPPORT

Natalia Semagina and Cathy Chin

Graduate students and postdoctoral fellows play a critical role in catalysis research all over the world. In Canada, highly qualified personnel training is a mandatory requirement for research grants allocation, as well as for faculty evaluation. Recognizing the value of the young researchers' support, the Catalysis Division of Chemical Institute of Canada (CIC), Canadian Catalysis Foundation (CCF), North American Catalysis Society (NACS) and International Association of Catalysis Societies (IACS) provide several mechanisms for supporting students towards their involvement in the catalysis-related conferences.

Catalysis Division and CCF Student Conference Support to attend Canadian Symposia on Catalysis (CSC)

A biennial Canadian Symposium on Catalysis is the premier showcase for the Canadian catalysis community. It draws together academic and industrial researchers from across Canada and abroad, with approximately 100-150 participants. The symposium provides ample opportunities for young researchers to present their research, for their education and networking. Many students deliver oral presentations, as well as posters, and receive valuable feedback on their work.

Recognizing the value of the symposium in the education of young catalysis researchers, as well as in the promotion of catalysis in Canada in general, the Catalysis Division of CIC and CCF provide financial support to graduate students to attend the symposia. The students must be enrolled in a thesis-based program at a Canadian University. The early registration fee is waived for a limited number of students who are presenting authors (oral or poster presentations). The support is spread to as many groups across Canada as possible so that the fee is waived at least for one graduate student per group. Further partial support for travel is also provided as permitted by the funding. The awards are administered by the Catalysis Division and sponsored by CCF. The terms of reference can be found at the Catalysis Division website, www.catalysisdivision.ca, as well at the respective symposia websites. Table 8.1 shows the student participation in the most recent CSC and the number of students who received the support provided by CCF.

Table 8.1 Student participation at, and CCF support for, Canadian Symposia on Catalysis.

Participant breakdown	23rd CSC (Edmonton) 2014	24th CSC (Ottawa) 2016	25th CSC (Saskatoon) 2018
Total participants	114	~100	125
Graduate students	43	not available	37
Graduate students from Canadian Universities who were granted free registration	24	29	26
Graduate students from Canadian Universities who were granted partial travel support	24	29	16

An awardee talks about the impact of the Student Conference Support by Catalysis Division of Chemical Institute of Canada and Canadian Catalysis Foundation

One of the 2018 grant recipients, Kanchan Dutta (McGill University), speaks to the Division: "In 2018, I attended my first conference as a Ph.D. Student in Saskatchewan, for which I was awarded the travel reward. It also gave me an opportunity to visit the historic city of Saskatoon. At the time of the conference, I had just published my first paper and was working on the second one. That conference opened doors to the different research works carried out by academic and industry stalwarts. I got a glimpse of what I should further contribute through my Ph.D. to the ocean of information in the scientific community. The conference enabled me to decide on the components, which my thesis should have. Without this conference, it would have been overwhelming for me as I was (and still) developing a new type of catalysts. Today, I have four accepted papers. I also had the opportunity to learn about the Canadian Light Source. I witnessed the science and engineering marvel myself during the tour. This award enabled me to attend the conference, which helped me increase my network in the scientific community."

Kanchan Dutta, Montréal, 2020



Kokes Awards to attend the NACS meetings (NAM)

As the Catalysis Division of CIC is one of the clubs of the NACS, graduate students from Canadian Universities are eligible for Kokes awards. Richard J. Kokes Travel Award by NACS supports the participation of students in the biennual NACS meetings (NAM). The award covers a portion of transportation, accommodation, and registration costs. Eligible students must be enrolled at a North American university, must present a paper at the meeting, contribute some time to help with running the conference and be present for the entire meeting. These awards are usually presented only to graduate students, although, for the 22nd NAM, undergraduate students were also considered. Students apply for the award during the abstract submission.

An awardee talks about the impact of the Kokes award

One of the 2015 award recipients, Hanieh Nassiri (University of Alberta), speaks to the Division: "NAM conference was a call for me to shake up the way I think, work and speak, and to make bold moves that would make meaningful changes for me in the workplace. I am sincerely honored and grateful to receive the 2015 Kokes award that encouraged and enabled me to attend this conference to share knowledge and benefit from meeting honorable scientists in the world. More importantly, I realized that one of the important things is networking, which allowed me to see my field from an industry perspective. Branching out of the university bubble is really valuable as it helps you realize what the "real world" is like."

Hanieh Nassiri, Edmonton, 2015



The awards are competitive. For example, for the 25th NAM in Denver (2017), 386 completed applications were received, and 98 were successful with an award per student of US$886 (as per DOE-BES Final Report DE-SC0017268). The number of students from Mexico, Canada, and the US was chosen so that the number of winners from each country was approximately proportional to the number of applicants from that country.

Table 8.2 shows the summary of Kokes awardees (the 19th-25th NAM data are reprinted from the report DOE/ER/15866-1 for the grant No DE-FG02-07ER15866, and DOE-BES Final Reports DE-SC0013082 and DE-SC0017268, all available in open web access).

Table 8.2 Summary of Kokes awardees attending NACS meetings (NAM).

Student university	19th NAM Phila-delphia 2005	20th NAM Houston 2007	21st NAM San Francisco 2009	22nd NAM Detroit 2011	23rd NAM Louisville 2013	24th NAM Pittsburgh 2015	25th NAM Denver 2017	26th NAM Chicago 2019[b]
USA	65	70	92	93	92(96)[a]	93	89	78
Canada	7	5	3	6	6(2)[a]	8	5	7
Mexico	9	10	6	7	9	9	4	9
Total	81	85	101	106	107	110	98	94
Award per student, $US	680	760	~860	969	981	1000	886	not available

[a] 4 students from Canada were not able to attend due to visa problems, they were still provided with Kokes certificates, but the funds were awarded to additional awardees; [b] Data from 26th NAM Abstract book.

The recipients of the Kokes awards from Canadian Universities are (in alphabetical order):

26th NAM (Chicago, 2019): Shuai Chen (U Guelph), Shida Liu (U British Columbia), Haoyu Nie (U Toronto), Gianluca Pauletto (Polytechnique Montreal); Kyle Rogers (U New Brunswick), Kazeem Sulaiman (U Saskatchewan), Yichen Zhuang (U Waterloo);

25th NAM (Denver, 2017): Peng Hu (U of Calgary), Petar Lachkov (U Toronto), Xiangchao Meng (U Ottawa), Asish K.R. Somidi (U Saskatchewan), Dongmin Yun (Western U);

24th NAM (Pittsburgh, 2015): Sandeep Badoga (U Saskatchewan), Pooneh Ghasvareh (U British Columbia), Hanieh Nassiri (U Alberta), Junnan Shangguan (U Toronto), Atal Shivhare (U Saskatchewan), Luis D. Virla (U Calgary), Thomas E. Wood (U Toronto), Yali Yao (U Saskatchewan);

23rd NAM (Louisville, 2013): Rahman Gholami (U British Columbia), Fan Lin (U Toronto), Yuanqing Liu (U Waterloo), A.S.M. Jahirul I. Mazumder (U Western Ontario), Mohsen Shakouri (U Saskatchewan), Hessam Ziaei-Azad (U Alberta);

22nd NAM (Detroit, 2011): Chinmoy Baroi (U Saskatchewan), Luis-Felipe Gutiérrez (Université Laval), Yin Liu (U Waterloo), A.S.M. Jahirul I. Mazumder (U Western Ontario), Harry Oh (U Waterloo), Zahra Sarshar (Laval University);

21st NAM (San Francisco, 2009): Kun Liu (U Waterloo), Naeimeh J. Naghashkar (U Alberta), Mariane Trepanier (U Saskatchewan), Victoria M. L. Whiffen (UBC);

20th NAM (Houston, 2007): Nabil Al-Yassir (Concordia University), Massimiliano Cimenti (U Calgary), Chandra Mouli Kotikalapudi (U Saskatchewan), William O'Keefe (U Waterloo), Mike Shields (U Calgary);
19th NAM (Philadelphia, 2005): Wa'el A. Abdallah (U Alberta), Ibrahim Inamah Abu (UBC), Christian Botchwey (U Saskatchewan), Deena Ferdous (U Saskatchewan), Ching Thian Tye (UBC).

Local Student Club Awards by NACS

As a local club of the NACS, the Catalysis Division of CIC can apply for a grant of 1,500 USD per year. The funds are intended to support graduate and postdoctoral students' involvement at the events by the local catalysis club. In the even-numbered years, when the Canadian Symposia on Catalysis (CSC) occurs, the funds are used to support student participation via travel support and presentation awards. The Catalysis Division selects the awardees on a competitive basis according to the approved terms of reference, available at the Division website www.catalysisdivision.ca.

For the 24th CSC in Ottawa (2016), the NACS-sponsored travel awards were provided to two graduate students. Oral presentation awards were granted to Jingfeng Wu (1st place, University of Calgary), Gwendolyn Bailey (2nd place, University of Ottawa), and Junnan Shangguan (3rd place, University of Toronto). Poster presentation awards were granted to Veeranmaril Sudheeshkumar (1st place, University of Saskatchewan), Uttam Das (2nd place, University of Ottawa), and Amir Habibi (3rd place, University of Alberta).

For the 25th CSC in Saskatoon (2018), one postdoctoral fellow was granted a NACS-sponsored travel award. Oral presentation awards were granted to Katelynn Daly (1st place, University of Calgary), Haiyan Wang (1st place, University of British Columbia), Haiting Cai (3rd place, University of Toronto) and Mohsen Shakouri (3rd place, University of Saskatchewan). Poster presentation awards were granted to William Barrett (1st place, University of Saskatchewan), Ross Arnold (2nd place, University of Calgary), and Muhammad Algamal (3rd place, University of New Brunswick).

In 2019, the Catalysis Division approved the allocation of the NACS grant in odd-numbered years towards student conference awards at Canadian Chemical Engineering Conferences and Canadian Chemistry Conferences and Exhibition for catalysis-related research work. For the first competition related to the 69th Canadian Chemical Engineering Conference in Halifax in 2019, two graduate students received the NACS student conference awards: Kanchan Dutta (1st place, McGill University) and Girish Kamath (2nd place, University of Saskatchewan).

Support towards International Congresses on Catalysis

Young researchers from Canadian Universities are also eligible to apply for the NACS-administered ICC Travel Award, when available, to attend International Congresses on Catalysis (ICC). The ICC take place every four years and bring together usually more than 2,000 catalysis researches from all over the world. The conditions and eligibility criteria are set by the NACS and funding agencies.

As the Catalysis Division of CIC is one of the societies of the International Association of Catalysis Societies (IACS), the young presenting researchers from Canada below 35 age (no distinction before or after Ph.D.) are also eligible to apply for the Young Scientists Travel Support Prize. It consists of a certificate presented during ICC and a contribution towards the registration fee. The terms of reference dictate that the Catalysis Division of CIC selects 3-4

nominees among the presenting authors; the final decision is made by the IACS selection committee.

For further information on the logistics and details of the ICC-related support, one may consult the IACS website www.iacs-catalysis.org, the website of a relevant ICC and/or Catalysis Division representatives to the IACS, as listed in the Tables in Chapter 3.

Other awards and support available to students

Those students, who applied for Kokes awards to attend a NAM, but were not successful, are eligible to apply for the Student Travel Support towards the same meeting. The award is administered by the Catalysis Division of CIC and financed by the Canadian Catalysis Foundation. It was put in place for the first time for the 25th NAM in 2017. For the two covered NAMs, 10 students from Canadian Universities received the financial support, in addition to Kokes awardees. The terms of reference of the Student Travel Support to attend NAM is available at the Catalysis Division website www.catalysisdivision.ca.

Canadian Symposia of Catalysis (CSC) often administers additional student awards for presentations or contributions sponsored by other parties. Such opportunities are specific for every CSC and are announced at the relevant symposium website.

Students working in the catalysis area are encouraged to apply for the awards administered by the CIC and Canadian Society for Chemical Engineering (CSChE). The opportunities and terms of reference can be found at the CIC website https://www.cheminst.ca/recognition/student-awards/. For example, in 2020, the CSChE announced new awards for CSChE Best Master's Thesis Award and Best Ph.D. Dissertation Award.

The Canadian Journal of Chemical Engineering offers annual awards for the Best Graduate Student Paper, starting from 2013. For research in catalysis, Ali Shekari from École Polytechnique de Montréal was awarded in 2014 for his paper on "Transient kinetics of n-butane partial oxidation of elevated pressure." The terms of reference are available on the journal website.

9 CIC CATALYSIS AWARD

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Bob Hayes (3rd Edition)

Prior to 1977 there had been no award dedicated to recognition of the work and achievements within the Canadian catalysis community. This deficiency was addressed by the formation in 1974 of a committee chaired by Dr. B.W. Wojciechowski with the objective of establishing a Catalysis Award. Under the auspices of The Catalysis Division of The Chemical Institute of Canada (CIC) an award was inaugurated for 1977, to be awarded biennially, and was designated "The CIC Catalysis Award". The award consists of a rhodium- plated silver medal and funds to enable the winner to attend a national meeting at which a paper is presented. The design of the medal was made by Mrs. P. Kruus, and is shown on the cover of this volume.

On behalf of the Division, Dr. J.R. Boocock negotiated sponsorship for the medal. The offer of Johnson, Matthey and Mallory Ltd. was accepted in late 1975, and continued to 1990. The costs for the travel of the winner were initially borne by the Division. From 1992, the full costs associated with the award have been generously covered through sponsorship by the Canadian Catalysis Foundation, and the award is now entitled "The Catalysis Award". The present terms of reference for the award are presented on the following page.

The winners of the award (Table 9.1) are each outstanding representatives of the Canadian catalysis community. Profiles of each are presented in the following pages. Their contributions are related in these brief biographies.

Table 9.1. CIC Catalysis Award winners.

Year	Winner(s)	Institute	Topic
1977	Y. Amenomiya and R. J. Cvetanovic	National Research Council of Canada	Development of a Technique for Catalyst Studies
1979	R. B. Anderson	McMaster University	Some Catalysts I Have Known
1982	Carl H. Amberg	Carleton University	no lecture given
1984	Howard Alper	University of Ottawa	Processes Catalyzed by Metal Complexes
1986	H. W. Habgood	Alberta Research Council	Research in Catalysis - A Personal View
1988	John B. Moffat	University of Waterloo	Multifunctional Microporous Heterogeneous Catalysts
1990	Brian R. James	University of British Columbia	Ruthenium Complexes - The Elite of Homogeneous Catalysts
1992	B. W. Wojciechowski	Queens's University	Chain Mechanisms in Hydrocarbon Cracking
1994	Ivo G. Dalla Lana	University of Alberta	Rational Catalysis: Mechanism, Kinetics and Design

1996	Marten Ternan	CANMET, Ottawa	Pore Diffusion of Vacuum Residue Molecules and Hydrogen Dissociation on Reaction Sites: Essential Steps in Hydrocracking Catalysis
1998	Serge Kaliaguine	Laval University	
2000	Garry L. Rempel	University of Waterloo	Polymer Modification via Homogeneous Catalysis
2002	Michael C. Baird	Queens's University	Catalysis by Organotransition Metal Compounds; Synergism between the Pure and the Applied
2004	Colin A. Fyfe	University of British Columbia	Investigations of Zeolite Molecular Sieve Catalysts and Structure Determinations of Their Host/Guest Complexes with Organic Molecules by High Resolution Solid-State NMR Spectroscopy
2006	Steve Brown	NOVA Research and Technology Centre	Advanced Sclairtech™ Technology
2008	Flora T.T. Ng	University of Waterloo	Catalysis for Green Chemical Processes
2010	R. Stanley Brown	Queen’s University	Development of metal ion-catalyzed alcoholis as a rapid methodology for the destruction of organophosphorus chemical weapons, their simulants and pesticides
2012	Charles Mims	University of Toronto	Uses and impacts of mechanistic insight *(in energy catalysis)*
2014	Warren Piers	University of Calgary	Metal Free Catalysis with Perfluoroarylboranes
2016	Mark Lautens	University of Toronto	New Catalytic Reactions Designed to Improve Efficiency in Organic Synthesis
2018	Cathleen Crudden	Queen’s University	N-Heterocyclic Carbenes as Ligands for Surfaces, Nanoparticles and Clusters
2020	Chao-Jun Li	McGill University	TBD

Terms and Conditions of the Catalysis Award (Established 1977, Revised 1995)

1. The Award shall be known as The Catalysis Award, sponsored by the Canadian Catalysis Foundation.
2. It shall be awarded biennially to an individual who while resident in Canada has made a distinguished contribution to the field of catalysis.
3. The Award Selection Committee shall consist of the Vice-Chair of The Catalysis Division as non-voting Chair, the Past Chair of The Chemical Institute of Canada Board of Directors as non-voting Vice-Chair, together with the three most recent Catalysis Award recipients, unless they have nominated or have supported the nomination of a candidate. In this case, The Catalysis Division Executive shall appoint replacements. Should the Vice-Chair of The Catalysis Division be unavailable, the position of non-voting Chair of the Award Selection Committee shall be filled by either the Chair or Secretary/Treasurer of the Division.
4. The recipient shall give The Award Lecture and receive the award at the Canadian Symposium on Catalysis or at the Annual Conference of the CSC or the CSChE, the choice to be made by the recipient in consultation with The Catalysis Division Executive.
5. The Award shall be made biennially unless the Award Selection Committee feels that no suitable nominee exists. The Committee shall select the recipient by November 1st of the year preceding the award year.
6. The recipient shall be known as The Catalysis Award Lecturer and shall receive a rhodium- plated silver medal and travel expenses to present the Award Lecture.
7. A call for nominations for the Award shall be published biennially in the June and July/August issues of the official journal of The Chemical Institute of Canada, “Canadian Chemical News”. A call for nominations shall also be published in The Catalysis Division Newsletter in the Spring issue of the same year.
8. Nominations for the Award shall be submitted in writing to the Program Manager Awards, The Chemical Institute of Canada, over the signatures of no fewer than three professional members of The Institute. Nominations shall be submitted in quadruplicate by October 1st of the year preceding the award year using The Chemical Institute of Canada award nomination form and shall follow the criteria detailed therein. All nominations shall remain in good standing for a period of three successive award selections.
9. The name of The Catalysis Award recipient shall be announced in the official journal of The Chemical Institute of Canada, “Canadian Chemical News”, together with other award winners, and will include a photo and biographical write-up. Additional publicity will be gained through advertising in the Conference/Symposium program announcing the Award Lecture. The above information will be provided to The Institute by the Vice-Chair of The Catalysis Division.
10. The Executive Committee of The Catalysis Division of the CSC and CSChE is responsible for ensuring that the Terms of Reference are followed.
11. Any amendments or alterations to the Terms of Reference shall be the responsibility of the Executive Committee of The Catalysis Division in consultation with the Canadian Catalysis Foundation as sponsor and requires the approval of the CIC Board of Directors.

The terms of reference as advertised by the CIC are given in Appendix 5. Biographies of the award winners are provided on the following pages.

1977 - Yoshimitsu (Yoshi) Amenomiya

Yoshimitsu (Yoshi) Amenomiya was born in Tokyo, Japan, on May 13, 1924. His father was an industrial chemist who established the paint industry in the Mitsubishi group. In a way, therefore, Yoshi followed his family tradition when he obtained a Bachelor's degree in industrial physical chemistry from the Tokyo Institute of Technology (TIT) in 1947. He continued as a research assistant at TIT conducting research in heterogeneous catalysis under the direction of Professor Shiba. This eventually led to his Ph.D. which he obtained in 1959 from Hokkaido University. He came to Canada in the same year and joined the Chemistry Division of the National Research Council of Canada in Ottawa as a postdoctoral fellow. He stayed with the Division for the next 28 years, first as an Associate Research Officer and then since 1968 as a Senior Research Officer. Then, over vigorous protests from his scientific peers, Yoshi was retired from NRC. He then joined the Department of Chemistry at the University of Ottawa as a Visiting Professor, where he reestablished himself and achieved great success. He held this position for four years. Yoshi passed away at the age of 90 on November 22, 2014.

Dr. Amenomiya worked in the field of heterogeneous catalysis for more than 40 years. He published many papers and reviews, authored one book, contributed to three others and delivered over thirty invited presentations. His research covered many aspects of catalysis carried out on oxide-supported metal catalysts. Catalyst surface characterization utilizing probe molecules and test reactions for elucidation of the concept of the catalytically active centre, the role of surface acidity and kinetics of adsorption and desorption constituted major themes. Temperature programmed desorption/reaction (TPD/R), infrared spectroscopy (IR), mass spectrometry (MS), gas chromatography (GC) and microreactors with on-line BC/MS analysis of products were his preferred research techniques. Yoshi's most substantial contributions were made in the areas of C_1 chemistry, the mechanism of methanation, small hydrocarbon isomerization and hydrogenation, the water gas shift reaction mechanism and surface characterization of alumina. He has made significant inroads in the above areas of catalysis. Clarity and a focused approach are trademarks of his widely cited papers.

In 1963, Dr. Amenomiya's most brilliant idea came to fruition, and it has since had an enormous long-term impact on heterogeneous catalysis. "Application of flash-desorption method to catalyst studies. I. Ethylene-alumina system" was published in the *Journal of Physical Chemistry*. An extensive summary of the new technique for catalyst characterization was published in 1967 as a chapter of Volume 17 of the *Advances in Catalysis* under the title "Application of a temperature-programmed desorption technique to catalysis studies". These publications marked the beginning of the temperature-programmed desorption (TPD) technique and the field of catalyst characterization was permanently altered. TPD is an elegantly simple and remarkably effective method for in-situ catalyst characterization. In TPD experiments, the surface of the catalyst is exposed to one or several volatile species, which are adsorbed, and which may react on the surface to form new surface bound moieties. Then the temperature of a catalyst having adsorbed species is increased linearly with time. The number of various surface species, their amounts and strength of adsorption are determined as they desorb as a function of temperature. The first detection system for the desorbed species was based on a thermal conductivity detector (TCD).

In the early sixties, technical advancements in the equipment required were relatively limited. For instance, linear temperature programmers were not commercially available. The development of the TPD technique was only made possible through the application of the exceptional experimental skill, combined with an outstanding multi-disciplinary knowledge

covering scientific and technical aspects possessed by Yoshi Amenomiya and Bob Cvetanovic . The multitude of microprocessors, computers and various powerful and selective detection systems, have enabled commercial versions of the TPD method, also termed temperature-programmed reaction (TPR). Recent application of the combined Fourier transform infra-red spectroscopy (FTIR) with mass spectrometry (MS) has enabled the specific identification of surface species and their various concentrations in a time resolved fashion during TPR/TPD experiments, enhancing even further the power of this methodology. Thousands of reports have been published in which TPD/TPR was employed. There is no question that the impact of TPD methodology on the advancement of knowledge in heterogeneous catalysis has been profoundly significant.

Almost upon the thirtieth anniversary of conceiving the TPD idea, Yoshi became a co-author of another international success. In 1990, Dr. Amenomiya and a group of Canadian scientists (Birss, Galuszka, Goledzinowski, Sanger) published an extensive review on oxidative coupling of methane. Oxidative coupling of methane became a highly researched catalytic processes and in the late eighties and early nineties yielded well above a hundred publications annually and numerous patents. Commercialization of the process appeared imminent. Substantial industrial support was provided with the objective of removing the 25% C_2 yield limitation. During the hey-day of oxidative coupling, it was daring to conclude that the 25% limitation in C_2 yield could not be circumvented catalytically. The review, after a sober analysis of the huge amount of experimental data, did just that. Yoshi Amenomiya with his Canadian colleagues saved many research dollars because of this publication.

Dr. Amenomiya's impact on the direction of national and international catalysis was widely recognized and honoured through numerous awards and representations. Only a few of the most outstanding examples from a much longer list are mentioned here. In 1973, he was elected a Fellow of The Chemical Institute of Canada (FCIC) and between 1978-1979 served as a Chair of the Catalysis Division of CIC. He received **the first** Catalysis Award of CIC (jointly with Cvetanovic) in 1977 and **the first** Canadian Catalysis Lectureship of CIC in 1995. He served as a council member of the International Congress on Catalysis (ICC) and its Canadian representative between 1979-1989. He was elected to the Secretariat of the ICC between 1984-1988 and served as a Program Chair of the 9th International Congress on Catalysis in 1988. He was a Director and Vice-President of the Canadian Catalysis Foundation from 1990.

Yoshi substantially contributed to the development of young Canadian and international scientific talent in catalysis through his active participation in NRC's Research Associate International Program. At various times between 1967-1987, he hosted eleven young scientists from Canada and abroad in his laboratory at NRC, sharing with them his immense expertise and providing guidance and mentorship. Despite his status as a scientist with a well-established international reputation, Yoshi was always easily available to his younger colleagues and peers whenever they desired his assistance in quenching their thirst for knowledge in catalysis. He is a role model for scientific excellence and the finest imaginative science carried out with an elegant simplicity and striking effectiveness. Throughout his career, he contributed immensely to a better understanding of the art of catalysis in its basic and applied aspects. He augmented the popularity of catalysis in Canada to put Canadian catalysis on the international map.

Yoshi passed away in 2014 (see In Memoriam page in Chapter 13).

1977 - Ratimir J. (Bob) Cvetanovic

Bob Cvetanovic received his first degree in 1936, a B.Sc. in Forestry from the University of Edinburgh, Scotland. His studies were supported by a scholarship from the Serbian Minister's Fund. He received the Harry Younger Medal for Practical Forestry, also in 1936. Bob then returned to Yugoslavia to work in the Ministry of Agriculture, and obtained his second degree, a B.A.Sc. in Chemical Engineering, in 1942 from the University of Belgrade. During World War II Bob was a lieutenant in the Royal Yugoslavian Army. As a prisoner of war he was given leave to fill the civilian post of superintendent of a vegetable oil factory from 1942 to 1945. During this period he demonstrated his diverse capabilities by also authoring an English-Serbian / Serbian-English dictionary.

After the war Bob became an Assistant Lecturer at the University of Belgrade and also undertook graduate studies. In 1948 Bob immigrated to Canada, and entered graduate studies at the University of Toronto. He received his M.A. in Chemistry in 1950, and his Ph.D. and the Nadine Phillips Scholarship in 1951. Thereafter he joined the National Research Council of Canada, initially (1951-52) as a postdoctoral fellow and then as an Assistant Research Officer in the Division of Applied Chemistry (1952). Throughout his career Dr. Cvetanovic continued to contribute through academia as well as NRC. He acted as supervisor of Dr. D.J. LeRoy's laboratory and students during a period of absence through illness. He has held distinguished visiting academic positions at Cornell University, the University of California at Davis, and Churchill College, Cambridge.

Dr. Cvetanovic was an early leader in catalysis and molecular processes. He studied the reactions of molecules, radicals, and ions, both during his career at the National Research Council of Canada and afterwards. Significant contributions were made in photochemistry, kinetics and catalysis. Dr. Cvetanovic's interests cover all phases of matter. An early contribution involved the development of a mercury photosensitization method for generating oxygen atoms. Using this method he studied the kinetics and mechanisms of reactions of ground state oxygen atoms with organic compounds. Other sub-molecular species of interest were excited oxygen atoms, O(1D), and the hydroxyl radical. This work led to the determination of radical rearrangement processes. These fundamental gas phase studies also contributed to our understanding of the role of O(1D) and hydroxyl radicals in atmospheric chemistry, especially in the stratosphere and troposphere.

Dr. Cvetanovic took advantage of improvements to the state of the art in gas chromatography. Using these tools he identified the products of reactions of atoms and radicals, and thereby determined the mechanisms of the reactions.

Applying his knowledge of reactions of atoms, ions, radicals and molecules, Dr. Cvetanovic provided insight into catalytic reactions. This led to an interest in the interactions of gas phase species with surfaces of solids, and the natures of the surface species so formed. In collaboration with Yoshimitsu Amenomiya (q.v.), the temperature programmed desorption (TPD) technique was developed. In this technique molecules are adsorbed from the gas phase onto a solid surface, the temperature of the solid is then steadily increased and the amount and nature of the molecules desorbed are measured. In this manner quantitative insights are gained into the nature of the surface. For this work Drs. Amenomiya and Cvetanovic became the first recipients of The Catalysis Award (1977).

Dr. Cvetanovic was an active member of the Canadian Committee on Catalysis. This informal body provided a focus for the Canadian catalysis community, and was instrumental in

the creation of the Catalysis Division of CIC. Dr. Cvetanovic was also one of the organizers of the first of the continuing series Canadian Symposia on Catalysis.

Dr. Cvetanovic was required to retire from NRC in 1978, the same year in which he received the CIC Medal in recognition of his major contributions to the chemical sciences. He accepted a position as Visiting Professor at the University of California, Irvine, where he worked with F.S. Rowland (Nobel Prize, 1996). His style was so well appreciated that his students applauded him at the end of his first lecture. From 1980-1988 he was a Visiting Scientist at the National Bureau of Standards, Washington, D.C. There he developed a chemical kinetics data base, and software for the NIST computer to facilitate searching. The task was complicated, lengthy, and required considerable judgement on Bob's part. In addition to several publications, the result was NIST Standard Reference Database 17, NIST Chemical Kinetic Database. The continuing value of this work is recognized, as it is currently available in Version 7. For this work Bob received a Certificate of Appreciation from the U.S. Department of Commerce.

In 1989 Bob retired from active scientific endeavours, but he retained his interest in the developments at the institutions to the reputations of which he has made such a strong contribution. Bob died peacefully in his sleep on February 23, 2002. An appreciation of his life and his research was published in *Canadian Chemical News*, July-August 2002, p.9.

Bob passed away in 2002 (see In Memoriam page in Chapter 13).

1979 - Robert B. Anderson

Professor Robert B. Anderson came to Canada from the United States and joined the Department of Chemical Engineering at McMaster University in 1965. He had established a distinguished record in Fischer-Tropsch synthesis (FTS) research at the United States Bureau of Mines, which he joined in 1944. Prior to this, Professor Anderson had completed doctoral studies at Iowa State University in physical chemistry followed by two years of postdoctoral work with P.H. Emmett at Johns Hopkins University.

While at the U.S. Bureau of Mines he developed new catalysts for FTS and was the first to show that iron nitrides are unique, durable catalysts for FTS that have high selectivity to alcohols. Professor Anderson also worked on the kinetics and mechanism of FTS. Perhaps the most significant contribution was made in 1950 when Anderson and Friedel published the equations that predict the isomer and carbon number distributions of the FTS products. Although the original version of their equation was improved by Anderson and others, the basic form remains valid and is used in most FTS publications that report product distributions. Anderson later referred to the equation as the "Bureau of Mines equation" but it is now most often called as the "Anderson-Schulz-Flory equation". Many of Anderson's contributions from this period were published in Emmett's series on Catalysis and in the classic reference text by Storch, Golumbic and Anderson titled *The Fischer-Tropsch and Related Syntheses* (1951). In recognition of the significant contributions Professor Anderson made in this area, he was awarded the Ipatieff Prize of the American Chemical Society in 1953 and its Pittsburgh Award in 1960. In 1966 the U.S. Department of the Interior bestowed on him its highest honour, the Distinguished Service Award.

At McMaster University, Professor Anderson established one of the strongest catalysis research laboratories in Canada. He was a teacher and mentor to undergraduate and graduate students, postdoctoral fellows and other visiting scholars, many of whom remain active in catalysis research. Under his guidance, his students and postdoctoral fellows were able to make

significant contributions in many areas including hydrocarbon hydrogenolysis, preparation and characterization of catalysts, Fischer-Tropsch synthesis and alcohol synthesis. He published more than 200 scientific papers, and authored and edited several books and monographs. Professor Anderson retired from McMaster University in 1981, but as Professor Emeritus continued an active research program. As a retirement project he wrote the book titled *The Fischer-Tropsch Synthesis*, (1984), which was an update of FTS research from 1955 to 1983.

He was on the Editorial Board of the Journal of Catalysis, session chair at international conferences, and served on the executive of The Catalysis Division of The CIC. In recognition of these contributions, Professor Anderson received many awards including The Catalysis Award of The CIC in 1979, Fellowship of The CIC, and Fellowship of the Royal Society of Canada in 1983. In 1984, a Special Fischer-Tropsch Session was held in his honour at the 9th Canadian Symposium on Catalysis in Québec.

As co-chair (with Harry Habgood) he was in the midst of organizing the 9th International Congress on Catalysis held in Calgary, Alberta in 1988, when he died suddenly on October 24, 1987 (see In Memoriam page in Chapter 13). Professor Anderson was a caring individual with good humour who was more than mentor and supervisor to most of his students. His friendly demeanor made it a pleasure to work for him and experience his kindness and hospitality. The latter was often expressed with an invitation to his home for a meal and description of the latest antique clock added to his impressive collection.

1982 - Carl H. Amberg

Dr. Carl H. Amberg obtained his PhD from the University of Toronto (1952), then joined the Applied Chemistry Division of National Research Council where he established a catalysis research group with postdoctoral fellows. After acquiring an international reputation as a catalysis researcher, in 1964 he moved to the Department of Chemistry at Carleton University. He became the Chair of the Department in 1976 and later the Dean of Graduate Studies and Research. Throughout his career he devoted himself not only to catalytic research but also to the education of the succeeding generations. Unfortunately an illness forced him to retire early.

Dr. Amberg was dedicated to the promotion of Canadian catalysis research. He was a member of the Canadian Committee on Catalysis (1965-1971), and then active in The Catalysis Division of which the “Committee” was a predecessor. After The Catalysis Division was officially established in 1971, by recommendation of the “Committee”, he served as Vice-Chair (1972-1973) and Chair (1973-1974). He was appointed Director of The Catalysis Society (of North America) from 1977 to 1980. Carl Amberg served as Canadian representative to the International Congress on Catalysis as a Councillor in 1972-1973 and in 1976-1977.

At NRC he was influenced by Dr. Ira Puddington, the leading Canadian scientist whose interests were focusing on the utilization of Canadian resources such as the Athabasca oilsands. Carl pioneered the micro-reactor technique to study the catalytic hydrodesulphurization (HDS) mechanism using sulphur-containing hetero-rings model compounds, in both continuous and pulse modes. The result was the first detailed insights into the HDS mechanism. Several proposed mechanistic routes were later confirmed by the efforts of Dr. Amberg and others. Dr. Amberg focused his attention on MoS_2 as the main species responsible for catalytic actions in commercial molybdate catalysts. Although much of this research was conducted many years ago, the works co-authored by Carl are still extensively cited by many scientists worldwide.

At Carleton University, Dr. Amberg continued his interests in catalysis, especially research into the promoting effects of Co and Ni on the catalytic actions of unsupported MoS_2 and WS_2

during HDS. The differences in the promoting effects could be used for interpreting differences in the performance of commercial molybdate and tungstate catalysts. During this research, the importance of the experimental method used for the addition of the promoters to the sulphides was recognized. Carl expanded his research on unsupported catalysts to include supported Mo and W catalysts during his collaboration with scientists at the Eindhoven University in the Netherlands. Many Canadian research groups have benefited from this collaboration, especially from Carl's leadership and active participation. The work on sulfide catalysts performed by Dr. Amberg has found applications in the use of catalysts for the upgrading of Canada's heavy hydrocarbon resources, including those used at the Suncor and Syncrude Canada oil sands plants.

Carl Amberg has undertaken studies in other areas of catalysis and surface science, such as the diffusibility study on silver catalysts, infrared studies of CO adsorption on zinc oxide catalysts as well as the adsorption and adsorption hysteresis studies of CO_2 and N_2O on charcoals and Vycor glass. His involvement in the development of applications of gas-liquid chromatography is sometimes overlooked. In the late 1950s chromatography was an emerging method. He was the first in Canada, if not in the world, to determine the elution times of many sulphur-containing compounds and subsequently applied this technique for determining the type and concentration of sulphur-containing compounds in distillates obtained during the cracking of the Lloydminster crude.

Carl passed away on October 14, 2011 (see In Memoriam page in Chapter 13).

1984 - Howard Alper

Howard Alper, a native of Montréal, received his B.Sc. from Sir George Williams University and his Ph.D. from McGill University (1967). After NATO postdoctoral studies at Princeton, Dr. Alper joined the faculty at the State University of New York, Binghamton, in 1968 and became an Associate Professor in 1971. In 1975 he joined the University of Ottawa, becoming Full Professor in 1978. Professor Alper served two terms as Chair of the Chemistry Department. He was the Vice-President Research at the University of Ottawa from 1997 until 2006. From 2001 to 2003, he was the President of the Royal Society of Canada.

Alper has received many prestigious Fellowships including the E.W.R. Steacie (NSERC, 1980-82), Guggenheim (1985-86), and Killam (1986-88) Fellowships. Major awards to Alper include the Alcan Award for Inorganic Chemistry (1986), Bader Award for Organic Chemistry (1990), Steacie Award for Chemistry (1993), all of the Canadian Society for Chemistry. The Chemical Institute of Canada presented Alper with the Catalysis Award (1984) and the CIC Medal (1997), its highest honour. He received the Urgel-Archambault Prize (ACFAS) in physical sciences and engineering and in 2000, the Gerhard Herzberg Canada Gold Medal in Science and Engineering.

He has served on a number of NSERC committees (e.g. Committee on Research Grants), and as Chair of the Partnership Group for Science and Engineering. Alper was appointed as a Titular Member of the European Academy of Arts, Sciences, and Humanities (1996), and as an Officer of the Order of Canada (1999). Alper was elected to the Royal Society of Canada in 1984. In 1998, he was made an Officer of the Order of Canada. In 2014, he was made a Commander of the Order of Merit of the Italian Republic.

Outstanding contributions have been made by Professor Alper in the development of new organic reactions, as well as in the significant improvement of known processes of both fundamental and applied interest. In the first 6-7 years of his career, he investigated the

application of organometallic complexes as reagents and intermediates in organic synthesis. For instance, he and his co-workers reported the first examples of sulfur-donor ligand ortho-metalated complexes, which proved to be valuable intermediates in the preparation of several classes of heterocyclic compounds of pharmaceutical importance. In subsequent years Professor Alper's group has investigated the use of metal complexes as catalysts for a number of processes. He is recognized as a pioneer in the application of phase transfer catalysis to metal catalyzed reactions. Of particular note was his discovery of exceptionally mild, regiospecific oxidation, reduction, and carbonylation reactions. Examples include the oxidation of olefins to ketones catalyzed by palladium, ruthenium, or rhodium complexes; the reduction of aromatic hydrocarbons or carbonyl compounds using rhodium(I) compounds; and the palladium, nickel, or cobalt catalyzed mono carbonylation of halides to acids, ketones, and lactones. Novel double carbonylation reactions of halides to keto acids, and of halodienes or epoxides to α-keto lactones have also been described. Other significant developments include the first examples of a triple carbonylation reaction, the use of lanthanides in phase transfer catalysis, and carbon monoxide trapping in a manganese(III) induced oxidation system. Quaternary ammonium salts, crown ethers, polyethylene glycols, and cyclodextrins have been employed as phase transfer agents in many of these studies.

Studies on processes effected under biphasic conditions have led to excellent methods for the dechlorination of chloroarenes (including polychloroarenes), and the carbonylation of chloroarenes to carboxylic acids under exceptionally mild conditions using a palladium catalyst. The mechanistic investigations are of broad significance, being applicable to the Heck and Suzuki reactions, among others. In addition, by use of a biphasic system of chloroform and alkali, Alper has discovered a novel method of achieving the carbonylation of halides (and presumably other substrates) to acids without involving carbon monoxide gas as a reactant.

Exciting results have been obtained by Professor Alper in other areas of homogeneous catalysis. A major achievement by Alper's group has been in the area of carbonylation-ring expansion reactions. The ability to "stitch" a carbonyl unit into an aziridine to give a b-lactam is a process of considerable potential, since the rhodium(I) catalyzed reaction occurs in a regio-, stereo-, and enantiospecific manner. Furthermore, one can realize the preparation of b-lactams in high optical purity by using a racemic aziridine, the rhodium catalyst, and a chiral ligand.

The above achievements are examples of Professor Alper's capabilities in design, investigation, and accomplishment of significant advances in molecular catalysis. He has made several other contributions of similar complexity and importance, for example in syntheses of heterocycles, hydroformylation of alkenes, and routes to isocyanates. More recently he has turned his attention to applications of molecular catalysts supported on a clay matrix.

Professor Alper is a scientist who loves a challenge, and who makes strenuous efforts to attain his goals.

1986 - Henry W. (Harry) Habgood

After receiving a B.Sc. and M.Sc. from Queen's University, Dr. Habgood initially applied his skills at Naugatuck Chemicals. He then returned to University, earning his Ph.D. from the University of Michigan. Following a postdoctoral fellowship at the National Research Council and one year teaching at Queen's, Dr. Habgood joined the Research Council of Alberta in 1954, where he led catalysis research until 1984. After retiring from Alberta Research Council, Dr. Habgood moved to Nova Scotia, where he remained highly active, with strong involvements with the Technical University of Nova Scotia and the professional affairs of catalysis science.

Dr. Habgood continued to pursue his interests in catalysis. He was vigorous in his efforts as co-chair for the 9th International Congress on Catalysis in Calgary (1988), especially after the lamentable and untimely loss of his long-time friend, colleague, and co-chair, Dr. R.B. Anderson. Following this enormously successful meeting, Dr. Habgood was instrumental in the application of the financial resources which this meeting created, and provided leadership within the team in their efforts toward the establishment of the Canadian Catalysis Foundation (CCF). He was subsequently elected its first President. He served the CCF with dignity and drive until passing the responsibility and honour to Dr. J.B. Moffat in 1990.

Dr. Habgood's career was characterized by his foresight in recognizing the future value of materials and processes, and to focus his attention on their development and applications. In the early 1950s he recognized that zeolites, with their precisely sized diffusion channels, offered a wide range of opportunities for applications in separations of molecules and in catalysis, through highly selective diffusion of molecules of specific sizes. Dr. Habgood's contributions were among the early studies of zeolites which have now led to industrial applications of immense economic and environmental value, including conversions of hydrocarbon resources, highly selective and efficient syntheses of organic chemicals, and removal and destruction of pollutants in gaseous and liquid effluent.

In the 1960s the technique of gas chromatography was being recognized as widely applicable and highly useful for the analysis of mixtures of chemicals in the vapour phase. In collaboration with Dr. W.E. Harris, University of Alberta, Dr. Habgood made a strong contribution to elucidating the principles of the technique. From this position of interest and the vantage point attained from his experience, Dr. Habgood recognized the potential of using the diffusion coefficients obtained for calculating intrinsic rate constants for reactions, and thereby gaining insights into catalytic reactions.

Today infrared spectroscopy is so widely used for characterization of materials that the technology is sometimes taken for granted. Dr. Habgood was one of the first to recognize the potential of the method for examining surface species, and therefore for studying adsorption or reactions at catalyst surfaces. In addition to his own efforts applying infrared spectroscopy to the study of catalytic systems, Dr. Habgood encouraged and supported parallel work of colleagues using it and other spectroscopic techniques.

As Dr. Habgood's career progressed so did the breadth of his responsibilities. As Chief of the Fuels Branch at the Research Council of Alberta or, later, as Head of the Chemistry Department and then Vice-President of the renamed Alberta Research Council, Dr. Habgood built a team with strong capabilities in catalysis, physical chemistry, chemical engineering, environmental applications, and separations science. Several of the scientists and engineers recruited to this team have since become significant contributors in industrial and academic catalysis laboratories.

Harry Habgood passed away in September 2008 (see In Memoriam page in Chapter 13).

1988 - John B. Moffat

John's undergraduate and graduate training at the University of Toronto (Ph.D. in Physical Chemistry with R. McIntosh) and five years with DuPont of Canada inspired the research interests he developed during his career in the Chemistry Department, University of Waterloo. John's entry into heterogeneous catalysis focused on boron phosphate in the 1965-1982 period. His first independent paper, in 1964, concerned LCAO-MO calculations on nitriles. Related quantum-theoretical studies on species such as HCN, BCN and dimers of cyanamide extended into the 1980s. Beginning with surface area, acidity and adsorbed molecule studies, surface properties were pursued using such techniques as diffuse reflectance, infrared spectroscopy and temperature programmed desorption. Catalytic properties of boron phosphate were also investigated using various alcohols, as well as iodide, H_2 and D_2 in these studies.

John's initial papers on the catalytic properties of heteropoly acids appeared in 1982 (with H. Hayashi as co-author). He made contributions on several aspects of these metal-oxygen cluster compounds having the Keggin structure. Studies concern the methods of synthesis, structural stability, solution species, ion exchange and surface and catalytic properties. Catalyzed reactions of various substrates (alkanes, alcohols, acids) were related to the physical, structural and surface chemistry of these heteropoly oxometalates. In one series of papers (with J.G. Highfield), FT-IR photoacoustic spectroscopy was employed to characterize sorbed species and to elucidate mechanisms. John studied the microporosity of several metal-oxygen cluster compounds using 129 Xe NMR (with J. Fraissard) and adsorption/reaction of nitrogen oxides (with R. Belanger).

John also achieved international recognition in the oxidative coupling of methane. Beginning in 1987 (with S. Kasztelan), they studied the nature of the catalyst, alkali-alkaline earth and lanthanide as well as heteropoly oxometalates, with the mechanism of the catalyzed process. In particular, it was discovered that very small quantities of a halogenated species (such as CCl_4) have remarkable effects on both the conversion and selectivity to ethane and ethylene. Later work on this important process extended to cation-exchanged hydroxyapatites and to experiments to unravel the nature of the observed enhancement of methane conversion.

John has been involved with numerous books. He wrote the chapter "General and Theoretical Properties of Triple-Bonded Molecules" for the 1983 book *The Chemistry of Functional Groups*. The area of *Microporous Heterogeneous Catalysts* was reviewed in a book edited by Bill Moser (1996). John edited *Theoretical Aspects of Heterogeneous Catalysis* in the Van Nostrand Reinhold Catalysis Series (1990). Cesar Sequeira and he co-edited *Chemistry, Energy and the Environment* for the Royal Society (1998). In 2001 he wrote *Metal-Oxygen Clusters - The Surface and Catalytic Properties of Heteropoly Oxometalates* for Kluwer Academic /Plenum.

John made invaluable "administrative" contributions to the catalysis community. He was Director of CSC in 1987-90, Chair of The Catalysis Division, CIC during 1984-86. John served on several editorial boards including the *Journal of Applied Catalysis*, *Journal of Molecular Catalysis*, and *Catalysis Letters*. He was President of the Canadian Catalysis Foundation and a member of the International Congress on Catalysis Board. John was the Program Chair for the 13th Canadian Symposium on Catalysis in Sarnia in 1994 and a member of the Program Committee of the 14th NAM of The Catalysis Society in Snowbird, Utah in 1995. John co-organized two symposia, on Solid Superacids and Heteropoly Oxometalates, at the 1995 Honolulu, Hawaii Pacific Basin Conference. John was instrumental in ensuring the success of The North American Catalysis Society Meeting held in Toronto, Canada in 2001. John is currently a Distinguished Professor Emeritus at the University of Waterloo.

1990 - Brian R. James

Brian James was born in England and obtained his degrees, including a doctorate, at Oxford University. He then spent two years at UBC as a postdoctoral with Jack Halpern before returning to the U.K. to work as a Senior Scientific Officer at the Atomic Energy Authority, Harwell. The attraction for Vancouver was strong, however, and Brian returned to UBC in 1964 as an Assistant Professor, becoming Professor in 1974. Professor James established a research program of international repute in homogeneous catalysis; many Ph.D. and M.Sc. students have graduated from his group in projects focused mainly on the binding and activation of small molecules at transition metal centres. Research activity has led to numerous publications and patents. Brian has received recognition through major awards [Noranda Award, 1975; Guggenheim Fellowship, 1983; Jacob Biely Award, 1986 (UBC's top research prize); Canadian Catalysis Award, 1990; Canada Council Killam Fellowship, 1993-95], and about a dozen other lectureships and fellowships, both Canadian and international.

Professor James has frequently been sought after as a lecturer at national and international meetings. He was elected a Fellow of the Royal Society of Canada in 1982, and served as Rapporter and Convenor of Academy III. Professor James was appointed a Faculty Associate within the Pulp and Paper Centre at UBC. The extent of professional services rendered at other local, national and international committees included work with NSERC, IUPAC, NATO, and Canadian Award committees. Professor James contributed strongly through organizing conferences (local, Canadian and international), including being "permanent" secretary of the International Symposia on Homogeneous Catalysis since 1980. Refereeing duties have been associated with journals (including service on 8 editorial boards), granting agencies, and promotion/tenure decisions associated with nearly all Canadian Universities. Of note, Professor James was the "Inorganic" editor of the *Canadian Journal of Chemistry* from 1978 to 1988.

Professor James has been strongly and widely influential on the Canadian chemistry scene via teaching courses from 1st year through to graduate level [including early development of courses in bioinorganic (1973) and aqueous environmental chemistry (1984)], and also significantly through contributions from past members of his research group - these are scattered throughout the world, and include several graduate, undergraduates, and postdoctorals, employed throughout Canada at universities, industrial companies, research agencies, community colleges and high schools. The number of postdoctorals and visiting scientists that have been associated with Professor James' laboratory approaches 100, and active collaborations were established with groups in Hungary, Poland, Japan, Italy, Brazil and Germany, as well as more local collaborative research with colleagues in chemistry, chemical engineering and PAPRICAN.

Brian James' research interests focused on the binding and activation of small molecules at transition metal centres, with the aim of understanding the mechanisms of homogeneous catalysis in order to develop new and improved catalysts (and processes) generally for the conversion of organics; the systems usually operate under mild conditions required for highly regio-, stereo-, and enantioselective processes. Studies have concentrated on platinum metal complexes (especially Ru and Rh), and with some excursions into the first-row metals (Fe, Co, and Ni), and their interactions with H_2 (for catalytic hydrogenation of organics), CO (carbonylation and decarbonylation), O_2 (for oxidations), C_2H_4 (Wacker-type oxidation to acetaldehyde), H_2O (hydration of olefins and acetylenes), and H_2S (for conversion to H_2 and sulfur).

The hydrogenation work has elucidated key elements of reduction of olefins, ketones, imines and nitriles, including systems with water-soluble, and chiral ligands (phosphines, amino acids,

and sulfoxides) for asymmetric hydrogenation. Molecular hydrogen complexes were shown to play a role in some olefin hydrogenations. The 1973 book *Homogeneous Hydrogenation* became the classic text in this area. Competing reactions such as catalytic dehydrogenation and dealkylation of amines have also been discovered for some Ru complexes.

Reductive carbonylation chemistry demonstrated with Rh species was later used as the initial chemical step in Monsanto's process for carbonylation of methanol to acetic acid. New catalysts for amine carbonylation, aldehyde decarbonylation, and intramolecular hydroacylation of unsaturated aldehydes (to give chiral 2-substituted pentanones) were discovered.

Professor James was one of the first to recognize the potential for O_2 activation by Rh^I, Ir^I, and Ru^{II} systems, and this led to the remarkable, first reported use of O_2/H_2 mixtures for selective O-atom transfer chemistry via reductive activation of O_2, and also led to the catalytic conversion of such a gas mixture to H_2O_2. The interest in O_2 activation led to interests in Fe- and Ru-porphyrin and -phthalocyanine chemistry in attempts to mimic Fe-based enzymatic systems. Catalyzed O_2-oxidations (or -dehydrogenations) of unsaturated and saturated hydrocarbons, aromatics, thioethers, alcohols, and amines have been effected via mono- and dioxygenase model systems, and insight gained into the P450 enzyme system. Complementary studies with this enzyme and the natural O_2 carrier myoglobin (in conjunction with David Dolphin) has led to increased understanding of the binding and activation of O_2. The interests in Ru-porphyrin chemistry have led to major developments in organometallic chemistry at such centres, and the possibility of novel, free-radical type catalysis involving hydrocarbons.

Knowledge of the H_2 hydrogenations and O_2 oxidations is currently being applied to conversion of lignin in pulp.

Professor James first reported the quantitative abstraction of H_2 from H_2S using a transition metal complex (a dinuclear Pd_2 species) in solution, and the catalytic conversion of H_2S to H_2 and an organosulfur compound; a current aim is to effect catalytic conversion to H_2 and elemental sulfur.

Brian is now a Professor Emeritus in the Chemistry Department at UBC.

1992 - Bohdan W. Wojciechowski

Professor Bohdan W. Wojciechowski was born in Poland (1935), obtained primary education also in Scotland, and completed both the Scottish and Polish high school curricula (1953). He then received academic degrees in chemical engineering from the University of Toronto (BASc (Hon), 1957, MASc, 1958). Bohdan obtained his doctorate in chemistry at Ottawa University (1960), with Professor K.J. Laidler, for research in which he applied kinetic principles to interpret the action of inhibitors in gas-phase pyrolysis. A number of long-standing controversies were resolved in connection with gas-phase chain reaction mechanisms. This work, which he continued as a postdoctoral fellow at NRC, was the beginning of his life-long research interest in kinetics and reaction mechanisms. Subsequently, Professor Wojciechowski began his work on catalytic reaction during three years at the Research and Development Department of Mobil Oil. His research covered subjects including both pure hydrocarbon systems and multicomponent mixtures in the presence of decaying catalysts.

Professor Wojciechowski then joined the Department of Chemical Engineering, Queen's University (1965), and was appointed full professor in 1972. An important contribution to the body of work in catalysis was the development of the Time on Stream (TOS) theory of catalyst decay, which significantly enhanced understanding of commercially important reactions such as

catalytic cracking. Professor Wojciechowski's group continued this work on catalytic cracking, extending the models to a kinetic analysis of selectivity patterns and introducing the concept of Optimum Performance Envelopes (OPEs). This allows extrapolation of experimental data to selectivity regions without catalyst decay, and uncovered previously unavailable information (using OPEs) on properties of active sites, the mechanism of the cracking reaction, and changes in kinetics and mechanism on active sites induced by reaction. With his colleagues, Professor Wojciechowski applied concepts he introduced (TOS, OPEs, refractoriness effect) to arrive at a rigorous "Chain-mechanism" description of the catalytic cracking process. Subsequently, models were developed for other catalytic reactions by introducing versatile adsorption isotherms for heterogeneous surfaces, and the kinetics of Fisher-Tropsch synthesis from carbon monoxide and hydrogen was more fully described. Here he advanced the methodology to account for product distribution of such reactions, a subject of two recent review articles.

Professor Wojciechowski built a systematic body of knowledge on the formation and rearrangement of hydrocarbon molecules, work stemming from his postgraduate years. This he achieved through a long-term commitment to the solution of complex fundamental issues. His research achievements have not only been of importance to the scientific community but also to industry, and have had an impact on researchers in catalyst manufacturing, transportation fuels and petrochemicals dealing with product quality and environmental issues.

His latest scientific invention is a revolutionary one. It deals with extracting kinetic data under transient conditions. Together with a colleague who is a mathematician, he developed the Temperature Scanning Methodology and system for kinetic data acquisition. In principle, this abandons conventional ways of studying reactions but allows the obtained data to be transferred to conventional results. He designed and commissioned the first Temperature Scanning Reactor (TSR). TSR has the extreme breakthrough potential of increasing the research productivity a thousand times. He presently continues his research work using this machine.

Professor Wojciechowski enjoys international recognition both for his research work and for his influence through various appointments. He was one of the key players within The Catalysis Division of The Chemical Institute of Canada, and was one of the active proponents for the creation of the Canadian Catalysis Foundation. He was instrumental in establishing The Catalysis Award, and is one of its recipients (1992). He represented Canada on the Executive Board of the International Congress on Catalysis.

In Canada, Bohdan Wojciechowski is known for his community and political work, being an outspoken commentator on government politics and policies. He combined his scientific and entrepreneurial skills to form a company for commercialization of the patented TSR and its associated software and algorithms. The unit was on display at the 14th North American Meeting of The Catalysis Society at Snowbird, Utah, 1995.

In summary, Professor Wojciechowski exemplifies excellence in research. He was become renowned as one of the pillars of the international catalytic community and is a credit to Canadian science.

When he retired, in 1997, his focus changed from technical matters to more socially oriented issues. He became a successful writer with several published works. His current *Zamora Texts* books present his thoughts on human progress over about 14 millennia.

1994 - Ivo G. Dalla Lana

Ivo Dalla Lana was born on 5 July 1926 in Trail, B.C. He received his Bachelor of Applied Science degree from the University of British Columbia. During 1948-51 he worked as an engineer in the Research and Development Department of Cominco Ltd. In 1953 he received his Master of Science degree from the University of Alberta and in 1958 he received a Ph.D. degree from the University of Minnesota, with a major in chemical engineering and minor in physical chemistry. From 1958 until his retirement in 1992, Dr. Dalla Lana was a professor in the Department of Chemical Engineering at the University of Alberta. During that time he supervised graduate work on 20 M.Sc. and 7 Ph.D. theses and collaborated with 25 postdoctoral fellows who participated in research programs that he initiated. This work resulted in over 100 publications and research reports, and a number of patents and patent applications. Dr. Dalla Lana's retirement did not interrupt his research activities which continued with unweakened energy, valuable experience and knowledge. After his retirement, he supervised research projects supported by three NSERC strategic grants: one NSERC operating grant and two industrial grants concerning olefin polymerization. His research group was truly an international one and his collaboration in the field of catalytic research involved five catalytic groups in different European countries. He was a visiting professor at the University of Bath, England, at Fritz-Haber-Institut der Max-Planck-Gesellschaft in Berlin, Germany (twice), and at Atomic Energy of Canada in Chalk River, Ontario. He delivered a number of invited lectures both in Canada and abroad, and he was also a keynote speaker. The Association of Professional Engineers of Alberta nominated him as a life member and The Chemical Institute of Canada nominated him as a fellow. Over ten scientific periodicals, publishing papers in the field of catalysis and chemical engineering, have asked Dr. Dalla Lana to referee submitted manuscripts. The Natural Sciences and Engineering Research Council nominated him a member of various committees and the Ontario Council of Graduate Studies invited him as a consultant for appraisal of a Ph.D. program. Due to his comprehensive knowledge of catalysis, he served as a consultant with a number of companies in Canada, and as an expert witness in a court case involving patent litigation in the United States of America.

Dr. Dalla Lana devoted much time to professional societies such as: 1) the Canadian Society of Chemical Engineering serving as director and secretary on the national executive and chair of the local executive, 2) The Chemical Institute of Canada serving as a regional counsellor for Alberta and Saskatchewan, 3) The Catalysis Division of The Chemical Institute of Canada serving as national chair and a founding member of its executive, 4) the 9th International Congress on Catalysis serving as vice-chair of the organizing committee, and 5) The North American Catalysis Society serving as Catalysis Division representative.

The main areas of Dr. Dalla Lana's research activities included: 1) utilizing infrared spectroscopy to study adsorption and surface reactions (since 1967; has been successfully applied to several industrial catalytic reaction systems), 2) sulphur recovery technology, primarily based on the modified Claus reaction, which made him an internationally recognized expert in this field, and 3) ethylene polymerization on supported chromium catalysts in slurry reactors and oligomerization of ethylene in a solution reactor (since the mid-1980s). The scientific and industrial importance of his work ensures that Dr. Dalla Lana thoroughly enjoys the research that he approaches with great enthusiasm.

Ivo passed away on March 5, 2018 (see In Memoriam page in Chapter 13).

1996 - Marten Ternan

Marten Ternan, FCIC, was born in Saskatoon, SK, and subsequently moved to Burnaby, BC, where he received his elementary and secondary education. He received a BASc in chemical engineering from the University of British Columbia in 1964. After graduation he worked as a process design engineer in Sarnia, ON, in the engineering division of Imperial Oil (1964-67) before moving to Montréal, PQ, for graduate studies. He received a PhD degree in chemical engineering from McGill University in 1972. He was then employed at the Process Research Stations of International Nickel at Port Colborne, ON (1971-73) before becoming a research scientist at the federal government's CANMET Energy Research Laboratories at Bells Corners near Ottawa.

At CANMET/ERL Dr. Ternan was Head of Catalysis Research for seven years and Manager of the Hydrocarbon Processing Research Laboratory for four years. Over a period of more than 20 years (1973-95) his research involved the use of catalysts for the conversion of oil sands bitumen, heavy oil, petroleum residuum, coal, and natural gas to transportation fuels. He is one of the two inventors of the first patent filed for the CANMET Hydrocracking Process used to convert vacuum residue material into lower boiling distillate products. As Manager of Hydrocarbon Processing he supervised 6 research groups with a total staff of 45-55 people which included Catalysis, Natural Gas Conversion, Hydrocarbon Conversion and Coal Gasification. During this period a number of high quality catalysis researchers were recruited to the laboratory and major purchases of catalysis equipment were made. The federal government's emphasis on sharing research costs with industry gave him the opportunity to be involved with a number of companies in projects concerned with Upgrading Heavy Oil, Reduction of NO_x in Diesel Exhaust, and Chemical Heat Pumps. He was also a member of the National Task Force on Oil Sands Strategies and in 1994 led an industrial research consortium which explored the application of methylcracking for upgrading oil sands bitumen. In 1995 Dr. Ternan transferred to the CANMET Energy Diversification Research Laboratory at Varennes, PQ. In 1998 Ternan joined H-Power in Montréal, a company specializing in research and development of fuel cells for commercial applications. He has also been an Adjunct Professor in Chemical Engineering at the University of Ottawa (1981-present).

Dr. Ternan is a past Chair of the Catalysis Division of The Chemical Institute of Canada and a past Chair of the Ottawa Local Section of the Society for Chemical Engineering. He represented Canada on the International Catalysis Council for four years. He has received the ERCO Award of the CSChE, the Sunshine Project Award from the National Chemical Laboratory for Industry, Tsukuba, Japan, and a federal government Public Service Merit Award (shared with 10 others) for the development and transfer to industry of the CANMET Hydrocracking Process. In 2001 he was co-chair of the 17th Meeting of the North American Catalysis Society, held in Toronto. He has seven patents and more than 60 publications.

Ternan's major research interests have focused on events that occur inside catalyst pores. Reactions for upgrading heavy hydrocarbon residues require the participation of both small hydrogen molecules in the gas phase and large carbonaceous molecules that originate in heavy oil. He developed an equation to describe the liquid phase diffusion of large carbonaceous molecules within catalyst pores based on theoretical concepts. It is superior to other equations that have been proposed because it is the only equation that satisfies the two end point conditions. It predicts an effective pore diffusivity that is equal to the diffusivity in the bulk liquid when the diffusing molecules are small compared to the pore diameter. It predicts an effective diffusivity of zero when the diffusing molecules are larger than the pore diameter. The

equation has been particularly useful in describing diffusion effects in the pores of catalysts used to hydrocrack the large molecules present in oil sands bitumen and heavy oil. The combination of these phenomena in an overall rate constant demonstrated that adding large macropores to a catalyst can decrease the length of the diffusion path in the smaller mesopores which contain the majority of the reaction sites. Insights such as these have contributed to the development of upgrading technology that can be used on a practical scale. He also proposed a mechanism for the dissociation of hydrogen molecules at electron holes on the catalyst surface. His work indicated that electron holes are the reaction sites for the dissociation of hydrogen molecules on the surfaces of Co-Mo-S hydroprocessing catalysts.

More recently Dr. Ternan has focused his research activities on fuel cells and the basic materials used for their operation. He has investigated fuel cell performance as a function of feedstock and examined applications of hydrogen, methanol, and fossil fuels. A comparison of these materials indicated that there are substantial theoretical advantages for using fossil fuels directly as a fuel cell feedstock. Life cycle calculations showed that fuel cell systems operating directly on fossil fuels are more efficient and that they emit less carbon dioxide to the atmosphere than other systems. Ternan has suggested that an alternative operation would involve feeding a natural gas or other hydrocarbon species directly to the fuel cell where the hydrocarbon would react directly in the electrochemical reaction. A significant advantage is that the hydrocarbon would not have to be converted outside the fuel cell and hence there would be no efficiency loss caused by steam reforming. A negative aspect that Ternan has noted is that the reaction rates in real direct hydrocarbon fuel cells are slow. Consequently their performances are significantly lower than those of hydrogen based fuel cells. Dr. Ternan has continued working with a team at the University of Ottawa on modelling direct hydrocarbon fuel cells using computational fluid dynamics.

In 2001 Dr. Ternan received the Canadian Catalysis Lectureship Award which is sponsored by the Canadian Catalysis Foundation. His lecture tour presented an overview of direct hydrocarbon fuel cells, and compared their potential and advantages with those of hydrogen based fuel cells.

1998 - Serge Kaliaguine

Serge Kaliaguine was born in Sigoules, France and lived for several years in North Africa. He received his higher education in Toulouse, France, his B.Sc. from l'Institut du Génie Chimique de Toulouse (1964) and his Ph.D. from the University of Toulouse (1967). He has been teaching at Laval University since the fall of 1967.

Dr. Kaliaguine chaired the Catalysis Division of the CIC in 1975. In 1982 he created GRASP at Laval University, a research group focused on applications of surface physico-chemistry In 1990 he was the founding director of a research centre on surface properties and catalysis. He was the main organizer of numerous conferences including the 9th Canadian Symposium on Catalysis (Québec 1984), a post-congress symposium (Québec 1988), the 35th Canadian Chemical Engineering Conference (1995), an International Zeolite Symposium (Québec 1995), the 15th Canadian Symposium on Catalysis (Québec 1998) the first and second International Symposia on Mesoporous Molecular Sieves (ISMMS) (Baltimore 1998, Québec 2000).

Kaliaguine is the author or co-author of more than 480 refereed publications and was editor or co-editor of four volumes in Elsevier's series *Studies in Surface Science and Catalysis*. He was appointed to the editorial board of *Applied Catalysis B: Environmental* in 1998. Kaliaguine

was plenary lecturer in several meetings: the International Symposium on Catalysis (Kyoto 1988), the Brazilian Conference on Catalysis (Salvador 1992), the International Zeolite Association Summer School (Taejon 1996), the 5th Conference of the Romanian Catalysis Society (Bucharest 1997) and the International Symposium on Catalysis (Kyoto 1998).

Since 1967, Dr. Kaliaguine has supervised or co-supervised over 50 MSc and PhD theses. He currently supervises several students and post-doctoral researchers. Dr. Kaliaguine has received the Best Paper Award of *The Canadian Journal of Chemical Engineering* (1976), the Urgel-Archambault Award from ACFAS (1994) and the Summa-Research Award of the faculty of Science and Engineering from Laval University.

The research interests of Dr. Kaliaguine involve industrial and environmental aspects of catalysis. His group works on all aspects of design, preparation, characterization and testing of heterogeneous catalysis. He deals with zeolites, ALPO's, mesoporous molecular sieves, supported oxides and perovskites as solid catalysts. Chemical reactions among the ongoing work encompass selective catalytic reduction of nitrogen oxides, catalytic combustion of volatile organic compounds, and oxidations and epoxidations using hydrogen peroxide as the oxidant. His activities include work on catalytic membranes both as catalysts and as proton conductors.

Dr. Kaliaguine has worked in collaboration with several industrial and government organizations including Natural Resources Canada, Biothermica International, Innovatech, Environair SIPA and Ballard Power Systems. Past sponsors include PetroCanada, Atomic Energy of Canada Ltd., Alcan, ESTAC, LRDE-Varennes, Venmar and others.

Serge Kaliaguine has taken a central organizational role in the International Mesostructured Materials Association (IMMA). The association grew out of the research community which participated in the International Symposia on Mesoporous Molecular Sieves. The name of the conference was changed and the scope of the research field was broadened to include other mesostructured materials. At the Third International Mesostructured Materials Symposium held in Jeju, Korea in 2002, Dr. Kaliaguine was elected to the IMMA council for a period of four years. After the election the council members also appointed him President of the IMMA. Dr. Kaliaguine was a keynote lecturer at the Fourth International Mesostructured Materials Symposium to be held in Cape Town, South Africa in May 2004.

2000 – Garry L. Rempel

Garry was born in Regina, Saskatchewan in 1944. He received his BSc (1965) and PhD (1968) degrees from the University of British Columbia, Vancouver, BC. After spending a year as a National Research Council of Canada Postdoctoral Fellow at the Imperial College of Science and technology in London, England, he joined the Department of Chemical Engineering at the University of Waterloo in 1969. He served as Chair of the Department from 1988 to 1996. Rempel was a Fellow of the Chemical Institute of Canada and a Fellow of the Royal Society of Canada, as well as being a member of several additional professional and service organizations. Notably, he served as President, Academy of Science, The Royal Society of Canada, November, 2001 – November, 2003. He enjoyed Visiting Professor or Visiting Scientist status with major institutions in North America and abroad.

In 2004, Garry became one of the first three faculty members to receive the title of University Professor at the University of Waterloo. Garry held the Bayer Inc./NSERC Industrial Research Chair in Advanced Rubber Technology at the University of Waterloo.

Garry was the Director of the Applied Sciences Division of the Royal Society of Canada from 1995-98 and was President of the Academy of Science of the Royal Society of Canada.

His research achievements and contributions to chemical engineering have been recognized by numerous awards: the Thomas W. Eadie Medal of the Royal Society of Canada, the Industrial Practice Award of the Canadian Society for Chemical Engineering, a Canadian Gold medal for Business Excellence (Invention Category), a University-Industry Research and Development Award sponsored by the Natural Sciences and Engineering Research Council of Canada and the Conference Board of Canada, the Macromolecular Science and Engineering Award of the Chemical Institute of Canada and the R.S. Jane Memorial Award. Rempel received a Century of Achievement Award for significant contributions in the field of chemical engineering at the 49th Canadian Society for Chemical Engineering Conference. In 2001 he received an Award for Excellence in Research from the University of Waterloo. In 2003 he received the prestigious Le Sueur Memorial Award from the Society of Chemical Industry for his development of technical excellence of benefit to Canada in a chemical based industry.

Garry Rempel's research interests were in the areas of applied catalysis, chemical modification of polymers, polymerization, polymer processing and separation science, including catalytic distillation. In particular, he was a recognized expert in kinetics and catalysis of both homogeneous and heterogeneous systems; polymer science and engineering, including polymerization, chemical modification of polymers, polymer processing and properties, metallocene polymerization and applications of functionalized polymers in catalysis and environmental separations; environmental chemistry and engineering, especially wastewater treatment and selective separations via ion exchange methods; ion and ligand exchange processes; catalytic properties of transition metals and their compounds, including organometallic catalyst systems.

Garry was internationally recognized in the area of chemical modification of polymers. His outstanding research in this area was instrumental in his inventions of novel catalytic processes for the selective hydrogenation of nitrile butadiene rubber (HNBR). This led to the commercial production of HNBR. His expertise was called upon in the resolution of legal issues concerning polymer technologies. His extensive capabilities and knowledge of catalysis called upon through service on editorial boards, as a member or chair of NSERC committees, and in support or review of research and applied technologies. Garry passed away on November 2, 2018 (see In Memoriam page in Chapter 13).

2002 - Michael C. Baird

Professor Baird was born in Hamilton, Ontario but raised in nearby Dundas. He studied chemistry at McMaster University, but distinguished himself rather more as an athlete. In his sophomore year he won the OQAA 220 yards dash and both the 100 and the 220 yards dashes in the only CIAU outdoor track and field championship ever held. He was also a double winner in the OUAA 100 and 220 in 1961-62, his graduating year. Mike went on to graduate school at the University of Toronto and, while still involved in sports, became a bit more serious and earned an M.A and a Ph.D. within three years. After two formative and extremely productive postdoctoral years with the late Geoffrey Wilkinson, at Imperial College, London, Mike returned to Canada in 1967 to a position at Queen's University. Here he has remained except for six months in 1975 as a Humboldt Fellow in the laboratory of E.O. Fischer at the Technische

Universität, München. Mike retired from Queen's in 2006, becoming an Emeritus Professor. He continued in active research until 2017, at which point he retired and closed his lab.

Mike is an outstanding scientist of international stature who received considerable recognition and acclaim for the breadth and the depth of his interdisciplinary interests. He worked in many quite different areas of chemistry, including fundamental and mechanistic organometallic chemistry, homogeneous catalysis, olefin polymerization by organometallic compounds, new anti-tumour drugs, metal-fullerene complexes and applications of computational methodologies to organometallic compounds. In the latter context, he was among the first to combine NMR and IR spectroscopic techniques with molecular mechanics calculations to determine structures of flexible organometallic compounds. He was also the first to prepare transition metal compounds containing coordinated thiocarbonyl, carbon disulfide, ylid and nitroxide ligands, and has for many years been one of the leading organometallic chemists carrying out research on mechanisms of organometallic chemistry. His work on fundamentally important processes such as CO and SO_2 insertion reactions, electrophilic metal-alkyl cleavage reactions, oxidative addition and β-elimination reactions, the direct transfer of hydride ions to coordinated olefins, and nucleophilic attack on coordinated CO and olefins is widely recognized, and aspects have appeared in text books. He has also been particularly prominent in developing a basis for the understanding of the structures and chemistry of once little known 17-electron, paramagnetic organometallic compounds (metal-centred radicals), showing that several widely accepted literature claims were invalid, and collaborating with a theoretician and an EPR spectroscopist to determine electronic structures of several unstable species.

On the applied side, Mike made has made numerous contributions to the field of homogeneous catalysis and was among the first to incorporate water-soluble ligands into otherwise water-insoluble metal compounds to provide new types of water-soluble homogeneous catalysts; some of these behave as very interesting biphasic catalysts for *e.g.* olefin hydrogenation. He has also ventured into the field of synthetic fuels, exploring methanol homologation to ethanol and the catalytic hydrogenation of carbon monoxide and dioxide to hydrocarbons, research of a type expected to make significant contributions to North American energy needs when petroleum stocks ultimately begin to dwindle.

More recently, he has explored the utilization of organometallic compounds as homogeneous catalysts/initiators for olefin polymerization. Indeed, his research group discovered a compound, $[\{\eta^5\text{-}C_5Me_5)TiMe_2][(\mu\text{-}Me)B(C_6F_5)_3]$, which exhibits unique, extraordinarily versatile properties in the field of olefin polymerization, acting as a Ziegler-Natta catalyst for the homo-, co- and terpolymerization of ethylene, propylene and α-olefins, as a cyclopolymerization catalyst for 1,5-hexadiene and a ring opening metathesis polymerization catalyst for norbornene. It also behaves as a carbocationic initiator for the polymerization of vinyl ethers, N-vinylcarbazole and isobutylene. The novelty of the latter process has opened up a new field of research, and Mike has been credited by The Catalyst Group, an important American consulting firm, as "above all others, the person who really stimulated interest in the polymerization of isobutylene" by organometallic catalysts (The Metallocene Monitor, October 1999). They also refer to his first paper in this area as "a key event in generating enthusiasm" for what is becoming a very important field.

Mike's success in the carbocationic polymerization of isobutylene and the copolymerization of isobutylene and isoprene has resulted in a very close collaboration with Bayer Inc., Sarnia, Ontario, in research directed to development of a commercial process for making tire rubber and

other elastomers. The high molecular weights necessary in this industry currently require polymerization at temperatures as low as –100 °C, a capital intensive, very expensive process, and use of the environmentally unfriendly solvent methyl chloride. His research has made it possible to carry out the necessary reactions at much more desirable higher temperatures and in environmentally more benign hydrocarbon solvents, and his group's findings were tested at the pilot plant level. Successful development of a new industrial process based on the Baird group's findings could have serious implications for the Canadian economy.

Mike's research in organometallic chemistry has resulted in well over 225 publications and several patents, and in numerous invitations to contribute oral conference presentations, book chapters and review articles. He has worked with over 70 graduate students, some two dozen postdoctoral fellows and at least 200 undergraduate students, and he was awarded the Chemistry Department Student Council Prize for Excellence in Teaching in 1989, 1994, 2002 and 2003. He has been a member of the Editorial Boards of the *Canadian Journal of Chemistry* and of *Organometallics*, has acted as consultant for DuPont Canada and is currently a consultant with Bayer Inc.

He has been the recipient of the Alcan Lecture Award of the CIC (1986) and the Queen's University Prize for Excellence in Research (1998), as well as the 2002 Catalysis Award of The Catalysis Division. He was elected a Fellow of the Chemical Institute of Canada in 1978, and a Fellow of the Royal Society of Canada in 2003.

2004 - Colin A. Fyfe

Colin A. Fyfe was born in Edinburgh, Scotland. He received his BSc (Hon) and PhD from St. Andrew's University in 1964 and 1967 respectively. He was a Killam Professor at the University of British Columbia from 1967 to 1969. After 18 years at the University of Guelph, he joined the Department of Chemistry at UBC in 1987. He has published over 300 papers and review articles, and authored the text *Solid State NMR for Chemists*. He has presented many invited lectures at international conferences, including Gordon Research Conferences, three NATO Advanced Study Institutes, and an International Zeolite Association Summer School. Four of his publications on zeolites have been in the top 100 cited papers in their respective time periods. He is a Fellow of the Royal Society of Canada.

Since 1981, his research group has developed high-resolution ^{29}Si solid-state NMR spectroscopy as a complementary technique to diffraction methods for the investigation of zeolite materials. In particular, they demonstrated that highly informative Si spectra of zeolites could be obtained by magic angle spinning (MAS) experiments on a commercial high resolution spectrometer. Fyfe has also pioneered the development of 2D solid-state NMR experiments to deduce the 3D Si-O-Si bonding connectivities within the zeolite lattice. This greatly extended the potential of solid-state NMR techniques for investigations of unknown zeolite structures. More recently, the Fyfe group has made substantial progress on two outstanding problems in zeolite catalysis and selectivity: the determination of sorbate/zeolite framework structures and the characterization of of multiple aluminium sites in acid zeolite catalysts. The range and scope of his studies can be seen from the detailed abstract of his Catalysis Award lecture at Montreal: "Zeolites are open framework silicates and aluminosilicates widely used in industry, particularly the petrochemical industry, as acidic catalysts and for gas separations. The analogous titanosilicates are oxidation catalysts. They contain well defined channels and cavities that are of molecular dimensions and these give the frameworks a size and shape selectivity towards

medium sized organic molecules which is unique for heterogeneous catalysts. A complete understanding of this selectivity depends on the determination of the structures of the complexes of organic molecules and other intercalates with the frameworks. However, with a very few important exceptions, it is not possible to apply single crystal diffraction techniques because of the small dimensions (few microns) of these materials and powder techniques have insufficient data to properly define the complexes.

Colin remains very active, and is extending the applications of the techniques he is pioneering into wider applications for catalysis.

From 2006 onwards, a statement for public release became part of the application process, and a word limit imposed (although not always followed).

2006 – Steve Brown *Photo: Courtesy of Steve Brown*



Dr. Steve Brown received a D. Phil. in Chemistry in 1985 from the University of York, England after receiving his B.Sc.(Hons) in Chemistry from the University of London in 1981. His D.Phil work was sponsored by ICI and resulted in this first grated patent. He then held several post-doctoral research positions in both Canada and Australia in areas ranging from analytical chemistry, to nickel-based ethylene oligomerization and hydrogenation catalysts for heavy oil upgrading. In 1990, Dr. Brown started his Canadian industrial career with DuPont of Canada at the Canadian Research Centre in Kingston, ON. In 1994, Dr. Brown became an employee of NOVA Chemicals and relocated to Calgary AB, where he is currently a Principal Research Scientist. Dr. Brown's technical contributions are represented in the numerous publications and presentations that bear his name. However, the most significant contributions to the advancement of catalysis are the invention and subsequent reduction to practice of innovative and commercially value-adding catalyst technologies. More than 20 patents granted worldwide since 1994 on which he is a co-inventor best represent these achievements.

2008 – FTT Ng

Professor Flora T. T. Ng obtained her B.Sc. at The University of Hong, and her M.Sc. and Ph.D. from the University of British Columbia in Canada. She joined the University of Waterloo in 1987, and was appointed University Research Chair in 2006. She holds the prestigious title of University Professor since 2008. She is a Fellow of the Royal Society of Canada. Professor Ng is well-known in the area of catalysis, green chemistry and engineering and a world leading expert on catalytic distillation, a green reactor technology. She has collaborated with Multinational Companies in developing green chemical processes which won awards. She received the Catalysis Award from the Chemical Institute of Canada (CIC) in 2008 and the Canadian Green Chemistry and Engineering Award from CIC in 2013. She was Chair of the Catalysis Division, CIC. She has represented Canada on the International Association of Catalysis Societies and also

served as President of the Canadian Catalysis Foundation. Her current research interests include the sustainable and energy efficient production of green fuels and chemicals from biomass, novel approaches to produce ultra-low sulfur diesel fuel and a greener process for upgrading oil sands bitumen using nanocatalysts.

2010 - R. Stanley Brown

R. Stanley Brown, FCIC, received a BSc (Hon) chemistry from the University of Alberta in 1968, and MSc and PhD degrees from the University of California at San Diego under the direction of Teddy G. Traylor in 1970 and 1972. After a two-year NSERC post-doctoral fellowship at Columbia University with Ronald Breslow, he became an assistant professor at the University of Alberta in 1974, and became professor of chemistry in 1984. In 1995 he moved to Queen's University as the head of the Department of Chemistry and since 2002 has been a professor of chemistry.

Brown's research work in electrophilic bromination, amide hydrolysis mechanisms, catalysis and model enzyme chemistry has led to 155 research publications, seven book chapters, numerous invited lectures at national and international meetings and scientific awards such as the CNC-IUPAC Award in 1987, the Syntex Award in 1991, McCalla and Killam Professorships at the University of Alberta in 1989 and 1993, the Alfred Bader Award in Organic Chemistry in 2004, a Killam Research Fellowship as well as the Queen's University Excellence in Research Prize in 2006 and most recently the R. U. Lemieux Award in 2007. These complement a record of service to the chemical profession in Canada and abroad through various editorial advisory boards, invitations to review graduate and undergraduate chemistry programs, and through involvement with the CSC as a board member and treasurer from 1988-1990 and later as Vice President and President of the CSC in 2003-2005. He established a partnership between the CSC and the Canadian Journal of Chemistry (NRC) with the longer-term objective of providing a publication arm to the Canadian chemical community which could be competitive with top journals in the world. He has served the chemistry grant selection committee of NSERC from 1993-1995 including membership on its Major Equipment and Installation Committee in 1999-2000 and the Chemistry Reallocation Steering Committee in 2001.

2012 – Charles Mims

Charles (Chuck) Mims Obtained a BS degree from the University of Texas and his PhD from Berkeley in 1972. In the years that followed, Dr. Mims worked for Exxon Research & Engineering and at Massachusetts Institute of Technology before joining the University of Toronto in 1990 as Professor, Chemical Engineering and Applied Chemistry. He was also Director, Surface Interfaces Ontario. His research addresses the fundamental properties of catalytic and electrocatalytic materials in energy conversion applications. These include natural gas and coal conversion, membrane catalysis, oxide fuel cell electrodes and oxygen activation. Professor Mims has contributed to dynamic isotope tracing of important catalytic reactions for approximately fifteen years. This work is of interest to many researchers in the field of catalysis. Fundamental understanding of reaction mechanisms will lead to improved catalyst selection for process development. This procedure allows an inventory of surface intermediates involved in catalytic reactions to be measured without disturbing the reaction steady state. This method was applied to the Fischer-Tropsch reaction and to ethylene epoxidation. Professor Mims has also applied in-situ surface science spectroscopy to surface redox processes and isotope exchange-depth profiling to studies of oxygen activation and mobility in complex oxides.

His book, "Introduction to Chemical Reaction Engineering and Kinetics" co-authored by RW. Misen, CA Mims and B.A. Saville, published by John Wiley and Sons in 1999, is a very useful textbook in the area of reaction engineering and mechanisms of reactions.

Professor Mims has served as Chair, Catalysis Division of the CIC, a member of the Canadian Catalysis Foundation Board of Directors, and on the Editorial Board of Journal of Molecular Catalysis and Applied Catalysis A. He is currently Professor Emeritus at the University of Toronto.

2014 – Warren Piers

Warren Piers obtained his BSc from the University of British Columbia in 1984 and his PhD from the same institution in 1988. He then spent two years at the California Institute of Technology as an NSERC and Killam Postdoctoral Research Fellow with Professor John Bercaw. From 1990 to 1995 he was an Assistant Professor at the University of Guelph. He then moved to the University of Calgary as an Associate Professor in the Department of Chemistry. In 2000 he was promoted and appointed to the S. Robert Blair Chair in Polymerization catalysis, and in July 2013 was named a Tier I Canada Research Chair in the Mechanisms of Heterogeneous Catalysis. This chair was established with support from Nova Chemicals.

Warren Piers is a synthetic organometallic chemist, whose research interests include the development of new olefin polymerization catalysts and co-catalysts, and the development of new catalytic processes using early transition metal organometallic compounds - in this latter area, methods for chiral synthesis using new borane-based catalysts are being investigated. Much of his work is theoretically highly significant, and it has broad implications for Lewis catalyzed reactions in general. His work has aroused great interest in industry (particularly the polymer industry), and among organic chemists as well as pharmaceutical, agricultural, and materials scientists. He is also interested in developing the fundamental chemistry of processes involved in catalytic water splitting.

In 2001, Dr. Piers received an E.W.R. Steacie Memorial Fellowship from NSERC. A Steacie Fellowship is the most prestigious award NSERC makes to outstanding young scientists, and Dr. Piers was the only chemist so honoured in 2001. He was also named as the winner of the 2001 Rutherford Memorial Medal for Chemistry from the Royal Society of Canada. This award is named in memory of Lord Rutherford of Nelson, an outstanding scientist who spent some of his early years in Canada. The fact that only one such award is given in Canada each year, and scientists in any area of Chemistry are eligible, highlights once again the outstanding quality of his research, and the national (indeed international) reputation that his work has achieved. In 2006 he became an Elected Fellow of the Royal Society of Canada. He held a prestigious Canada Council of the Arts Killam Research Fellowship from January 1 2012 to December 31, 2013.

Dr. Piers is currently a member of the Editorial Advisory Board of both the ACS journal Organometallics and the Canadian Journal of Chemistry.

2016 – Mark Lautens

Mark Lautens was born in Hamilton, Ontario and attended the University of Guelph, where he obtained a BSc (Distinction) in 1981. During his BSc, he worked on natural product synthesis, catalytic processes and low valent metal complexes. He then completed doctoral studies in 1985 with Barry M. Trost at the University of Wisconsin-Madison, working in the area of molybdenum catalyzed allylations and palladium enyne cycloisomerizations. This was followed by postdoctoral studies (NSERC PDF) at Harvard University working with David A. Evans in the area of natural product synthesis.

He joined the faculty at the University of Toronto in 1987 as aURF Assistant Professor. He was promoted to Professor in 1995 and since 1998 has been AstraZeneca Professor of Organic Synthesis.From 2003-2013 he was Merck Frosst/NSERC Industrial Research Chair. In 2012 he was promoted to University Professor, the highest rank at the University of Toronto. Since 2013 he is J. Bryan Jones Distinguished Professor.

Among his honours and awards are E.W.R. Steacie Fellow, CIC Medal, Pedler Award from the RSC, Humboldt Awardee, Fellow of the Royal Society of Canada and most recently Office of the Order of Canada.

2018 – Cathleen Crudden

Cathleen Crudden was born in Belfast, N. Ireland to Patrick and Linda Crudden. Shortly thereafter, her family emmigrated to Canada, where they settled in Toronto and gave Cathleen two younger sisters, Mary and Sarah, and her only brother, Patrick. Cathleen grew up in Toronto attending Notre Dame high school in the Beaches before starting her B.Sc. at the University of Toronto. After this, she stayed on at the U. of T. to complete a master's degree with Professor Mark Lautens. Ottawa was the next stop where Cathleen completed her Ph.D. under the supervision of Professor Howard Alper. During this time, she had the pleasure of an extended stay in Japan, doing research with Professor Shinji Murai and Naoto Chatani at Osaka University.

After completing her Ph.D., she was an NSERC postdoctoral fellow with Professor Scott E. Denmark at the University of Illinois at Urbana-Champaign, USA. In 1996, she started her own research group at the University of New Brunswick. After 5 years at the University of New Brunswick, where she learned to canoe, pick fiddleheads and tell the difference between hostas and skunk cabbage, she was offered a job at Queen's University, where she moved in 2002 as a Queen's National Scholar. In 2006, Cathleen and the distinct pleasure of taking part of her sabbatical back in Japan, this time in Nagoya in the Noyori Research Labs, with Professor Kenichiro Itami as her host. In addition to learning some great chemistry, she experienced an earthquake, improved her Japanese and enjoyed a few nights out at local karaoke bars. In 2007, it was off to Spain for a half sabbatical with Elena Fernandez, enjoying the fabulous Catalan hospitality, chemistry and food. In 2010, Cathleen became Mom to her beautiful daughter Caitlin, and shortly after her return from maternity leave, became head of an NSERC CREATE award in Chiral Materials. For 2011-13, she was Vice President, President and Past President of the Canadian Society for Chemistry. In 2013, Cathleen was offered a position at the Institute of Transformative Bio-Molecules in Nagoya Japan as a Research Professor. With the help of her very talented Assistant Professor Masakazu Nambo, she runs a satellite group there year round.

She has won numerous research awards including the 2018 Canadian Catalysis Society Award, the 2017 R. U. Lemieux award and the 2011 Clara Benson award. She is a fellow of the

Chemical Institute of Canada and the Royal Society of Chemistry. She was a Killam Research Fellow from 2015–2016. Crudden has been a visiting professor in the labs of Ryoji Noyori, was awarded a Global Center of Excellence Professorship at Kyoto University and a Visiting Professorship in Tarragona, Spain. Crudden is associate editor for ACS Catalysis and sits on the editorial advisory boards of Chemical Record (Japan), Synthesis, Organometallics, ACSOmega and Chemical and Engineering News. Her work in catalysis and materials has received significant acclaim, with recent work identifying a new class of carbon-based SAMs being called "game changing" and "the new gold standard" by international experts in the area.

2020 - Chao-Jun Li

Dr. Chao-Jun Li received Ph.D. at McGill University (1992) and was a NSERC Postdoctoral Fellow at Stanford University (92-94). From 1994-2003, he was on the faculty at Tulane University (US) and, in 2003, returned to McGill University, where he holds the Canada Research Chair (Tier I) in Green Chemistry and E. B. Eddy Chair of Chemistry. He served as the Co-Chair of the Canadian Green Chemistry and Engineering Network (2009-2016), the Director of CFI Infrastructure for Green Chemistry and Green Chemicals, the Director of NSERC CREATE for Green Chemistry, the Co-Director of the FRQNT Center for Green Chemistry and Catalysis (CCVC), and the Associated Editor for Green Chemistry (RSC). He is a Fellow of the Royal Society of Canada, the Chemical Institute of Canada (CIC), RSC (UK), AAAS, ACS, and TWAS. He has published >460 research articles, 7 books, and has given 450 plenary/keynote/invited lectures. His research focuses on exploring new chemistry that complements conventional reactivity and possesses high “atom-efficiency”—with a goal towards Green Chemistry. His work has been widely cited (>43,000, h index >100) and was listed as one of the World’s Most Highly Cited Scientists by Thomson Reuters/Clarivate Analytics (2014-2017).

10 CANADIAN CATALYSIS LECTURESHIP AWARD

Alan Sanger (1st Edition)
Updated by Alan Sanger and Jacques Monnier (2nd Edition)
Updated by Bob Hayes (3rd Edition)

The CCF created and sponsors the Canadian Catalysis Lectureship Award (CCLA). The lectureship is restricted to researchers who are currently working in Canada in the area of catalysis. It is presented to a Canadian scientist who has made an outstanding contribution to the understanding of catalysis and catalysis reactions and is intended to provide exposure of the awardee's research to other Canadian scientists/engineers. The lecture tour was initially held annually, and typically includes 4 to 6 Canadian cities. The recipient is chosen by a committee appointed by The Catalysis Division, and can be either a researcher recognized as a leader in a particular field of research, or someone who has just completed a new and interesting or controversial piece of work but who is not yet widely recognized.

The inaugural lectureship award was made in 1994 with Yoshimitsu Amenomiya being the first recipient. No award was made in 2008, and starting in 2015, the award is offered every second year. In Table 10.1, the indicated institution was the one to which the awardee was associated at the time of the award.

1994 **Yoshimitsu Amenomiya**, FCIC, presented a series of lectures to enthusiastic audiences in six Canadian cities in the spring of 1995. Amenomiya's lectures titled 'Dynamic Study of Surface during Catalytic Reaction' and 'Acid and Base Centers as Observed by TPD' were presented in Fredericton (University of New Brunswick), Québec City (Laval University), Kingston (Joint CSChE/CSC Meeting), Saskatoon (University of Saskatchewan), Calgary (University of Calgary) and Vancouver (University of British Columbia).

Amenomiya, a native of Tokyo, Japan, received his BEng from the Tokyo Institute of Technology and his DSci in the field of heterogeneous catalysis from Hokkaido University in 1959. He joined the Chemistry Division of the National Research Council of Canada as a Postdoctoral Fellow in 1959 where he held the positions of Associate Research Officer and Senior Research Officer until his retirement from NRC in 1987. Amenomiya was an Honorary Visiting Professor at University of Ottawa, and in 1990 he was an Invited Professor at the International Cooperation Center, Tokyo Institute of Technology. Elected a Fellow of the CIC in 1973, Amenomiya pioneered the technique of temperature-programmed desorption for characterizing the acid-base properties of heterogeneous catalysts, and was jointly awarded the first Catalysis Award of The Chemical Institute of Canada in 1977 with R.J. Cvetanovic. Amenomiya's research interests include heterogeneous catalysis, chemical properties of solid surfaces and catalytic activation of methane. A detailed bio of Yoshi appears in the Catalysis Award section of this book.

Table 10.1 Holders of the Canadian Catalysis Lectureship Award.

Year	Awardee	Institution
1994	Yoshimitsu Amenomiya	University of Ottawa, Ottawa
1995	Jerry F. Kriz	CANMET, Natural Resources Canada, Ottawa
1996	John B. Moffat	University of Waterloo, Waterloo
1997	Karl T. Chuang	University of Alberta, Edmonton
1998	Serge Kaliaguine	Université Laval, Ste-Foy
1999	Brian R. James	University of British Columbia, Vancouver
2000	Tom Ziegler	University of Calgary, Calgary
2001	Marten Ternan	CANMAR Engineering Inc., Ottawa
2002	Warren E, Piers	University of Calgary, Calgary
2003	Charles A. (Chuck) Mims	University of Toronto, Toronto
2004	Phillip Jessop	Queen's University, Kingston
2005	Peter D. Clark	University of Calgary, Calgary
2006	Peter H. McBreen	Université Laval, Ste-Foy
2007	Abdelhamid Sayari	University of Ottawa, Ottawa
2008		No award given
2009	Michael C. Baird	Queen's University, Kingston
2010	Cathleen Crudden	Queen's University, Kingston
2011	Ajay Dalai	University of Saskatchewan, Saskatoon
2012	Kevin J. Smith	University of British Columbia, Vancouver
2013	Aicheng Chen	Lakehead University, Thunder Bay
2014	Trong-On Do	Université Laval, Ste-Foy
From 2015, the CCLA Award is nominated in January of the even year and the recipient gives tour lectures in the following odd year		
2016	Robert E. Hayes	University of Alberta, Edmonton
2018	Zhibin Ye	Concordia University, Montreal
2020	Shuhui Sun	INRS, Montreal

1995 **Jerry Kriz**, FCIC, gave lectures in six Canadian cities in the spring of 1996. Kriz's lecture titled 'Processing and Environmental Catalysis' was presented in Québec City (Laval University), Sarnia (Joint CSChE/CSC Meeting), Edmonton (University of Alberta), Calgary (University of Calgary), Vancouver (University of British Columbia), and Whistler (14th Canadian Symposium on Catalysis).

Dr. Kriz received his Dipl. Eng. in Chemical Engineering from the Institute of Chemical Technology (Prague) in 1968 and his PhD in Physical Chemistry from Dalhousie University (Halifax) in 1973. He held the positions of Research Fellow in the Department of Chemical Engineering, University of Western Ontario, and NRC Postdoctoral Fellow in the Department of Chemistry at Simon Fraser University. In 1976, Kriz joined the Energy Research Laboratories of CANMET (now part of CANMET Energy Technology Centre) located in Ottawa. In his twenty year career as a research scientist with CANMET, Kriz conducted R&D in various applications of heterogeneous catalysis to hydrocarbon processing: catalyst deactivation and coking propensity in heavy

oil upgrading, aromatics saturation in synthetic crude distillates, catalytic processing of waste-derived oil, catalytic isomerization of gasoline range paraffins and benzene removal from gasoline. Kriz was head of the Catalytic Hydroprocessing Section between 1980 and 1991.

1996 **John B. Moffat**, FCIC. Moffat served on the executive of the Catalysis Division successively as Secretary-Treasurer, Vice-Chair, Chair and past Chair during 1980-1986, was a director of the CSC during the period from 1987 to 1990 and is a founding Director of the Canadian Catalysis Foundation of which he was President from 1991 to 1995. He has served on the Editorial Boards of the *Journal of Molecular Catalysis*, and *Applied Catalysis*, and continues on *Catalysis Letters* and on the organizing committees of a number of conferences related to catalysis. He was Secretary for the International Congress on Catalysis held in Calgary in 1988 and continues to serve on the International Scientific Committee for the International Natural Gas Conversion Symposia held in New Zealand, Norway, Australia and South Africa, the latter in 1995. He co-chaired a symposium on Solid Superacids in Hawaii in December 1995, and will co-chair a conference on Chemistry, Energy and the Environment in Portugal in 1997 and as the Chair for the North American Catalysis Society Meeting to be held in Canada for the first time in 30 years in 2001. A detailed bio of John appears in the Catalysis Award section of this book.

1997 **Karl T. Chuang, FCIC.** Chuang received his BSc degree in chemical engineering from Cheng-Kung University, Taiwan in 1963, his MSc degree in chemistry from St. Francis Xavier University, NS in 1968, and his PhD degree in chemical engineering from the University of Alberta in 1971. His professional experience includes a tenure in industry as section head of chemical engineering at Chalk River Nuclear Labs of the Atomic Energy of Canada Ltd. (AECL) during the period 1972 to 1986. From 1982 to 1986, he was also an adjunct professor of chemical engineering at the University of Ottawa. He returned to full-time teaching and research in 1986 by joining the Department of Chemical Engineering at the University of Alberta as a full professor.

At AECL, Chuang directed an R&D program to develop a model for design of improved sieve tray and packed towers at Canadian heavy water plants. Revamping of the towers has resulted in increased heavy water production worth millions of dollars per year. He was a member of the Technical Advisory Committee at Fractionation Research, Inc. (USA) for eleven years and contributed a great deal in setting the FRI program for distillation and absorption research. In recognition of his innovative contributions towards the development of new separation processes, he was awarded the AECL Discovery Award in 1985 and again in 1986.

One of Chuang's main research interests, since joining the University of Alberta, is in the area of environmental cleanup involving such processes as removal of NO_x, H_2S in waste streams, catalytic wet air oxidation for eliminating organic compounds in industrial waste streams, and removal of volatile organic compounds in waste water or polluted air. A second major area deals with separation processes involving membrane separation, distillation and absorption, novel high capacity and high efficiency gas-liquid contactors. He has fifteen patents based on his novel ideas. Several of the processes developed by

him are being used in industry worldwide. Karl is currently Professor Emeritus at the University of Alberta.

1998 **Serge Kaliaguine, FCIC**, presented his lecture tour by speaking at the CANMET Energy Technology Centre in Nepean, at the University of Ottawa, the University of Toronto, the University of Waterloo the University of Calgary, the University of Alberta, the National Centre for Upgrading Technology, Devon, AB; and the University of British Columbia.

Serge Kaliaguine was born in Sigoules, France and lived for several years in North Africa. He received his higher education in Toulouse, France, his B.Sc. from l'Institut du Génie Chimique de Toulouse (1964) and his Ph.D. from the University of Toulouse (1967). He has been teaching at Laval University since the fall of 1967. A detailed biography of Serge appears in the Catalysis Awards section of this book.

1999 **Brian James**, Brian presented lectures at the University of Victoria, University of Western Ontario), York University, Queen's University, McGill University and Dalhousie University.

After receiving a D.Phil. from Oxford, Brian completed postdoctoral fellowships with the UK Atomic Energy Authority and the University of British Columbia before joining UBC in 1964. His research focused on the chemistry of the platinum metals for applications in homogeneous catalysis and chemotherapy. Sixty students have completed graduate degrees with Dr. James and he has generated 310 publications, 4 patents and a book entitled *Homogeneous Hydrogenation*. Dr. James received the Catalysis Award in 1990 and a biography of Brian appears in the Catalysis Award section of this book.

2000 **Tom Ziegler, FCIC**, presented the Canadian Catalysis Lecture tour in 2000. Tom was a world leader in the development of Density Functional Theory (DFT), which has changed the role of theoretical chemistry by making accurate calculations on large molecules possible for the first time. DFT permits the accurate calculation of bond energies, molecular structures, transition states and reaction paths, and its implications for understanding catalytic processes – and predicting new catalysts, particularly for reactions conducted in homogeneous solution with organometallic catalysts – are immense. His software package for the theoretical study of structure and reactions is now used by more than 300 academic and industrial research centers worldwide; he is one of the top 1% of chemists quoted in the world's chemical literature.

Tom graduated with a B.Sc. in chemistry from the University of Copenhagen, Denmark, and then received an M.Sc. in theoretical chemistry, University of Copenhagen, followed by a PhD in inorganic/theoretical chemistry, from the University of Calgary, AB. Tom had postdoctoral fellowships at the Free University in Amsterdam and McMaster University in Hamilton, ON. He was an NSERC University Research Fellow at the University of Calgary from 1981 to 1986, and then became an assistant professor, and finally a full professor in 1993. Tom was a Fellow of the Royal Society of Canada, the Royal Danish Academy of Sciences and Letters, received two national awards from the Canadian Society for Chemistry, and was welcomed as a visiting professor in Japan, Switzerland, and the Netherlands. Tom passed away on March 24, 2015.

2001 **Marten Ternan**, **FCIC**, was the winner of the 2001 Canadian Catalysis Lectureship Award. Dr. Ternan spoke at 20 locations on "Fuel cell performance as a function of feedstock: hydrogen, methanol, or fossil fuels." The talk addressed climate change, urban smog, acid rain, and loss of species that are environmental phenomena whose effects are known to be negative. Comparisons of fuel source for fuel cells was discussed, and three feed stocks were compared. The phenomena discussed included: the diffusion of gaseous reactants (hydrocarbons, air), the structure of the porous electrodes, formation of protons and their diffusion through the electrolyte, the pressure profile through the cell, and the net flow of oxygen atoms. Of particular interest are the conventional platinum electrocatalyst and the potential of alternative electrocatalysts. Phenomena at the catalytic surfaces of the oxygen cathode and the hydrocarbon anode were discussed.

Ternan has degrees in chemical engineering from the University of British Columbia and McGill University. He has worked for a number of organizations (Imperial Oil, INCO, the federal government's CANMET laboratories, H-Power) on projects such as process design, pilot plant operation, fossil fuel conversion, environmental catalysis, ammonia reactions in chemical heat pumps, and hydrogen synthesis for fuel cells. Ternan has also held part-time appointments at the University of Ottawa (adjunct professor) and at Université du Québec (professeur associé). He has 7 patents and 62 publications. Ternan won the Catalysis Award from the Canadian Catalysis Foundation and the ERCO Award (now the Syncrude Award) from the Canadian Society for Chemical Engineering. He has been active at the local and national levels of the Catalysis Division of the Chemical Institute of Canada and the Canadian Society for Chemical Engineering. In 2001, Ternan was the co-chair of the 17th Meeting of the North American Catalysis Society, held in Toronto. A complete biography of Ternan appears in the Catalysis Award section.

2002 **Warren E. Piers**, Professor Piers presented talks at UPEI, Mt. Allison, Acadia University, Dalhousie University, University of Victoria, University of British Columbia, Simon Fraser University and The King's University College, Edmonton. The presentation topic was "Cationic Organoscandium and Organoyttrium Olefin Polymerization Catalysts." Single site olefin polymerization catalysts based on well-defined organometallic compounds are revolutionizing the polyolefins industry. While most of the commercially important catalysts are based on group 4 metals such as titanium and zirconium, catalysts based on other metals are growing in prominence.

Dr. Piers obtained his Ph.D. from the University of British Columbia in 1988, and then spent a post-doctoral period at Cal Tech working with John Bercaw. He was a faculty member at the University of Guelph before joining the Department of Chemistry, University of Calgary in 1995. Dr. Piers was named to the S. Robert Blair Chair in Polymerization Catalysis and Polymer Synthesis at the University of Calgary in 2000. Dr. Piers is currently a member of the Editorial Advisory Board of both the ACS journal Organometallics and the Canadian Journal of Chemistry. Warren also won the 2014 CIC Catalysis Award, and a complete biography is given in Chapter 9.

2003 **Charles A. (Chuck) Mims** of the University of Toronto was the winner in 2003, and presented his lecture across Canada. Professor Mims has contributed significantly on the use of isotopic labelling for the investigation of reaction mechanisms of catalytic reactions. This work is of interest to many researchers in the field of catalysis. Fundamental understanding of reaction mechanisms leads to improved catalyst selection for process development. Chuck also contributes to the activities of the Catalysis Division of the CIC and the North American Catalysis Society. His recent book, "Introduction to Chemical Reaction Engineering and Kinetics" co-authored by RW. Misen, CA Mims and B.A. Saville, published by John Wiley and Sons in 1999, is a very useful textbook in the area of reaction engineering and mechanisms of reactions.

Chuck received his PhD from Berkeley in 1972, and worked for Exxon Research & Engineering and at the Massachusetts Institute of Technology before joining the University of Toronto in 1990 as Professor, Department of Chemical Engineering and Applied Chemistry. His research addressed the fundamental properties of catalytic and electrocatalytic materials in energy conversion applications. These include natural gas and coal conversion, membrane catalysis, oxide fuel cell electrodes and oxygen activation. Professor Mims has contributed to dynamic isotope tracing of important catalytic reactions for approximately fifteen years. This procedure allows an inventory of surface intermediates involved in catalytic reactions to be measured without disturbing the reaction steady state. This method was applied to the Fischer-Tropsch reaction and to ethylene epoxidation. Professor Mims has also applied in-situ surface science spectroscopy to surface redox processes and isotope exchange-depth profiling to studies of oxygen activation and mobility in complex oxides.

Professor Mims was Chair, Catalysis Division of the CIC, a member of the Canadian Catalysis Foundation Board of Directors, and on the Editorial Board of Journal of Molecular Catalysis and Applied Catalysis A. More details about Chuck can be found in the information about the Catalysis Award (Chapter 9).

2004 **Phillip Jessop** Dr. Jessop gave a seminar on “The Utility of Carbon Dioxide in Homogeneous Catalysis” at the Universities of Saskatchewan, Alberta, Calgary, New Brunswick, Prince Edward Island, St. Mary's, Dalhousie, Western Ontario and Toronto during early 2005. While CO_2 fixation is obviously of great interest as a reagent, CO_2 has increasing utility even in reactions which do not result in its fixation. The talk described studies of homogeneous catalysis in which CO_2 serves as a reagent, a solvent, an accelerant, a trigger for catalyst changes or a trigger for switchable solvents.

Phillip received his B.Sc. in Chemistry from the University of Waterloo and Ph.D. from the University of British Columbia, where he studied the synthesis and reactivity of phosphine ruthenium complexes under the direction of Dr. Brian James. Dr. Jessop carried out postdoctoral research at the University of Toronto with Dr. Robert Morris before taking a position in the Research Development Corporation of Japan in a project headed by 2001 Nobel Prize winner, Professor Ryoji Noyori, investigating hydrogenation in supercritical CO_2. From 1996 to 2003 he served as an Assistant Professor at the University of California-Davis, and in 2003 he took up his current position at Queen’s University. He is the holder of an NSERC Canada Research Chair in Green Chemistry. His research interests include homogeneous catalysis in unusual solvents (supercritical fluids, ionic liquids, and gas-expanded liquids) and the catalytic conversion of CO_2 to useful products. Jessop has

published over 50 papers and book chapters, including papers focused on novel aspects of homogeneous catalysis in neoteric solvents. In addition, he is an inventor on five patents, has organized conference symposia on green chemistry, and co-edited a book entitled *Chemical Synthesis using Supercritical Fluids.*

2005 **Peter D. Clark** The title of Dr. Clark's lecture during his tour across Canada was "Investigations into the Catalysis of Sulfur Recovery by the Claus Process: Opening the Door to New Technology for the Canadian Refining and Petrochemical Industry". He holds the appointments of Professor in the Department of Chemistry at University of Calgary and Technical Manager of Alberta Sulphur Research Ltd. (ASRL). The research interests of Dr. Clark focus on the recovery of sulphur from fossil fuels and the chemistry relating to the use of sulphur in industry. He has contributed to the understanding of the mechanism and kinetics of the Claus reaction and demonstrated that sulphur is formed over alumina through a series of reactions involving sulphite, thiosulphate and polythionates. Research at ASRL showed that formation of sulphur from polythionates resulted in regeneration of thiosulphate, which is the actual reactive intermediate. This work also provided evidence that sulphate is part of the catalytic cycle leading to sulphur, rather than acting as a poison as previously thought. These studies have lead to the investigation of short contact time catalytic oxidation of H_2S to simplify sulphur recovery technology. Dr. Clark has also studied natural and synthetic clay catalysts for the synthesis of organosulphur compounds and for the removal of sulphur from petroleum and its products. Recent work investigated partial oxidation of ethane, propane and butane in the presence of hydrogen sulphide as a means improving industrial scale olefin manufacture and limiting emissions associated with conventional steam cracking methods. Dr. Clark received his B.Sc. and Ph.D. from the University of Hull, United Kingdom. Dr. Clark has over a hundred publications in refereed journals and numerous reports prepared for government and industrial clients.

2006 **Peter H. McBreen,** the winner of the 2006 award, is a professor in the Department of Chemistry at Laval University.He obtained his PhD from the University of Toronto in 1981, which was followed by postdoctoral work Surface Science Institute (IGV), Julich, Germany (1981-83) and the Materials Science Department, University of Ben Gurion, Israel (1984-85). His current research uses surface spectroscopy and tunneling microscopy to study the chemical reactivity of catalytic surfaces. This research establishes knowledge of surface reactions at the molecular level, provides new chemical methods for manipulating nanostructures and explores the intersection of organometallic catalysis and heterogeneous catalysis.

2007 **Abdelhamid Sayari** is a Professor of Chemistry at the University of Ottawa. He obtained his PhD in the area of catalysis from the Universities of Tunis and Claude Bernard in 1980. He held a Tier 1 Canada Research Chair from 2001 to 2015. Professor Sayari is interested in the design and synthesis of inorganic porous materials such as zeolites and periodic mesoporous materials as well as organic-inorganic hybrid materials such as periodic mesoporous organosilicates and surface-functionalized inorganic materials. He also specializes in heterogeneous catalysis with projects in selective organic synthesis, light hydrocarbon activation and environmental catalysis. In addition, Dr.

Sayari has an extensive research program in gas separation and purification, including greenhouse gas mitigation.

2009 **Michael Baird,** Professor of Chemistry at Queen's University was the 2009 award winner. Mike has had a long and distinguished career at that institution. His main focus was on homogeneous catalysis. He received a PhD from the University of Toronto in 1965, which was followed by a two year postdoctoral stint at Inperial College in London. He joined Queen's in 1967, and remained there until his official retirement in 2006. As an Emeritus Professor he remained active in research until 2017, at which time he fully retired and closed his lab. A more detailed account of Professor Baird's activities can be found in Chapter 9, under CIC Catalysis Award winners.

2010 **Cathleen Crudden** In late October/early November Dr. Crudden visited several Universities on the east coast as part of this lectureship. The first tour started with the University of New Brunswick in Fredericton where she presented her work related to both homogeneous and heterogeneous catalysis. The lecture began with a highlight of the importance of catalysis to chemistry since three of the Nobel Prizes in the last decade were given in the area of catalysis! This fact impressed virtually everyone on the tour. After UNB, the next stop was Acadia University where she had an outstanding turnout of third and fourth year undergraduates. The students were extremely keen and asked remarkably insightful questions. She was since told that at Acadia the students rank all the lecturers for the year. The last time she talked to the Department Chair there, her lecture was still ranked number one for the year! After Acadia, Dr. Crudden traveled to Cape Breton University where she again had a very large crowd of students and faculty. The lecture was very well received, and several students came up to her at the end saying that they would be interested in going to grad school to study catalysis. Finally, in February she went to Mount Allison in Sackville New Brunswick and gave her talk to a packed crowd. The last part of the trip was to the University of Calgary and the University of Alberta. Crudden was also the winner of the 2018 Catalysis Award, and a complete biography is given in Chapter 9.

2011 **Ajay K. Dalai** toured University of British Columbia, University of Alberta, University of Waterloo, McMaster, University of Toronto, University of Ottawa, École Polytechnique de Montréal, Université de Sherbrooke, University of New Brunswick and Memorial University. The title of his presentation was "Development of Carbon Nanotubes Supported Novel Catalysts for Fischer-Tropsch and Higher Alcohol Syntheses".

Ajay obtained his B.Sc. and M.Tech. from India and his Ph.D. (all in Chemical Engineering) from the University of Saskatchewan. He is Professor and Canada Research Chair (Tier 1) in Bioenergy and Environmentally Friendly Chemical Processing in the Department of Chemical Engineering, University of Saskatchewan. Professor Dalai has been a member of the Chemical Institute of Canada since 1987. He has held Chair of Northern Saskatchewan Section of CIC (1997-2000) and has been a member of the executive committee of the Catalysis Division of CIC since 2000. The Catalysis and Chemical Reaction Engineering (CCREL) laboratory led by Professor Dalai is widely known and respected for both academic and industrial research, and he has tremendous

contacts in industry and academia, both nationally and internationally. Professor Dalai's current focus is the development of gas to liquid technologies and Fischer-Tropsch synthesis. He is a leader in biodiesel research, and his other research interests include value-added products from biomass, solid acid catalysis for the production of alkylates, activated carbon production and applications for mercury and hydrogen sulfide capture, and hydroprocessing of heavy gas oil derived from Athabasca bitumen. Professor Dalai has nine patents and patent applications related to catalytic processes. He has published 200 research papers in international journals and conference proceedings, over 110 research reports for funding agencies, and he has presented 250 papers at national and international conferences. Professor Dalai has given over 50 invited lectures in his areas of expertise in Canada, USA, Australia, China and India. He is a member of many national and international strategic initiatives on the bio-economy. He has held the Petro Canada Young Innovator Award (1999), the Syncrude Owl Award (2003), Kentucky Colonel Award (2004), Institute of Chemical Technology Mumbai Professor R.A. Rajadhyaksha Memorial lecture Series Award (2006), Indian Chemical Engineering Congress NEERI Distinguished Speaker award (2006), McMaster University's Brockhouse Institute for Materials Research Distinguished Speaker award (2009) and DAAD Fellowship (Germany) Award (2010). Recently, he has received fellowship of Engineering Institute of Canada (EIC) and Innovator Award from Industrial Liaison Office at the University of Saskatchewan and Innovation Place in Saskatoon.

2012 **Kevin Smith, P**rofessor in the Department of Chemical and Biological Engineering at the University of British Columbia, has more than 25 year experience in applied catalysis research that has focused on issues related to the Canadian energy scene. His primary interests are in C1-catalysis and upgrading Canadian oilsands. He has published widely and consistently in the areas of alcohol synthesis from syngas, methane conversion, hydrotreating and hydroconversion of heavy oils, and has more than 85 journal publications. He is the recipient of the Canadian Council of Professional Engineers Medal for Distinction in Engineering Education (2006) and the APEGBC Teaching Award for Excellence in Engineering and Geoscience (2005). He has served as Head of the Department of Chemical and Biological Engineering at the University of British Columbia (2001-2009), Chair of the Catalysis Division of the CIC (2000-2002) and President of the Canadian Catalysis Foundation (2002-2004). In 2004, he was elected Fellow of the CIC.

2013 **Aicheng Chen** is a Professor of Chemistry at the University of Guelph. He has made significant contributions to electrocatalysis and photocatalysis. His research group has recently developed novel TiO2- based nanomaterials with high photocatalytic activity and superb visible light response, which are promising for hydrogen production and the utilization of solar energy. He has also developed a facile approach for the direct growth of Pd-based nanomaterials, showing high capacity for hydrogen storage. The nanoporous Pt-based networks developed by his group possess a high active surface area and exhibit excellent electrocatalytic activity for fuel cell applications and electrochemical sensor development. Most recently, Dr. Chen has developed a novel bifunctional electrode technology, which effectively integrates electrochemical oxidation and photochemical degradation for water purification. This innovative approach was featured by MIT's

Technology Review and was profiled by the Industrial Wastewater Newsletter. His research contributions are making significant impacts toward addressing critical environmental and energy issues that confront both Canada and the world. Professor Chen holds a Tier 1 Canada Research Chir in Electrochemistry and nanoscience, and is a Fellow of the Royal Society of Chemistry (UK) and the CIC.

2014 **Trong-On Do** presented his lecture titled "Nanocomposites as sunlight-driven photocatalysts for H_2 generation from water splitting and for air depollution" at five locations. These were: Department of Chemical and Biological Engineering, University of British Columbia; Department of Chemical and Petroleum Engineering, University of Calgary; Department of Chemical and Biochemical Engineering, Western University; Department of Chemistry, Lakehead University; CCVC- Annual meeting at McGill University.

Trong-On Do received his MSc in 1986 and PhD in 1989 from the University of P. and M. Curie (Paris 6). After a period at Brunel University (UK) and the French Catalysis Institute (France), he moved to Laval University in 1990. He then spent two years 1997-1999 in Prof. Fujishima's group at Tokyo University under the Japanese STA Fellowship Award before re-joining Laval University as a professor associated with Prof. Kaliaguine's NSERC Industrial Chair. Trong-On's research focuses on the design and synthesis of innovative and smart materials and their application in heterogeneous catalysis and renewable energy. Trong-On recently made a pioneering contribution towards the efficient photocatalytic production of H2 from water splitting, CO2 photo-conversion to chemicals/fuels and the degradation of air pollutants under solar light irradiation. He is also a major contributor in the field of zeolite-based materials including controlled-size nanozeolites and hybrid zeolite/mesoporous molecular sieve materials. He has published over 160 papers and review articles in refereed journals and holds 5 international patents.

2016 **R.E. (Bob) Hayes** FCIC presented a lecture titled "Multi-scale modelling of structured catalytic reactors" at six locations in the Fall of 2016 and Winter of 2017. The locations were University of Saskatchewan, University of Calgary, University of British Columbia, University of Ottawa, Ecole Polytechnique and University of Toronto.

Bob is a Professor of Chemical Engineering at the University of Alberta who has been active in Catalysis since his undergraduate years. Following a B. Eng. earned in 1979 at the Technical University of Nova Scotia (TUNS), he pursued a PhD with Professor John Thomas at the University of Bath, UK, finishing in 1982. He continued his work on catalysis at TUNS as an Assistant Professor, studying the methanation reaction, before moving to the University of Alberta in 1985. Since 1990, he has worked primarily in the area of catalytic combustion in structured reactors, both for the mitigation of fugitive methane emissions and in the development of catalytic converters. His research work has been conducted in collaboration with both industrial and government laboratories. He is the author or co-author of over 150 scientific papers and six textbooks, including the reference work, Introduction to Catalytic Combustion, published in 1997.

2018 **Zhibin Ye, FRSC**, Zhibin received his BSc and MSc degrees from Zhejiang University, and a PhD from McMaster University in Hamilton. From 2004 to 2009 he was Assistant Professor at Laurentian University, before moving to Concordia in 2009. He is now a Full Professor there.

Dr. Zhibin Ye is internationally recognized for his significant contributions to olefin polymerization catalysis. He has advanced the state of the art in the Pd–diimine-based catalyst technologies for synthesis of novel polyethylenes of controllable complex architectures. He invented a catalytic emulsion polymerization technology for the production of ultra-small carbon nanospheres of superior performance for electrochemical energy storage applications, which is being transferred for large-scale commercial manufacturing. His impactful research works are well known to international researchers in the field. Dr. Ye received about four million dollars of research funding. He was awarded a Canada Research Chair (2011–2020) and was a member in NSERC Evaluation Group (2011–2014). He is a Fellow of Royal Society of Chemistry (UK) and a recipient of Ontario Premier's Early Researcher Award, NSERC Discovery Accelerator Supplement Award, and the 1st Faculty of Science and Engineering Research Excellence Award at Laurentian University.

2020 **Shuhui Sun**, Professor at the Center for Energy, Materials and Telecommunications, Institut National de la Recherche Scientifique (INRS) in Montreal, is a winner of the 2020 Canadian Catalysis Lectureship Award from the Canadian Catalysis Foundation. Sun has made significant contributions to electrocatalysis and photocatalysis for energy conversion and storage technologies. He has developed a facile green chemistry approach to synthesize noble metal one-dimensional (1D) nanostructures, showing excellent catalytic performance in H_2 fuel cells. He also developed atomic layer deposition (ALD) technique to fabricate highly efficient Pt single-atom/graphene hybrid catalysts for methanol fuel cell applications. The single-atom electrocatalysts and photocatalysts developed by his group exhibit excellent catalytic activity for water splitting hydrogen generation and CO2 reduction. Sun developed various high-performance and inexpensive non-noble-metal catalysts (e.g., Fe/N/C, biomass-derived materials), targeting to replace the rare and expensive Pt-based catalyst for practical fuel cells. Most recently, Sun developed novel bi-functional catalysts and flexible electrodes for rechargeable metal-air batteries.

11 THE ROBERT B. ANDERSON AWARD

Jacques Monnier and Kevin Smith

The directors of the CCF recognized the necessary interaction of the Canadian catalysis community with the other members of the international community. To help foster such interactions the CCF has established and sponsors a biennial tour in which an internationally prominent catalysis worker lectures at several sites across Canada. This tour was originally named the Cross-Canada Lecture Tour but renamed the Robert B. Anderson Award in 2016.

The tour is sponsored by the Canadian Catalysis Foundation. The intent of this award is to choose a speaker to present lectures at 4-6 locations across Canada. The speaker will be someone active in the field of catalysis, who is recognized as a leader in the field, without regard for nationality or location at which the research was carried out. The selection of the speaker is made by a committee appointed by The Catalysis Division. The tour will be held every two years, in alternate years to the Burwell Lectureship.

Table 11.1 Holders of the Cross-Canada Lecture Tour (1993-2012) and the Robert B. Anderson Award (2016-present).

1993 Mark Barteau, University of Delaware (CCLT)
1994 Lanny D. Schmidt, University of Minnesota (CCLT)
1996 Mark Davis, California Institute of Technology (CCLT)
1998 Leo E. Manzer, DuPont de Nemours, Delaware (CCLT)
2000 Robert J. (Bob) Farrauto, Englehard, New Jersey (CCLT)
2002 Harold Kung, Northwestern University (CCLT)
2004 James Dumesic, University of Wisconsin-Madison (CCLT)
2006 Avelino Corma, Polytechnical University of Valencia (CCLT)
2010 Enrique Iglesia, University of California at Berkeley and Lawrence Berkeley National Laboratory (CCLT)
2012 Ganapati D. Yadav, Institute of Chemical Technology, Mumbai, India (CCLT)
2016 Johannes Lercher, Technical University of Munich and Pacific Northwest National Laboratory (RBAA)
2018 Bert Weckhuysen, University of Utrecht, The Netherlands (RBAA)
2020 Jingguang Chen, Columbia University and Brookhaven National Laboratory (RBAA)

The inaugural award (1993) was made to Professor **Mark Barteau**, Professor of Chemistry and Chemical Engineering and Director of the Center for Catalytic Science and technology, University of Delaware. Professor Barteau spoke in Québec City, Montréal, Ottawa, Toronto, Calgary, and Vancouver. A one-day symposium was held on the occasion of his visit to Ottawa. Professor Barteau gave an enlightening account of his work on the characters and applications of surface science, and their relationship to investigations of surfaces and species thereon for catalysts and catalyst deactivation phenomena.

The second award (1994) was made to Professor **Lanny D. Schmidt**, of the Department of Chemical Engineering and Materials Science, University of Minnesota. Professor Schmidt spoke

on “Partial Oxidation of Alkanes on Pt and Rh at Millisecond Contact Times”. Lectures were presented in Ottawa, Québec City, Calgary, Edmonton, and Vancouver. In the lecture Professor Schmidt described his innovative work on the conversion of methane and ethane to synthesis gas by partial oxidation using metal catalysts. The lectures discussed kinetics, the role of surfaces, and several practical aspects of performing such experiments in the laboratory. The design of practical reactors, and potential impacts on applications to existing industrial processes, were emphasized.

Mark Davis, Warren and Katherine Schlinger Professor of Chemical Engineering at the California Institute of Technology held the 1996 award. His talk on “Zeolite Catalysis: Past Present, Future” covered a range of applications: He showed that zeolites have found widespread use as catalysts and their applications to environmentally friendly, selective conversions continue to burgeon. Active sites in zeolites can be due to framework constituents or from occluded matter. A transition is occurring, from traditional zeolite catalysts involving framework acid sites and occluded metal particles to framework redox centers and occluded metal oxide clusters. The implications from these changes were discussed. Future directions for both catalytic applications and materials compositions were enumerated.

The 1998 award was made to **Leo E. Manzer**, DuPont de Nemours. The title of Dr. Manzer’s address was “Environmental Catalysis: Challenging New Opportunities.” In the abstract he expressed his concern over the environment, which is becoming a major issue for all responsible citizens. Dr Manzer stressed that cleaning up past problems and developing green processes for the future present exciting new opportunities for catalytic science and technology. This talk gave some specific examples from DuPont to show how catalysis can address many environmental problems. The examples included: (1) development of a new catalyst for phosgene production that essentially eliminates byproducts by increasing the yield to 99.99%; (2) a novel inductively-heated reactor for destruction of waste from a paraxylene oxidation plant; (3) a new electrochemical process for production of anhydrous HCl; and (4) process improvements for selective catalytic oxidations.

In 2000, the award was made to Dr. **Robert J. (Bob) Farrauto**, Englehard, New Jersey. Dr. Farrauto is a Research Fellow at the Corporate Research Laboratories of Engelhard in Iselin, New Jersey, USA. He presented his lectures in Edmonton, Vancouver, Calgary, Waterloo, Toronto, Quebec City, and Ottawa. He has worked extensively in the development of catalysts for the environmental, chemical and petroleum industries. His major responsibilities have included the development of advanced automobile emission control catalysts for passenger cars. He was technical leader of the Engelhard team that developed diesel oxidation catalysts now commercialized in the U.S. and Europe for trucks and passenger cars. Currently he is engaged in developing new technologies for bonding homogeneous catalysts to support the production of bulk and pharmaceutical chemicals. He is also managing a research team investigating hydrogen production for fuel cells to be used for stationary and vehicular applications. Dr. Farrauto has co-authored a book entitled "Catalytic Air Pollution Control: Commercial Technology" published in 1995 by Van Nostrand Reinhold, NY and is the co-author of a second book entitled "Fundamentals of Industrial Catalytic Processes" published by Chapman and Hall, London, 1997. In 1995 he received an outstanding teaching award from the New Jersey Institute of Technology where he is an Adjunct Professor of Chemical Engineering and teaches graduate courses in industrial catalysis.

Professor **Harold Kung** was the recipient of the 2002 Cross-Canada Lecture Award. He is a professor at the Department of Chemical Engineering, Northwestern University and also an Editor of Applied Catalysis A. He is a world recognized expert in the area of selective oxidation

of light alkanes and NOx reduction in an oxidizing atmosphere, and has contributed significantly in the area of supported Au catalysis and hydrocarbon cracking over acidic zeolites. In each of these areas, he has advanced the fundamental understanding of the nature of the active sites and the reaction mechanisms which provide very valuable information for designing better catalysts and processes. His work also has been recognized by his peers with the 1991 Paul H. Emmett Award, the 1999 Robert L. Burwell Jr. Lecturership of the North American Catalysis Society, and the 1999 Herman Pines award of the Chicago Catalysis Club. He gave lectures in Ottawa, Toronto, Waterloo, and other Canadian universities.

Professor **James Dumesic** was the winner of the 2004 Cross-Canada Lecture Award. Dr. Dumesic is the Steenbock Professor of Chemical Engineering at the University of Wisconsin in Madison. He is well known for his leading-edge work in kinetic modeling of heterogeneous catalyzed reactions and is considered one of the worldwide leaders in this field. Dumesic is the author of more than 270 publications in the field of catalysis. He is the recipient of the Colburn Award - AIChE, the Emmett Award - North American Catalysis Society, and the Wilhelm Award - AIChE. He received the Parravano Award from the Michigan Catalysis Society, the Byron Bird Award for Excellence in Research at the University of Wisconsin, the Herman Pines Award from the Chicago Catalysis Club, and he was recognized in the Scientific American Top 50 Technology Leaders of 2003. He was elected to the National Academy of Engineering in 1998. Dr. Dumesic received a B.S. in Chemical Engineering from the University of Wisconsin and a Ph.D. from Stanford University.

Dr. Dumesic and his group have illustrated how microkinetic analysis can be applied to a test problem with excellent predictive results. His textbook on microkinetics has become a classic and is widely considered the definitive reference on microkinetic modeling. Dumesic has led the whole field of catalysis to many successes. Most notably, he developed microcalorimetry methods which led to new depths of understanding of many catalytic reaction mechanisms, developed a chemical process that uses metal catalysts to generate hydrogen from sugar and other carbohydrates. An inexpensive nickel-tin combination catalyst is used that generates hydrogen at least as well as platinum in their process. Nickel-only catalysts generate polluting methane along with hydrogen, but the addition of tin staves off methane formation. He has shown that polyoxometalate (POM) compounds can be used to oxidize CO in liquid water at room temperature over gold catalysts. The compound not only removes CO from gas streams for fuel cells, but also converts the energy content of CO into a liquid that subsequently can be used to power a fuel cell. This process can be used for producing electrical energy from renewable biomass-derived oxygenated hydrocarbons, because these fuels generate H_2 and CO in nearly equal amounts during catalytic decomposition.

Dr. Dumesic visited the University of Toronto, CANMET Energy Technology Centre - Ottawa, Queen's University and the University of Calgary in March and April of 2005.

Professor **Avelino Corma** was the winner of the 2006 Cross-Canada Lecture Award Award. Dr. Avelino Corma is director of the Instituto de Tecnologia Quimica, Universidad Politécnica de Valencia. He obtained his BSc degree in Chemistry at the University of Valencia (1967-1973) and received his Ph. D. "with honours" in the Chemical Engineering Department at the University Complutense of Madrid in 1976. After two years of postdoctoral work in the Chemical Engineering Department at Queen's University in Canada with Professor B.W. Wojciechowski, he returned to Spain and obtained a position as an associated researcher at the Instituto de Catalysis in Madrid (1979). In 1987 he was nominated to be a full Professor and started, from zero, to build the Instituto de Tecnología Química at the Polytechnical University

of Valencia (1989) where he is also the scientific director. His expertise ranges from catalyst preparation, characterization to reactivity studies. His research work involves both fundamental studies and applied research, especially related to acid-base catalysis, catalytic cracking, redox catalysis and novel catalytic materials. He has made significant contributions to the fundamental aspects of catalysis (reaction mechanisms, rationalization of catalyst behaviour, new concepts for synthesis of catalysts) as well as to the design of new catalysts and catalytic systems that are now used in commercial processes. Professor Corma gave lectures at the Universities of Calgary, Saskatoon and Waterloo in the Fall of 2009.

Professor **Enrique Iglesia** has been awarded the 2010 Cross-Canada Lecture Award. Dr. Iglesia is the Theodore Vermeulen Chair in Chemical Engineering at the University of California at Berkeley and the Faculty Senior Scientist in the Lawrence Berkeley National Laboratory of the U.S. Department of Energy. He received a B.S. Degree summa cum laude from Princeton University and a PhD degree from Stanford University. Professor Iglesia's has made a significant impact in catalysis. His research addresses the design, synthesis, and structural and mechanistic characterization of inorganic solids useful as catalysts for chemical reactions important in energy use, petrochemical synthesis, and environmental protection. Professor Iglesia has 254 publications and 40 U.S. patents. Professor Iglesia was the Editor-in-Chief of the Journal of Catalysis from 1997 to 2010. He currently serves as President of the North American Catalysis Society. He is the founding and current Director of the Berkeley Catalysis Center. Professor has won numerous prestigious awards including the 2005 George A. Olah Award in Hydrocarbon Chemistry, the 2004 Award for Excellence in Natural Gas Conversion, the 1997 Paul H. Emmett Award in Fundamental Catalysis and the 2006 Robert Burwell Lectureship. He was elected to the National Academy of Engineering in 2008. In 2007, he received a Humboldt Senior Scientist Award, and a Doctor Honoris Causa from the Universidad Politecnica de Valencia. In 2009, he was named the inaugural recipient of the Tanabe Prize in Acid-Base Catalysis. Professor Iglesia delivered presentations at University of Toronto, University of Ottawa, University of Waterloo, University of Saskatchewan, University of Calgary, and University of British Columbia on his Cross-Canada Lecture Tour, June 13-22, 2011.

Professor **Ganapati D. Yadav** was awarded the 2012 Cross-Canada Lecture Tour. Professor Yadav is the Vice Chancellor and R.T. Mody Distinguished Professor of the Institute of Chemical Technology, Mumbai, India. Professor Yadav is well known for his seminal and extensive contributions to Green Chemistry and Technology, Catalytic Science and Engineering, Nanomaterials, Nanocatalysis and Biocatalysis and for providing innovative professional leadership and yeomen services to the profession of Chemical Engineering, and Chemical and Allied Industries in India. He has provided breakthroughs in design, synthesis and industrial applications of novel catalytic materials. He has devised elegant selectivity engineering principles in multiphase reactions using inert nano particles, new solid superacid catalysts, multiple liquid phases such as tri-liquid phase transfer catalysis. Prof. Yadav has 248 publications and 53 patents. He authored/co-authored 3 books. Prof. Yadav toured Universities of British Columbia, Alberta and Saskatchewan from May 12-18, 2013 as part of his CCLT. His seminar was on "Science & Engineering of Pores, Particles and Interfaces: Forays into Development of Clean and Green Processes". His tour attracted from 30 to 40 students and 3-6 faculty members in each location. Professor Yadav had a very successful tour in Eastern Canada from July 8-12, 2013, delivering his Award lecture at the University of Toronto, University of Waterloo, York University and Laval University.

Professor **Johannes Lercher** was awarded the inaugural Robert B. Anderson Award in 2016. Professor Lercher studied Chemistry at the Technical University of Vienna, Austria, receiving his PhD in 1981 at the same institution. After a visiting lectureship at Yale University, he joined TU Wien as Lecturer, later Associate Professor. In 1993, he was appointed Professor in the Department of Chemical Technology at the University of Twente, the Netherlands, and in 1998, in the Department of Chemistry of TU München, Germany. Since 2011, he has also served as the Director of the Institute for Integrated Catalysis at the Pacific Northwest National Laboratory (PNNL), USA. He is external member of the Austrian Academy of Sciences as well as Member of the Academia Europaea and the European Academy of Sciences and Honorary Professor at several institutions in China. He is the author of over 500 papers and 19 patents; he is currently President of the European Federation of Catalysis Societies and Editor-in-Chief of the Journal of Catalysis. Recent awards include the Kozo Tanabe Award for Acid-Base Catalysis, the Burwell Lectureship of the North American Catalysis Society and the Francois Gault Lectureship of the Federation of European Catalysis Societies. His interests are related to catalysis in zeolites as well as on nanostructured oxides and sulfides, focusing on bifunctional and concerted catalysis, as well as understanding the influence of the steric and chemical environment on the properties of active centers in a catalytic site. Lercher's group has pioneered the use of in situ molecular spectroscopy for characterizing surface reactions, using this information to develop novel complex catalysts with successful examples being e.g., xylene isomerization and methylamine synthesis. As part of the newly structured Robert B. Anderson Award, Professor Lercher delivered two award lectures at the 24th Canadian Symposium on Catalysis:

Plenary Lecture: Acid-base catalysis in constraints – A general principle to enhance catalytic rates?

Plenary Lecture: Understanding and controlling bifunctional catalysis in zeolites

Professor **Bert Weckhuysen** was presented with the Robert B. Anderson Award in 2018. Professor Weckhuysen received both his Masters and PhD degrees from Leuven University (Belgium) in 1991 and 1995, respectively. He was appointed Full Professor of Inorganic Chemistry and Catalysis at Utrecht University (The Netherlands) in 2000 and is currently a Distinguished Professor at the same institution. He has authored more than 460 publications in peer-reviewed scientific journals, which have gathered more than 19,400 citations. Professor Weckhuysen has pioneered the development and use of in-situ and operando spectroscopic methods (including synchrotron methods) for heterogeneous catalysts in order to develop relevant structure-activity relationships for catalytic processes, catalytic conversion of biomass to fuels and bulk chemicals, synthesis and characterization of ordered (micro-) porous materials with catalytic potential, and the molecular design of transition metal ion complexes in inorganic hosts for catalyst applications. Professor Weckhuysen received the award at the 25th Canadian Symposium on Catalysis and presented two award lectures:

Plenary Lecture: Hunting for the Hidden Chemistry in Catalysts – Towards a Molecular Movie

Plenary Lecture: Catalysts Live and Up Close: The Clean Energy Transition

Professor **Jingguang Chen** was the recipient of the 2020 Robert B. Anderson Award. Professor Chen is the Thayer Lindsley Professor of chemical engineering at Columbia University, and holds a joint appointment as Senior Chemist at Brookhaven National Laboratory.

He received a B.Sc. from Nanjing University and a Ph.D. from the University of Pittsburgh in 1988, before completing an Alexander von Humboldt Postdoctoral Fellowship at the Forschungszentrum-Julich, Germany. Professor Chen started his career as a staff scientist at Exxon Corporate Research Laboratories. In 1998 he moved to the University of Delaware and rose to the rank of the Claire LeClaire Professor of chemical engineering and the Director of the Center for Catalytic Science and Technology. He moved to Columbia University in 2012. He is currently the President of the North American Catalysis Society and an Associate Editor of ACS Catalysis. He has received many catalysis awards, including the 2015 George Olah award from the American Chemical Society and the 2017 Robert Burwell Lectureship from the North American Catalysis Society. He has authored over 380 journal publications more than 20 United States patents. Professor Chen has made pioneering contributions to the understanding and use of novel catalytic materials for catalysis and electrocatalysis such as bimetallic and metal carbide catalysts. His research has inspired fundamental studies in catalytic and fuel cell processes, including the exploration of ways to reduce the use of platinum in the catalytic process used to produce hydrogen. Professor Chen was scheduled to be presented with the award at the 26th Canadian Symposium on Catalysis.

12 CANADIAN CENTRES

Contributors listed below

A. Canadian Light Source, *Gianluigi Botton, Ning Chen, Yongfeng Hu, Robert Scott, Mohsen Shakouri, Jafar Soltan, Hui Wang*

The Canadian Light Source (CLS), Canada's only synchrotron facility, is located on campus at the University of Saskatchewan in Saskatoon and first became available to users in May of 2005. The CLS is a third-generation synchrotron facility with a 2.9 GeV and 171 m circumference storage ring. Since 2005, the CLS has become a critical infrastructure for the catalysis community, in offering tools for the characterization of catalysts, including *in situ* methods that allow to understand catalytic speciation under realistic operating conditions. As of January 2020, the CLS has 22 operating beamlines that have led to over 500 publications involving catalysis research. The Canadian Light Source also has a strong Industrial Sciences group that works with industrial partners to solve industry-specific problems. Active beamlines range in energy from the Far-IR to the hard X-rays. Below is an overview of the main beamlines that have been used by catalysis researchers at the CLS and the capabilities of the beamlines:

Hard X-ray Microanalysis Beamline (HXMA): Energy Range 5-40 keV

HXMA was one of the first beamlines that opened to users in 2005, and was initially a multipurpose high energy beamline that had X-ray absorption spectroscopy, X-ray scattering, high-pressure X-ray diffraction, and X-ray absorption spectroscopy mapping end-stations. X-ray absorption spectroscopy work involves both the use of X-ray absorption near edge structure (XANES) and extended X-ray absorption fine structure (EXAFS) measurement of many elements of catalytic interest. *In situ* cells and solution/gas handling equipment have also been developed for use on the HXMA beamline that allow to probe catalysts under different conditions, including high temperatures and under gas flows.

Soft X-ray Microcharacterization Beamline (SXRMB): Energy Range 1.7-10 keV

SXRMB became available to users in 2009 and has become a valuable line for tender-energy X-ray absorption spectroscopy. The energy range encompasses many elements of catalytic interest including the K edges of 3d transition metals and the L edges of 4d transition metals. In addition, several *in situ* cells have been developed on this beamline for probing catalysts in solution and gas-phase environments. This includes capabilities to follow electrode speciation during *in situ* electrocatalysis experiments. Other capabilities of the SXRMB include high energy X-ray photoelectron spectroscopy to extract information from buried interfaces and elementary mapping using XAS.

Soft X-ray Spectromicroscopy Beamline (SM): Energy Range 130-2700 eV

The SM beamline has been operational since the early days of the CLS and allows spectromicroscopy experiments such as X-ray photoemission electron microscopy (X-PEEM) and Scanning Transmission X-ray Microscopy (STXM). These techniques allow chemical mapping of materials of catalytic interest with a *ca.* 30 nm resolution. STXM can be used to map different chemical species of the same element; for example, nitrogen in doped carbon nanotubes can be distinguished from nitrogen gas that is trapped within the nanotubes. Other

examples of uses include imaging of alumina speciation in zeolite catalysts, and the imaging of water channels in fuel cells.

High Resolution Spherical Grating Monochromator (SGM) Beamline: Energy Range 250-2000 eV

SGM is a low-energy beamline that has both X-ray absorption spectroscopy and X-ray photoelectron spectroscopy endstations. SGM encompasses the energy range that covers both carbon and oxygen K-edges, as well as the L-edges of 3d transition metals. While typically operating under ultrahigh vacuum, ambient pressure XAS measurements are also possible with in-situ reactors and liquid cells that operate inside the chamber have been developed.

Canadian Macromolecular Crystallography Facility (CMCF): Two beamlines, Energy Range 6-18 keV

CMCF has been in operation since January 2006, and houses two beamlines specializing on X-ray diffractions. These beamlines have been workhorse instruments that have led to the structural determination of hundreds of biological structures, producing the highest impact work of CLS. In addition, one of the beamlines is used for high-resolution powder diffraction.

Brockhouse Diffraction Sector: Three beamlines that encompass energy range from 5-94 keV.

The Brockhouse sector began its scientific commissioning access in 2019 and some of the capabilities are open to general CLS users. The beamlines offers a wide range of characterization techniques that will have utility for catalysis researchers including high resolution powder X-ray diffraction, including grazing angle experiments, and total scattering techniques such as pair distribution function (PDF) analyses. Capabilities will include cells for *in situ* diffraction and scattering experiments.

Biomedical Imaging and Therapy: This facility is comprised of two separate beamlines dedicated to fast imaging of samples with the aim of 3D reconstruction and fast imaging over large areas. This beamline has been used over the years for a broad range of applications, from small animals and plants 3D imaging to dynamic studies of fuel cells and batteries in operation. With high-flux and the highly penetrating power of hard X-rays (up to 140keV) one of the beamlines has the potential for dynamic imaging of the operation of fuel cells stacks to visualize the formation of water.

CLS@APS: The CLS@APS represents a partnership between the CLS and the Advanced Photon Source (APS) at Argonne National Laboratory. This arrangement gives Canadian researchers preferential access to techniques and beamlines at APS, some of which they helped develop (particularly sector 20 beamlines at the APS).

Many of the most highly-cited papers over the first 15 years of operation of the CLS have involved advances in catalysis research. These include many publications in high impact journals such as Nature, Science, Angewandte Chemie, Journal of the American Chemical Society, and Catalysis Today. Examples of prominent studies include the characterization of nickel and nickel/iron hydroxide electrocatalysts for oxygen evolution reactions from water, initial examples of single-atom catalysts developed by atomic layer deposition, carbon dioxide reduction catalysts, mapping of alumina speciation in used zeolites, and the analysis of biochars developed from waste biomass. The CLS is also supporting the development of catalysis research capabilities enabling the CLS to host a “catalysis hub” designed to help Canadian researchers working in this field to carry out a broad range of experiments, including *in situ* and *operando* testing, necessary to understand the catalysts in operation.

B. The Centre for Catalysis Research and Innovation (CCRI) at the University of Ottawa, *Tom Baker*

The Center for Catalysis Research and Innovation (CCRI) was created in 2000, to bring together outstanding established and emerging researchers from the departments of Chemistry, Biochemistry and Chemical Engineering, and the Loeb Institute for Medical Research. Professor J. C. (Tito) Scaiano, a world leader in photochemistry and photocatalysis, was appointed Interim Director, with broad responsibility for structuring the Center and for identifying outstanding candidates for the position of permanent Director. With an initial CFI/MEDI grant led by Sandro Gambarotta that provided key infrastructure, research within the CCRI encompassed the fields of *Catalysis, Biocatalysis* and *Materials Science*, three powerful cores covering all major aspects of catalysis. Key focus areas included organic, inorganic and materials synthesis and characterization, process development, polymer chemistry, and biomedical research. Cohesiveness was promoted by policies directed at supporting intercollaborative research, and the active pursuit of funding for interdisciplinary research.

In 2001 Prof. Abdel Sayari moved to uOttawa from Laval University to become the first official CCRI Director. In 2004 a second CFI/MEDI grant enabled the dedication of two floors of the new Biosciences teaching building as the CCRI's new home. Accompanying infrastructure included an X-ray photoelectron spectrometer, electron imaging tools (TEM, SEM, sample prep), surface characterization instruments, a four-reactor heterogeneous catalysis set-up with on-line analysis, a 400 MHz NMR spectrometer with sample changer, and Symyx robotic high-throughput instrumentation with accompanying GC, SCFC and HPLC analytical tools. An ORF grant co-sponsored by six different industry partners allowed for the purchase of additional infrastructure, sparking a host of new collaborations. By the end of Prof. Sayari's term, there were 17 professors and their co-workers from the faculties of Science, Engineering, and Medicine using the infrastructure and building joint projects.

In 2008 R. Tom Baker moved from Los Alamos National Lab in New Mexico, USA to become the second CCRI Director. With a focus on catalyzed biomass conversion serving the new bio-based economy, Prof. Baker's term saw an expansion of the participants to 35, including 10 from engineering and 4 from Medicine. A 2012 CFI/MEDI grant updated the CCRI equipment including a solids-handling high throughput platform, EPR and 600 Mz NMR spectrometers with a cryo-probe, six 25 mL pressure reactors with sampling capabilities, a new MALDI-TOF interfaced to a glovebox, and a suite of biocatalysis-related infrastructure including orbitrap mass spectrometer, flow cytometer, and high-throughput imaging and enzyme crystallization tools. This equipment served well the CCRI faculty participants and their collaborations such as Canada's Lignoworks strategic network, the FUNCAT collaboration with CNRS and Université de Lyon, and U de Montréal's Flow Chemistry CREATE program.

In 2014 Prof. Deryn Fogg chaired the International Symposium on Homogenous Catalysis in Ottawa that served as a showcase for the CCRI, featuring several tours of the facilities. In 2016 Prof. Michael Organ moved from York University to become the third CCRI Director. With a shift in focus to medicinal chemistry, a number of new Medicine faculty participants became involved with an innovative 'postdoc-for hire' program initiated to build the interface with Chemistry in the faculty of Science. Prof. Organ also started a 'catalyst collection' to which both internal and external researchers can send their catalysts to have them tested by industry partners. As CCRI approaches its 20th anniversary, it continues to flourish, providing Canadian catalysis researchers with unique high-throughput and flow chemistry facilities and collaborators.

C. FRQNT Strategic Cluster-Centre en chimie verte et catalyse (CCVC)/Centre for Green Chemistry and Catalysis (CGCC), *Chao-Jun Li and André Charette*

Innovation is at the heart of sustainable chemical production whether it relates to the energy, telecommunications, healthcare, agriculture, or manufacturing sectors. In order to remain among the leading actors in the field and to be globally competitive, the Canadian chemical research must join efforts in developing sustainable and environmentally benign processes that are both safe for production and economically viable.

The FRQNT strategic cluster Centre en chimie verte et catalyse (CCVC) which was first funded in April 2009 now brings together 59 members, 24 international collaborators and 17 professionals and is currently co- directed by Prof. André B. Charette (Université de Montréal) and Prof. Chao Jun Li (McGill University). This unique research cluster addresses many of the major issues in the development of sustainable methodologies applied to the various Canadian sectors and has at heart the training of the leaders of tomorrow. CCVC team is not only composed of renown experts with an outstanding record in both research excellence and training of HQP but also emerging leaders in the various axes of green chemistry (12 prestigious chairs, >700 publications, 18 declared inventions, patents, and licenses, 8 start- up companies). The center builds on first-class research infrastructure and collaborations between 7 academic institutions in Québec: Université de Montreal, McGill University, Université Laval, Université Sherbrooke, Concordia University, École Polytechnique, and UQAM. Currently, the team members supervise over 500 undergraduate, graduate students and PDFs contributing to the excellence of Canadian research in the axes of development of green solvents (axe 1), invention and harnessing of new homogenous catalytic reactions (axe 2), development of readily recyclable heterogeneous catalytic reactions (axe 3), biocatalysis (axe 4), green molecular synthesis (axe 5), catalytic transformation of biomass and the evaluation (axe 6), commercialization, and development of policies for the implementation of Green Chemistry in industry (axe 7).

The success of CCVC resides in bringing together state of the art research infrastructure in Québec (CFI, NSERC, and FRQNT funded) with open access to researchers (academic, industrial, governmental) to collaborate with professionals for hands on training and knowledge transfer. This optimized use and sharing of infrastructure, in turn, greatly enhances the quality of the training of students and contributes to the development of a collegial, multidisciplinary and an open-minded generation seeking new heights in the areas of novel drug candidate discovery, production of polymers and materials with innovative structural and electrical properties, and the use of renewable feedstocks for a sustainable chemistry. Furthermore, CCVC members actively contribute to public awareness and value a diverse and inclusive work environment.

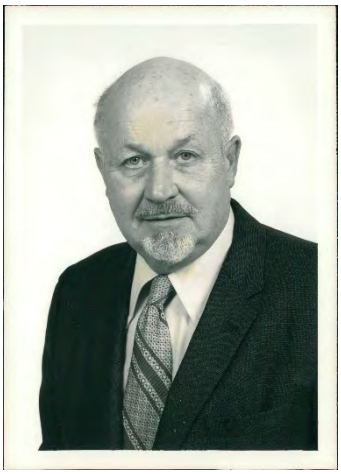
D. Ontario Centre for the Characterisation of Advanced Materials (OCCAM), *Charles Mims*

Advanced characterization equipment, housed in several departments at the University of Toronto, offers surface analysis and electron microscopy. An open facility, OCCAM serves regional, national and international clients on a fee for service basis in a collaborative mode.

13 IN MEMORIAM

Viola Birss, Bob Hayes, Josephine Hill, Jacques Monnier, Graeme Norval, Natalia Semagina, Kevin Smith, and Ying Zheng

The following pages list some of the Division Executive members who have passed away. Every effort was made to collect information but in some cases, the information is incomplete.



Professor Robert B. Anderson

(1915 – 1987)

BSc Augustana College of Illinois
PhD Iowa State University
PDF Johns Hopkins University (with P.H. Emmett)
1965 – 1981 McMaster University
1981-1987 Emeritus Professor, McMaster University

Photo: Courtesy of Susan Anderson Shawki

Professor Robert B. Anderson came to Canada from the United States and joined the Department of Chemical Engineering at McMaster University in 1965. Prior to this, Professor Anderson had completed doctoral studies at Iowa State University in physical chemistry followed by two years of postdoctoral work with P.H. Emmett at Johns Hopkins University. He had a distinguished career in Fischer-Tropsch synthesis (FTS) research at the United States Bureau of Mines, which he joined in 1944. In 1950 he published a seminal work with Friedel on FTS kinetics that predicted the isomer and carbon number distribution of the FTS products. In recognition of the very significant contributions Professor Anderson made in this area, he was awarded the Ipatieff Prize of the American Chemical Society in 1953 and its Pittsburgh Award in 1960. At McMaster University, Professor Anderson established one of the strongest catalysis research laboratories in Canada. Under his guidance, his students and postdoctoral fellows were able to make significant contributions in many areas including hydrocarbon hydrogenolysis, preparation and characterization of catalysts, Fischer-Tropsch synthesis and alcohol synthesis. He published more than 200 scientific papers, and authored and edited several books and monographs. He retired from McMaster University in 1981, but as Professor Emeritus continued an active research program at the university. In recognition of these contributions, Professor Anderson received The Catalysis Award of The Chemical Institute of Canada in 1979, Fellowship of The Chemical Institute of Canada, and Fellowship of the Royal Society of Canada in 1983. He was in the midst of organizing the 9th International Congress on Catalysis held in Calgary, Alberta in 1988, when he died suddenly on October 24, 1987.

Professor Anderson was a caring individual with good humour who was more than mentor and supervisor to most of his students. His friendly demeanor made it a pleasure to work for him and experience his kindness and hospitality. The latter was often expressed with an invitation to his home for a meal and description of the latest antique clock added to his impressive collection.

A more detailed of his achievements can be found in the article in the section on the Catalysis Award (Chapter 9).



Photo: Courtesy of Bob Hayes

Kenneth Edward Hayes
(1928 – 1989)

1928	*Born in Southampton, England*
1949	*B.Sc. University London*
1952	*Ph.D. University of Oregon*
1952 – 1954	*Postdoctoral Fellow, Princeton University*
1954 – 1958	*National Research Council, Ottawa*
1958 – 1989	*Professor of Chemistry, Dalhousie University*

Kenneth Hayes was part of the small group who were responsible for the development of the Catalysis Division of the CIC during the 1960's. He was active in the original "Canadian Committee on Catalysis" and what is now referred to as the first Canadian Symposium on Catalysis. Ken was a native of the United Kingdom. He obtained his undergraduate degree from the University of London in 1949, and went on to obtain his PhD at the University of Oregon, working with R.B. Dean in the area of surface pressures of insoluble liquid layers in 1952. After postdoctoral work with Sir Hugh Taylor at Princeton University, Dr. Hayes moved to Canada as an Assistant Research Officer at the National Research Council chemistry laboratories in Ottawa. In 1958 he moved to Dalhousie University to join the Chemistry Department as Assistant Professor. He was promoted to Associate Professor in 1963 and Full Professor in 1971. When he came to Dalhousie in 1958, Ken Hayes was solely responsible for all instruction in physical chemistry.

His research area was in the area of heterogeneous catalysis. A large part of his research effort was related to surface hydrogenation and decomposition reactions over supported metal catalysts. In his later years, he focused on the study of reaction mechanisms as revealed my multiple reflectance infrared spectroscopy.

Professor K.E. Hayes, FCIC, died at home on December 23, 1989 at the age of 61. He had retired from his position as Professor of Chemistry in 1988, but continued his research on heterogeneous catalysis by multiple reflectance IR spectroscopy until shortly before his death. He is survived by his two children, Elizabeth and Robert.

Ratimir J. (Bob) Cvetanovic
(1913 – 2002)

1913	*Born in Belgrade, Yugoslavia*
1936	*B. Sc. University of Edinburgh, Scotland*
1942	*B.A.Sc. University of Belgrade, Yugoslavia*
1950	*M.A. Chemistry, University of Toronto*
1951	*Ph.D. University of Toronto*
1951 – 1952	*Postdoctoral Fellow, NRC*
1952 - 1978	*Senior Research Officer, NRC*
1978 – 1980	*Visiting Professor, University of California, Irvine*
1980 – 1988	*Senior Scientist, National Bureau of Standards*

Along with his colleague at NRC, Bob was instrumental in the development of catalysis in Canada during the 1950's and 1960's. As seen above, Bob had degrees from several nations, before settling in Canada. As the head of the kinetics, photochemistry and catalysis section of the NRC's division of chemistry for several years he oversaw the early development of catalysis in Canada.

Dr. Cvetanovic was an early leader in catalysis and molecular processes, studying the reactions of molecules, radicals, and ions. Significant contributions were made in photochemistry, kinetics and catalysis. Dr. Cvetanovic's interests cover all phases of matter. In collaboration with Yoshimitsu Amenomiya, the temperature programmed desorption (TPD) technique was developed. In this technique molecules are adsorbed from the gas phase onto a solid surface, the temperature of the solid is then steadily increased and the amount and nature of the molecules desorbed are measured. In this manner quantitative insights are gained into the nature of the surface. For this work Drs. Amenomiya and Cvetanovic became the first recipients of The Catalysis Award (1977).

Dr. Cvetanovic was an active member of the Canadian Committee on Catalysis. This informal body provided a focus for the Canadian catalysis community, and was instrumental in the creation of the Catalysis Division of CIC. Dr. Cvetanovic was also one of the organizers of the first of the continuing series Canadian Symposia on Catalysis.

Bob retired from NRC in 1978, after which he accepted a position as Visiting Professor at the University of California, Irvine. From 1980 to 1989, he worked in Washington, DC as senior research scientist for the office of environmental measures in the National Bureau of Standards.

A more detailed of his achievements can be found in the article in the section on the Catalysis Award (Chapter 9), the first of which was jointly awarded to him and Yoshi Amenomiya.

Brian E. Conway
(1927 – 2005)

1927	*Born in Farnborough, England*
1949	*Ph.D. Imperial College, University of London*
1949 – 1954	*Chester Beatty Cancer Research Institute, London*
1954 - 1956	*Assistant Professor, University of Pennsylvania*
1956 – 1962	*Associate Professor, University of Ottawa*
1962 – 2005	*Professor, University of Ottawa*

Brian Conway had a highly illustrious career, having been a pioneer in the area of physical electrochemistry in Canada and also a recognized international leader in this field. His work is recognized for its exemplary depth and insights that have stood the test of time and now underpin many of the modern applications of electrochemistry, especially in electrochemical energy storage and conversion.

Brian began his career at Imperial College in 1946, working mainly on the kinetics and mechanism of hydrogen evolution at different metals. He then took on a PDF position at the University of Pennsylvania, investigating proton transfer in solution and the mechanism of metal deposition processes. Brian was then invited to visit Ottawa by Keith Laidler, shortly thereafter taking on a position at the University of Ottawa in 1956. He remained there for nearly 50 years, carrying out pioneering fundamental and industry-sponsored research, covering an enormous breadth of topics, from organic electrocatalysis, battery and fuel cell materials and processes, pseudo-capacitance and supercapacitors, ion hydration/electrostrictions, oscillatory kinetics, compressibility of salts, solvent isotope effects, the effect of high temperatures and pressures on electrochemical reactions, surface film formation, development of a theory to explain the anomalous temperature dependence of the symmetry factor in electrode kinetics, and the recognition of entropy effects in electrode reactions.

Brian received scores of awards and honors during his long distinguished scientific career, including the Noranda Lecture Award from the CIC in 1964, and many international awards. He was active in many professional societies, was the author of close to 500 papers, and served as the editor of a very successful series, Modern Aspects of Electrochemistry.

On the personal side, Brian was a true connoisseur of food and wine. He also greatly appreciated nature, history, music and art, and was an outstanding self-taught glass-blower, making many of the glass parts used by his group members throughout the years.

Henry W. (Harry) Habgood
(1922 – 2008)

1922	*Born in Calgary, Alberta, Canada*
	B. Sc. Queen's University, Canada
	M.Sc. Queen's University, Canada
	Naugatuck Chemicals, Elmira, Canada
	D. Phil. University of Michigan, USA
	Postdoctoral Fellow, National Research Council
	Instructor, Queen's University, Canada
1954 – 1984	*Alberta Research Council*

A dedicated practitioner, eminent Canadian scientist, and long time supporter of the Canadian Buddhist monastery, Gampo Abbey, Dr . Harry Habgood died quietly Sunday September 7th, 2008 surrounded by family and friends at his home of many years, Gampo Cottage on Cape Breton Island N.S. In addition to Harry's eminent career in Catalysis and related disciplines, a career characterized by his tremendous foresight and recognition of the importance of materials and processes, Dr. Harry Habgood had a second long time interest and dedicated study in the monastic life around Buddhism. Many of us were aware of Harry's regular "disappearance" for weeks on end without knowing precisely what he was up to.

In fact, Harry spent a lot of time in Tibet studying and learning the very complex techniques of meditation on breath. Sharon Berkenshaw writes: "I would not be a Shambhala Buddhist if it were not because of Ani Migme (Gelongma Migme Chödrön) and her late husband, Harry Habgood. They both founded the Edmonton Dharma Study group in the late 1970's: I was living in Edmonton at the time and my first encounter with buddhism was at their home. That is where we sat every other Sunday (now called nyinthuns) for the whole day. There was mostly just 3 of us; because Ani Migme had started this group I learned quite quickly about shamatha meditation.....".and much more

Harry, along with the great Buddhist nun and teacher, Pema Chödrön helped build the first Western Buddhist Abbey in the Shambhala tradition on the tip of a bluff overlooking pleasant bay in Cape Breton Island around 1983. Residents of Gampo Abbey include monks and nuns who have taken life ordination, monks and nuns who have taken temporary ordination, and laymen and laywomen.

Mark Eckler (November 2016) writes **"..... I see you in the stars Migme, smiling, laughing, and Harry too....."** amongst other lovely words.

I spoke with Ani after Harry's death and she fondly spoke of him and their life together despite their ultimate break-up. She and Harry both guided my personal meditation over time.

Harry and Ani were no longer together when I visited him at Gampo Cottage where at that time he lived with his partner, Gabriele Yakushkin (sp?); Harry was provided the cottage by the Abbey for his use for life. He never took ordination but contributed to life at the Abbey in significant ways. He built an extensive Bonsai garden near the cottage (which is referred to in the document I have included along with this). It was absolutely beautiful and reflected his long time interest in the art.

A more detailed of his achievements can be found in the article in the section on the Catalysis Award (Chapter 9).

John Roger Brooke Boocock
(1936 – 2010)

John Boocock was born and educated in the U.K. He immigrated to Canada, and began work at the DuPont Research Centre in Kingston, Ontario. He worked in many product areas, with a special focus on polyolefin and nylon synthesis, and the modification of the polymerization process to better control the product properties. It was through his work in homogeneous catalysis that he became active with the catalysis community, and was one of the early champions of the Catalysis Division

John passed away on April 15, 2010. He was survived by his wife Freda and their two sons, Johnathon and Peter.

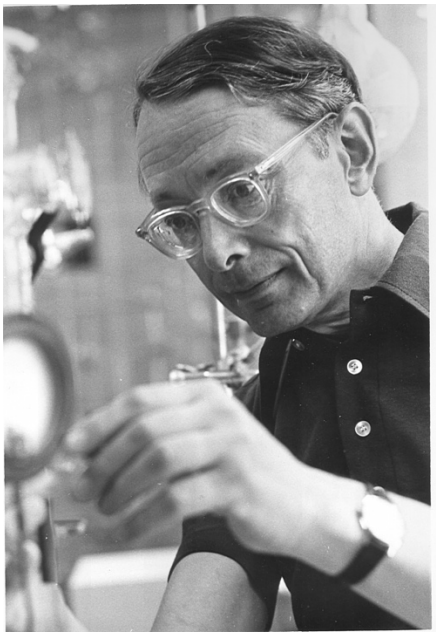


Photo: Courtesy of Chemistry Department, Carleton University

Carl Helmut Amberg
(1923 – 2011)

1923	*Born in Nuremberg, Germany*
1946	*B.A. Queen's University, Canada*
1947	*M.A. Chemistry, Queen's University, Canada*
1947 - 1949	*Lecturer, University of New Brunswick, Canada*
1952	*Ph.D. Chemistry, University of Toronto, Canada*
1952 – 1953	*Lecturer, St. Andrew's Univeristy at Dundee, Scotland*
1953 – 1955	*Instructor, Amherst College, USA*
1955 – 1964	*Research Officer, National Research Council*
1964 – 1970	*Professor, Carleton University, Canada*
1971 – 1972	*Acting Dept Head, Eindhoven Technological University, Netherlands*
1976 - 1980	*Department Chair, Carleton University, Canada*

Carl Helmut Amberg was born on December 16, 1923 in Nurnberg Germany. He attended primary and secondary school mostly in Aachen with one year in Berlin. In 1937 or 1938 Carl and his three older sisters were sent to England when political tensions grew in Germany. Carl attended Winchester College in England. The Nazis invaded Poland on September 1, 1939 and the Netherlands on May 10, 1940. At that time England interned "aliens".

On August 10, 1940 it was announced that a camp for enemy aliens was being established near Fredricton, New Brunswick. Carl arrived at the camp on October 1940 (with a few fellow non-English students from England) and the prisoners.

In May 1942 he was released to his "sponsor", Mrs. Campbell Laidlaw. He attended Glebe Collegiate in Ottawa where he finished his senior matriculation. He attended Queens University in Kingston, for his BA and MA degrees in chemistry. For two summers he worked at Eddy Paper Mills in Ottawa.

In addition to work on hydrodesulphurization, he made contributions on other topics, including, a chapter on Infra-red in a two volume summary on the "Solid - Gas Interface" (1967), and several papers that were substantial contributions on the topic of dimensional changes that occur in solids during the adsorption process.

Outside of science, Carl was an accomplished Cello player and played in a string quartet. When he was a professor of chemistry at Carleton U, he was one of the people pushing Carleton to establish a Music Faculty. When that was done, he was considered as a possible first Dean of Music. After his stroke he lost the use of one hand and could no longer play the cello.

Carl passed away on October 14, 2011. A more detailed of his achievements can be found in the article in the section on the Catalysis Award (Chapter 9).



Photo: Courtesy of Vera Sanger

Alan R. Sanger
(1943 – 2013)

1943	*Born in Southampton, England*
1963	*B. Sc. University of Sussex, UK*
1966	*M.Sc. University of Sussex, UK*
1969	*D. Phil. University of Sussex, UK*
1969 – 1972	*Postdoctoral Fellow, University of Alberta*
1973	*Postdoctoral Fellow, Simon Fraser University*
1973 – 1993	*Senior Research Officer, Alberta Research Council*
1993 – 1998	*Sole Proprietor, Alan R. Sanger Consulting*
1998 – 2013	*President and Director, Alvesan enterprises Inc.*
2001 – 2004	*Patent Writer, BigBangwidth Inc.*
1993 – 2013	*Adjunct Professor, University of Alberta*

Born and raised in Southampton, England, excelled from an early age in his academic endeavors. He entered King Edward VI Grammar School at the age of eleven, which was followed by BSc, MSc and D.Phil. degrees at the University of Sussex where he finally graduated at the age of 26. Upon graduation, Alan moved to Canada, where he held two post-doctoral fellow positions before joining the Alberta Research Council as a Senior Research Officer in 1973. During his 20 years at ARC, Alan specialized in the use of catalysis in a wide range of issues in the petrochemical industry. After 20 years at Alberta Research Council, Alan went on to form his own consulting company, Alvesan enterprises. At the same time he became Adjunct Professor at the U of A with Chemical Engineering where he taught several courses and contributed to fuel cell research. Alan's publication record includes over 190 papers, books and review articles, patents, conference proceedings and abstracts.

During his life, Alan had significant involvement with the catalysis community. He was a board member (1989-98) and Vice-President (1991-97) of the Canadian Catalysis Foundation. He held several executive positions in the Catalysis Division, including Vice-Chair (1986-88), Chair (1988-90) and Past-Chair (1990-92). He was also a board member on the Catalysis Society of North America (1986-88) and held various positions on the Edmonton Section of the CIC. His organizational abilities were always in demand, and he played key roles in the Canadian Symposia on Catalysis in 1977 (Treasurer), 1980 (Chair), 1992 (Chair), 1994 (Finance), 1996 (Program Chair) as well as acting as Treasurer for the 17th Meeting of the North American Catalysis Society (2001). Alan also wrote the first edition of Catalysis in Canada.

Alan passed away on April 26, 2013, three days after his 70th birthday. He is survived by his wife Vera and their two sons, Michael and Matthew.

Yoshimitsu (Yoshi) Amenomiya
(1924 – 2014)

1924	*Born in Tokyo, Japan*
1947	*B. Sc. Tokyo Institute of Technology, Japan*
1959	*Ph.D. Hokkaido University, Japan*
1959 – 1968	*Associate Research Officer, NRC*
1968 - 1987	*Senior Research Officer, NRC*
1987 – 1991	*Visiting Professor, University of Ottawa*

The development of catalysis in Canada is inexorably linked to Yoshi and his colleague at NRC, Bob Cvetanovic. Yoshi followed in his father's footsteps, earning his B.Sc. in chemistry in 1947. Following his Ph.D. in 1959, Yoshi came to Canada to work at the NRC, where he stayed until 1987. The development of the temperature programmed desorption technique, in collaboration with Bob Cvetanovic, is considered to be a major achievement. Considering the technology avaialbel at that time, the achievent is considered all the more remarkable.

Dr. Amenomiya's impact on the direction of national and international catalysis was widely recognized and honoured through numerous awards and representations. Only a few of the most outstanding examples from a much longer list are mentioned here. In 1973, he was elected a Fellow of The Chemical Institute of Canada (FCIC) and between 1978-1979 served as a Chair of the Catalysis Division of CIC. He received **the first** Catalysis Award of CIC (jointly with Cvetanovic) in 1977 and **the first** Canadian Catalysis Lectureship of CIC in 1995. He served as a council member of the International Congress on Catalysis (ICC) and its Canadian representative between 1979-1989. He was elected to the Secretariat of the ICC between 1984-1988 and served as a Program Chair of the 9th International Congress on Catalysis in 1988. He was a Director and Vice-President of the Canadian Catalysis Foundation from 1990.

Yoshi was prominent the group of scientists and engineers who were key to forming the Catalysis Division of the CIC and the bi-annual symposia that we have today. During his career, he was also heavily involved in the promotion of younger scientists, hosting many of them in his laboratory.

More details of his achievements can be found in the article in the section on the Catalysis Award (Chapter 9), the first of which was jointly awarded to him and Bob Cvetanovic



Photo: Courtesy of the Department of Chemical and Materials Engineering, University of Alberta

Ivo Giovanni Dalla Lana
(1926 – 2018)

1926	*Born in Trail, BC*
1948	*B.A.Sc. University of British Columbia*
1948 – 1951	*Cominco Ltd.*
1953	*M.Sc. University of Alberta*
1957	*Ph.D. University of Minnesota*
1958 – 1992	*Professor of Chemical Engineering, University of Alberta (U of A), remained active for a decade afterwards*

Ivo Dalla Lana thoroughly enjoyed a fruitful career of a distinguished catalysis scientist. His main areas of research included infrared spectroscopy studies of surface reactions, sulfur recovery technology, which made him an internationally recognized expert in the field, and ethylene polymerization technologies. His contributions were recognized by the 1994 Catalysis Medal of the Catalysis Division of the Chemical Institute of Canada (CIC).

Dalla Lana supervised 27 graduate students and 25 postdoctoral fellows. His research involved extensive collaborations with industrial and academic partners in Canada and abroad. The work resulted in more than 100 publications and several patents. Due to his renowned expertise in catalysis, he served as a consultant and a reviewer for multiple governmental and private organizations.

Ivo Dalla Lana will be especially remembered for his seminal role in the formation of the Catalysis Division of the CIC in 1971 and his extraordinary activity in professional societies and conference organizing committees. The proceeds of 9th International Congress on Catalysis in 1988 in Calgary, for which Dalla Lana served as a Vice-Chair, were used to establish the Canadian Catalysis Foundation, with the intent to promote and support catalysis in Canada.

Ivo Dalla Lana helped found the U of Ager’s gymnastic group at the U of A. Ivo loved to travel with his family, often by a trailer. His salad-making was legendary, with no leftovers. Ivo and his wife Mary were married for 61 years. He is survived by Mary and their five sons. His children and grandchildren were his greatest pride.

Ivo Dalla Lana left a legacy of an extraordinary citizen and will be remembered by the Canadian catalysis community as one of its pioneers. More details of his achievements can be found in the article in the section on the Catalysis Award (Chapter 9).



Courtesy of Flora T.T. Ng:
Dr. Garry Llewellyn Rempel, C.M., F.R.S.C., F.C.I.C.
University Professor, University of Waterloo

Garry L. Rempel
(1944 – 2018)

1944	*Born in Regina, Saskatchewan, Canada*
1968	*Ph.D., University of British Columbia, Canada*
1968 –1969	*NATO Postdoctoral Fellow, Imperial College, London, UK*
1969 – 2018	*Professor, Department of Chemical Engineering, University of Waterloo, Canada*
1988 – 1996	*Chair, Department of Chemical Engineering,*
1992	*Fellow of The Royal Society of Canada*
2001–2003	*Vice-President, The Royal Society of Canada*
2001–2003	*President, Academy of Science, The Royal society of Canada*
2015	*Member of the Order of Canada*

Garry was born in Regina, Saskatchewan on August 20, 1944. He completed his Ph.D. degree in the area of homogeneous catalysis under the supervision of Professor Brian James in the Chemistry Department of the University of British Columbia at the age of 24. He was a postdoctoral fellow with Sir Geoffrey Wilkinson, FRS, at the Imperial College, London, UK. In 1969, he joined the University of Waterloo, Department of Chemical Engineering as an Assistant Professor and was promoted to Full Professor in 1980. In 2004, he was conferred the prestigious title of University Professor. He held the Bayer Inc./NSERC Industrial Research Chair in Advanced Rubber Technology at the University of Waterloo.

Garry's research is in the area of applied catalysis, polymer science and engineering, and catalytic distillation. He is internationally recognized for his work on chemical modification of polymers, in particular, his work on the selective hydrogenation of nitrile butadiene rubbers to produce high performance elastomers (HNBR) which was commercialized.

He supervised over 50 Ph.D. and 30 M.A.Sc students, numerous postdoctoral fellows, visiting professors and scholars. He has published over 400 referred journal papers, over 35 patents, numerous conference proceedings and book chapters. Garry received numerous awards and recognitions for his academic achievements and contributions to science and engineering. More recently, he was honored with the Queen Elizabeth ll Diamond Jubilee Medal in 2012. In 2015, he was appointed to Member of the Order of Canada.

Garry was the Chair of the Catalysis Division of CIC (2012-2014) and an Executive member of Canadian Catalysis Foundation (2012-2018). Garry served on NSERC Grant Committees, Advisory Boards, Award Selection Committees, Editorial Boards and consulted for industry in Canada, US, China and Thailand.

Garry passed away peacefully on November 2, 2018. He was survived by his wife, Professor Flora T.T. Ng, of 43 years. Garry was a mentor, teacher and friend to many students and colleagues in Canada and around the world. He will be greatly missed.

More details of his achievements can be found in the article in the section on the Catalysis Award (Chapter 9).

14 BIBLIOMETRIC REVIEW OF CATALYSIS IN CANADA

Gregory Patience

Bibliometric analyses adopt statistical tools to identify common tendencies in research literature indexed in Web of Science and Scopus. VOSViewer is an open access program that assembles bibliometric data and plots parameters (authors, keywords, countries, and institutes) against criteria such as number of articles, citations, and co-citations. For example, they generate plots to illustrate: relationships between authors and how many articles they publish; which universities or countries contribute the most number of papers over a specified time period; and, how closely keywords of a subject are related. The number of articles is one metric to gauge how prolific a field is and whether it is growing or shrinking with time. Since 1989, Web of Science has indexed 612 000 articles and reviews that refer to catalyst or catalysis and 50 000 proceedings papers, book chapters and other contributions. The People's Republic of China has been the most prolific with 150 000, followed by the United States (105 000), Japan (51 000), Germany (42 000), and India (39 000). Canadian researchers contributed 16 500 articles, and are ranked 13th. The number of articles published per year in Canada has increased linearly from 200 in 1991 to 1050 in 2019, averaging 32 more articles per year.[1]

The University of Toronto published the most article (1620) followed by UBC (1350), University of Waterloo (1260), University of Alberta (1260), and University of Ottawa (960) in the 30 years since 1989 (Figure 14.1 – the size of the circle is proportional to the number of articles published). They maintain their leadership and have published 783 articles since 2011. Figure 14.1 is a co-authorship type of analysis and the unit of analysis is organization. The map includes organizations that have contributed at least 25 articles (73 of 2982 organizations in the data base). This map was generated with number of documents as a weight factor (links and link strengths are alternative weight factors). The size of the circle correlates with number of articles while the colour and proximity correlate with co-occurrences/collaboration. This analysis grouped Toronto with Queen's, Lakehead and several other universities in Ontario (red cluster). UBC, University of Alberta, and University of Calgary dominate the blue cluster and most of the institutes included in this cluster are in Western Canada – so proximity seems to be a driving force for collaboration. Universities in Quebec mostly belong to the yellow cluster including McGill, Concordia, Laval, University of Montreal, and University of Ottawa (on the Quebec border). The magenta cluster includes Western University, Waterloo, the National Research Council of Canada, and surprisingly Polytechnique Montréal (since it is geographically remote from the others). The green cluster is the most diverse with universities across the country from Newfoundland and Nova Scotia (Memorial and Dalhousie), Ontario (OIT and York), and Saskatchewan. University of Toronto had the most publications with 783 of the 7775 articles Web of Science indexed. UBC had the second highest number (632), followed by University of Alberta (612), University of Waterloo (534), University of Ottawa (428), and McGill University (423).

Of the 250 science categories in the Web of Science, 75 % mention either catalysts or catalysis (Table 14.1). Physical chemistry has the most articles (3735), followed by multi-disciplinary chemistry (2987), and chemical engineering (2419). Many journals are assigned to multiple categories and for this reason the sum of the number of articles in the third column is greater than the total number of articles in the sample. Multidisciplinary chemistry has the most

cites per article at 52, while chemical engineering has the least at 25. The *Journal of Computational Chemistry* published the most cited article in this time frame by te Velde et al. (2001) entitled "Chemistry with ADF" with (6318 cites).[3] The second most cited article, "Co_3O_4 nanocrystals on graphene as a synergistic catalyst for oxygen reduction reaction", appeared in *Nature Materials* (3551 citations since 2011).[4] Rounding up the top 5 cited articles includes: "Arylaryl bond formation by transition-metal-catalyzed direct arylation" in *Chemical Reviews* (2936 citations); "Resolving surface chemical states in XPS analysis of first row transition metals, oxides and hydroxides: Cr, Mn, Fe, Co and Ni" in *Applied Surface Science* (2265 citations); and, "Iron-Based Catalysts with Improved Oxygen Reduction Activity in Polymer Electrolyte Fuel Cells" in *Science* (2028 citations).[5–7]

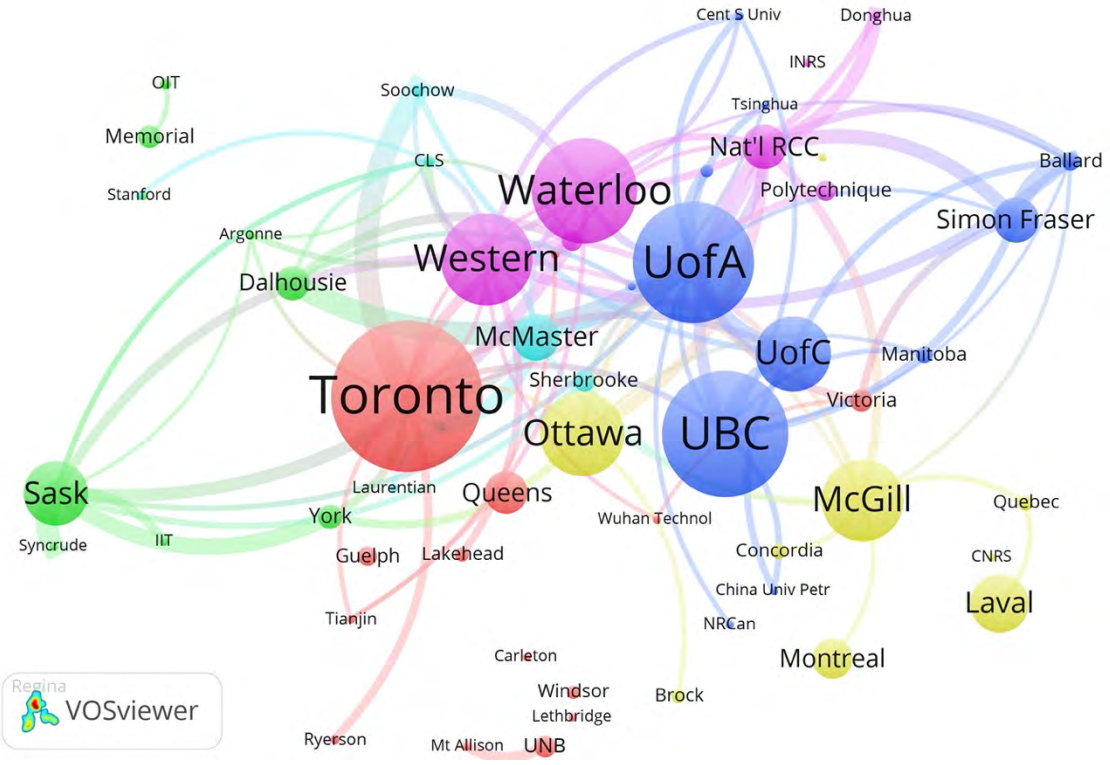


Figure 14.1 Bibliometric map of the number articles indexed by Web of Science Core Collection® per institute that mention catalyst or catalysis as keywords (2011 to 2019). The smallest circles represent 25 articles.

The bibliometric maps illustrated in Figures 14.1-5 are based on articles indexed by Web of Science Core Collection® with *catalyst* **or** *catalysis* in the search bar *Topic*. This operation identified over 600 000 (worldwide) and 16 500 with Canada in the search topic *Countries/Regions*. This search criterion includes any article in which at least one author had a Canadian address. Figures 14.1, 14.3, and 14.5 include research published from 1989 to 2019 while Figures 14.2 and 14.4 include data from 2011 to 2019 (7770 articles).

Table 14.1 Distribution of the articles in Web of Science according to category.[1]

Rank	Category	$N_{articles}$	N_{cites}	$N_{cites}/N_{articles}$
1	Physical Chemistry	3735	134557	36
2	Multidisciplinary Chemistry	2987	154887	52
3	Chemical Engineering	2419	59964	25
4	Organic Chemistry	2163	76034	35
5	Multidisciplinary Materials Science	1872	71514	38
6	Energy & Fuels	1571	59156	38
7	Inorganic & Nuclear Chemistry	1463	49144	34
8	Biochemistry & Molecular Biology	1435	54124	38
9	Electrochemistry	1282	51421	40
10	Polymer Science	866	24097	28
11	Nanoscience & Nanotechnology	769	21828	28
12	Applied Chemistry	597	17065	29
13	Environmental Sciences	566	25088	44
14	Applied Physics	543	24171	45
15	Environmental Engineering	372	10270	28

Figure 14.2 is a bibliometric map of keywords. VOSViewer grouped the major research themes into 5 clusters: oxidation - (843 articles– the largest circle of the red cluster), complexes (990 articles), kinetics (739 articles), systems (397 articles), and mechanisms (1188 articles). The red cluster – oxidation – has 48 of the 148 most common keywords and appears in 13 900 of the 16 500 articles. This cluster could be divided in two: fuel cells, electrochemical catalysis, anode, cathode, and electro-oxidation populate the far left of the map. The other major topics near the centre include oxidation, reduction, nano-particles, thin films, Pt, adsorption and surface (the large circles to the left and above oxidation with missing text). The green cluster, further to the right of the map (complexes), has the second most keywords (43) and occurrences (10 912). Among the topics in this cluster are precious metals – Ru, Rh, and Pd – and heterogeneous and homogeneous catalysis. The blue cluster (29 topics and 6980 occurrences) is centered on kinetics and small molecules (syngas, methanol, ethanol), Fischer-Tropsch, and biodiesel. The yellow cluster (systems) has many topics associated with polymerization. Density functional theory is also assigned to this cluster that has 16 topics and 3712 occurrences. Finally, the magenta cluster centered on mechanisms includes crystal structure, active sites but also enzymes, purification, and escherichia coli – these last three might also be considered a separate cluster but as it is, there are only 12 topics and 4260 occurrences. It is surprising that the mechanism topic is not more closely related to DFT and that the 100 links are mostly confined within each cluster.

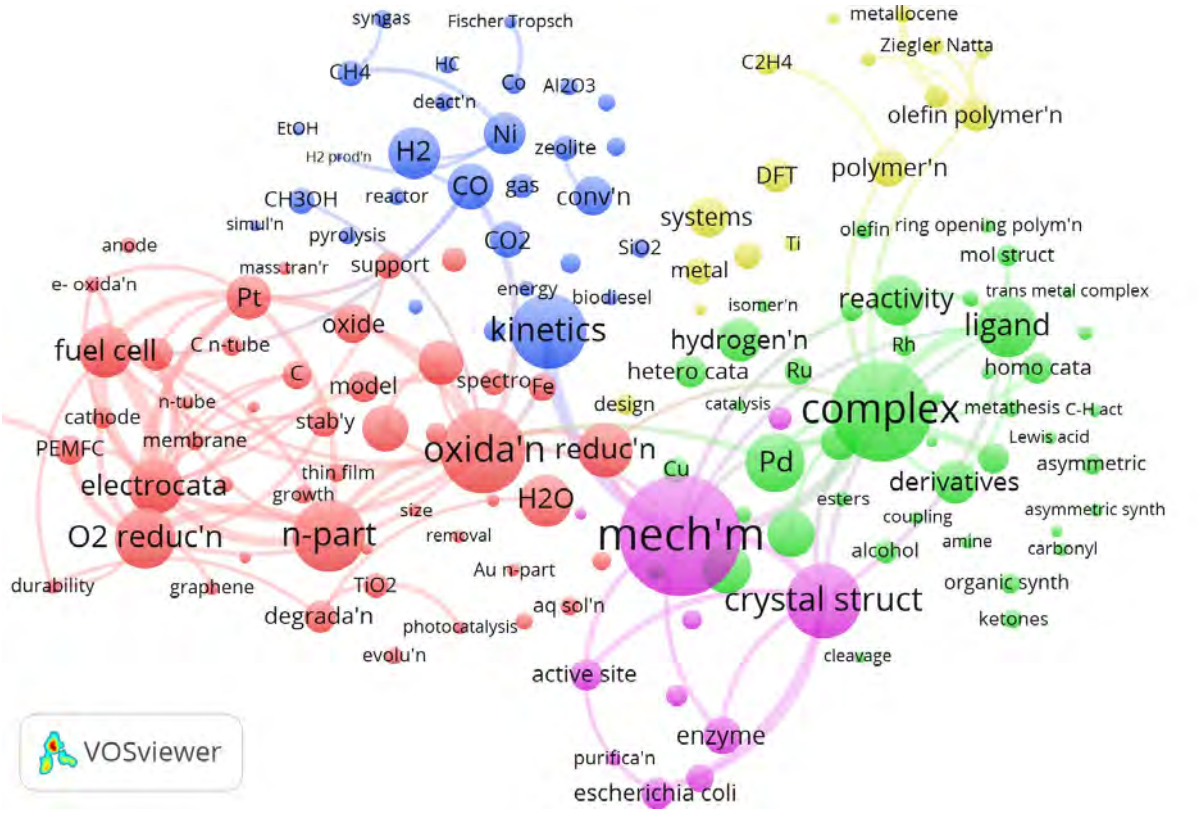


Figure 14.2 Bibliometric map of keywords in the 16 500 articles attributed to Canada by Web of Science from 1989 to 2019 with *catalysis* **or** *catalyst* as the search criteria in Topic. [1,7] The web-based program VOSviewer generated the map – the type of analysis was co-occurrence with full counting of all keywords.[1,7] The data base consists of 150 of the most mentioned keywords. The smallest circles (films and nano-structure, cyclization, ethanol, electronic structures, and dynamics) represent 120 articles.

Spectroscopy is in 256 articles and NMR and XPS are the two techniques mentioned most as keywords. However, in the abstract, XRD appears 1243 times in the abstracts of the articles published by Canadian researchers and it is the most mentioned analytical technique in the Web of Science.[8] Surprisingly, NMR is applied the second most often (1115) while it is ranked 6th among all techniques. The other most often mentioned analytical techniques are: XPS (650), FTIR (421), Raman (276), SEM (275), TPR (246), TPD (240), TEM (236), TGA (186), and DSC (148). As these are more routine, researchers exclude them as keywords.

In Figure 14.3, rather than organization as a unit of analysis, authors in the full counting mode is the unit of measure. The map consists of the 100 researchers that have published the most articles between 1989 as indexed by Web of Science (at least 43 documents). Whereas VOS Viewer grouped research topics (keywords) into only 5 clusters, the links between authors are more ambiguous and so there are 18 clusters for researchers (Figure 14.3). The red cluster has 21 researchers and is centered around the University of Waterloo with strong links to many other institutes like University of Ottawa, University of Calgary, University of British Columbia, Queen's University, Waterloo University, Laurentian Universtiy, and McMaster University. The green cluster has 15 researchers and the most prolific researchers – A.K. Dalai (University of

Saskatchewan, 261 articles), D.W. Stephan (University of Toronto, 181 articles), S. Kaliaguine (Laval, 165 articles), J.P.B. Soares (University of Alberta, 165 articles), and C.J. Li (McGill, 161 articles). The blue cluster is central and has the most links with other clusters, notably magenta, baby blue, and green. However, the links between clusters is modest: of the 100 links identified with the lines between the researchers, the baby blue and magenta cluster are linked most. Figure 14.3 illustrates most of the top 100 researchers but six lie well above the group (E. Buncel, X.G. Li, R. Kluger, C. P. Berlinguette, R.R. Hudgins, and P. Silveston) and another nine much below (W.J. Wang, Z. B. Ye, S.P. Zhu, A. B. Charette, H. DeLasa, J.B. Moffat, H. Song, A.A. Neverov, and R.S. Brown), which indicates that there is less synergy with the other researchers. Figure 14.4 includes researchers that published the most from 2011 to 2019. Many of the researchers are the same but the position has changed a little bit. A.K. Dalai (University of Saskatchewan) continues to be the most prolific author with 150 articles during the time period, followed by D.W. Stephan (University of Toronto) with 116, Z. W. Chen (University of Waterloo) with 116, C.J. Li (McGill University) with 106, and X.L. Sun (Western University) with 101.

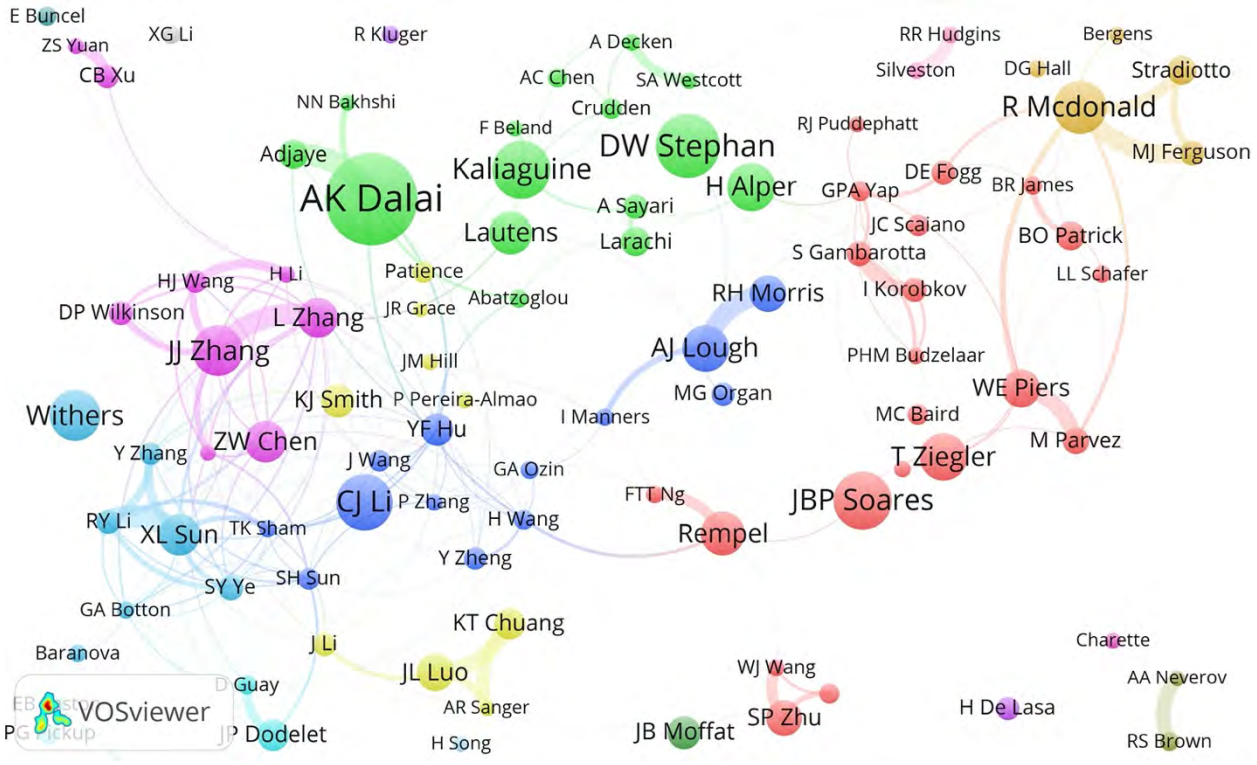


Figure 14.3 Prolific Canadian authors publishing from 1989 to 2019 with catalysis or catalyst as the search criteria in Topic of Web of Science Core Collection®. [1,7]. The smallest circles correspond to 43 articles. [1,7]

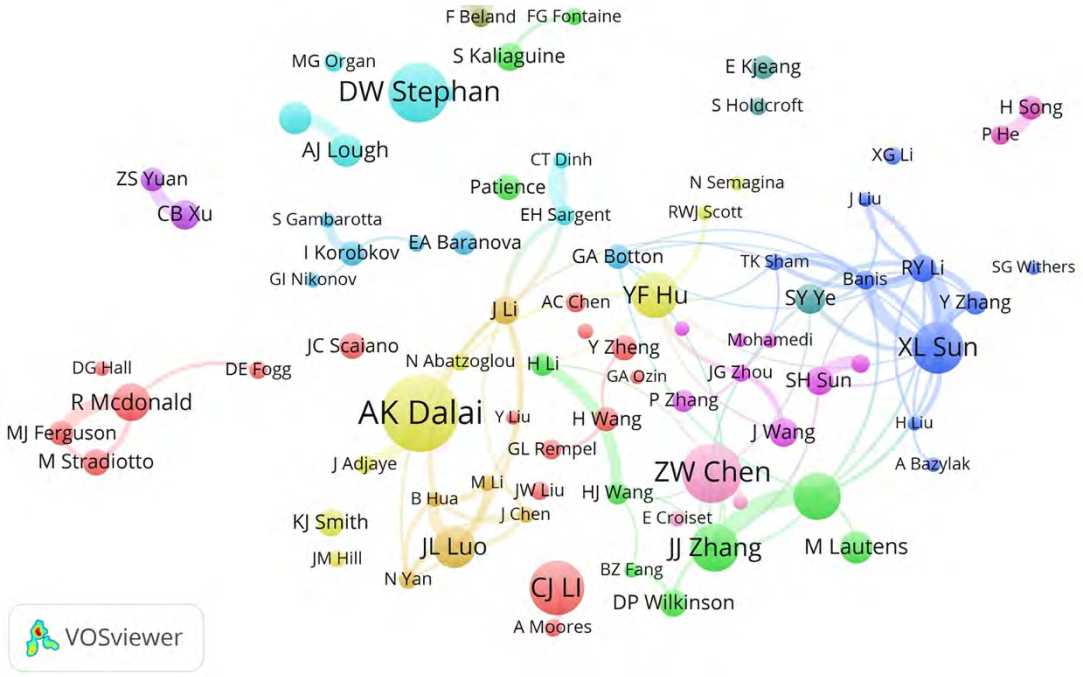


Figure 14.4 The most active Canadian authors from 2001 to 2019 with *catalysis* **or** *catalyst* as the search criteria in Topic of Web of Science Core Collection®. [1,7] The smallest circles represent 28 articles.[1,7]

The journal bibliometric map (Figure 14.5) mimics the map of keywords. Engineering type journals are in blue to the top left including *Journal of Catalysis, Catalysis Today, Chemical Engineering Science,* and *The Canadian Journal of Chemical Engineering*. The red cluster, just above the engineering type journals, has journals with a greater focus on physics, electricity, and materials of which *Journal of the Electrochemical Society, Journal of Power Sources, Science,* and, several *Phys-Chem* and *Chem-Phys* journals. Journals with a greater focus on chemistry are grouped together in the green cluster including: *Canadian Journal of Chemistry,* JACS (not shown as it dwarfs all other journals), Agnew CIE (reduced in size by a factor of 10), *Organometallics*, and *Chemical Reviews*. The beige and magenta clusters have fewer journals, and focus on biological systems and polymers, respectively.

Reflections

The Canadian Catalysis community is a very strong subject division of the Canadian Institute of Canada. Every other year, they hold a prestigious conference and attract the most decorated scientists and engineers from around the world. The community continues to grow, as evidenced by the number additional articles every year. Catalyst research is resource intensive and researchers in the field have been successful in funding applications. The number of articles per university reflects the research intensity of these institutes: University of Toronto is first followed by University of British Columbia, University of Alberta, and University of Waterloo. Perhaps University of McGill and University of Montreal have less research in the area versus expectation (their size and University rankings) while Western University and University of Ottawa have more. The Government of Canada, through NSERC, encourages cross-institutional research and large teams (CREATE and Strategic Networks, for example) but most collaborations are clustered into five regions rather than pan-Canadian (with the exception of the

green cluster including the University of Saskatchewan, York University and Dalhousie University). Furthermore, the collaboration between researchers is quite limited and dispersed with 18 clusters. In part, this large number of clusters reflects the diverse applications of catalysis but perhaps the Canadian Catalysis Society could take a more active role promoting research across disciplines and Canada.

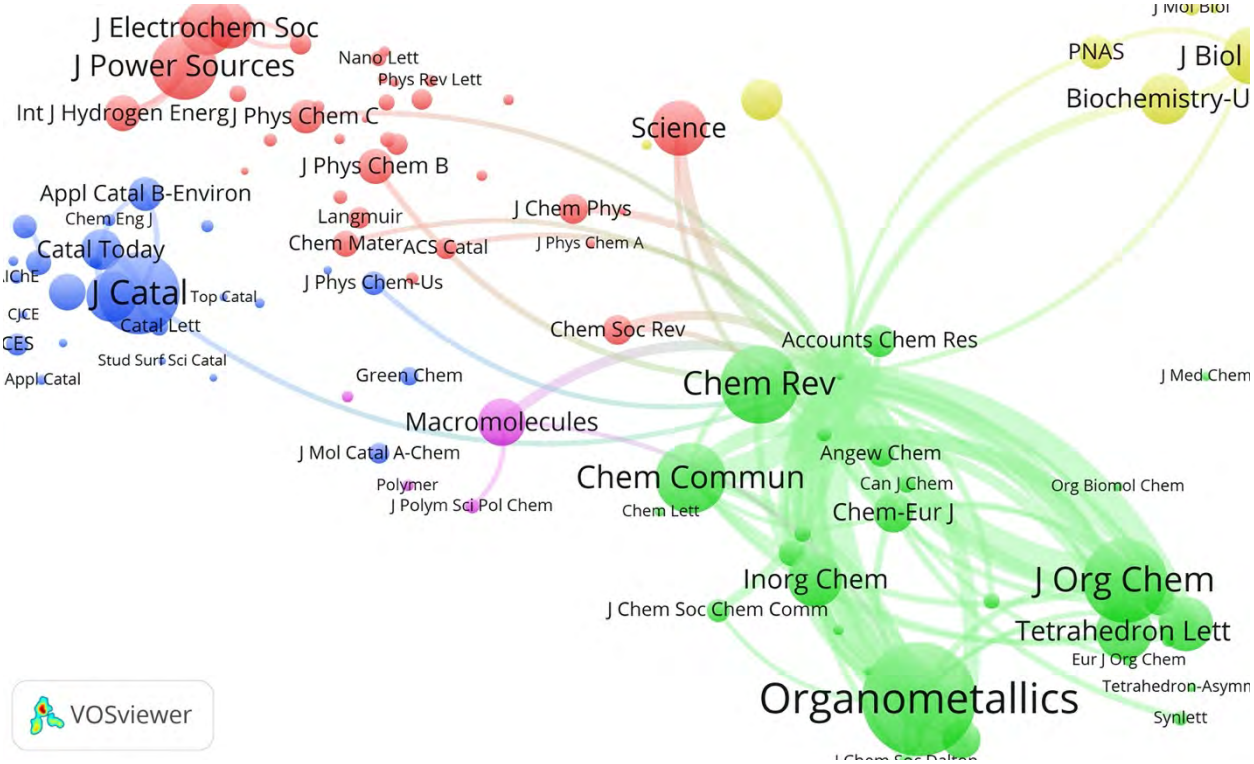


Figure 14.5 Journal correlation map with VOSviewer based on articles indexed by Web of Science Core Collection® from 1989 to 2019. [1,7] The data base consists of 103 of the most mentioned journals. The JACS circle dwarfed all other and so was excluded from the map, while the size of the Agnew CIE circle was reduced by a factor of 10.

References

[1] Clarivate Analytics, Web of Science Core Collection, accessed on 19 December 2019, http://apps.webofknowledge.com 2019.
[2] N. J. van Eck, L. Waltman, Sci. 2010, 84, 523.
[3] G. te Velde, F. M. Bickelhaupt, E. J. Baerends, C. F. Guerra, S. J. A. V. Gisbergen, J. G. Snijders, T. Ziegler, J. Comput. Chem. 2001, 22, 931.
[4] Y. Liang, Y. Li, H. W. J. Zhou, J. Wang, T. Regier, H. Dai, Nat. Mater. 2011, 10, 780.
[6] D. Alberico, M. E. Scott, M. Lautens, Chem. Rev. 2007, 207, 174.
[7] M. C. Biesinger, B. P. P. A. P. Grosvenor, L. W. M. Lau, A. R. Gerson, R. S. C. Smart, Appl. Surf. Sci. 2011, 257, 2717.
[7] M. Lefevre, E. Proietti, F. Jaouen, J.-P. Dodelet, Sci. 2009, 324, 71.
[8] G. S. Patience, Can. J. Chem. Eng. 2018, 11, 2312.

15 FUTURE DIRECTIONS FOR CATALYSIS IN CANADA

José Herrera, Drew Higgins, and Jan Kopyscinski

Canada is globally positioned as a leader in two fields: energy conversion and environmental stewardship. The attainment of these two apparently opposing goals has historically demanded, from Canadian researchers in catalysis, an intimate synergy between fundamental research and the needs of the Canadian Energy Industry. In the past 5 years, external and internal geopolitical stressors have impacted the projected timeframe for the transition to a low-carbon energy scheme. This transition will take longer than initially anticipated, allowing researchers in catalysis to continue pursuing long-term work geared toward the generation of ground-breaking new catalytic chemistry and technology; and, at the same time, continue with critical incremental technology improvements required to immediately advance the global competitiveness of the Canadian industry.

Therefore, is not unexpected that current and future catalysis research work in Canada will continue to be slightly tilted towards applied research in close collaboration with industrial partners. This is also due to the current structure of research funding programs at the Federal and Provincial levels that strongly encourage academic-industrial partnerships to create economic, social and environmental benefits for Canada. However, it is expected that the most long-range impactful advances in the area of catalysis will be achieved by researchers pursuing scientific investigations with a particular technology or market opportunity in mind, but with a deep appreciation to the fundamentals that can generate new scientific knowledge and understanding. With continued commitment, collaboration and an emphasis on interdisciplinary advances, these research efforts and the strong network of catalysis researchers across our country will be crucial to maintain and strengthen Canada's position as a global leader in catalysis research through the 2020's and beyond. There is no doubt that catalysis will continue playing a critical role to current and future energy conversion technologies and environmental applications.

Two common themes among catalysis research efforts in Canada are (1) the need to maximize energy efficiency and reduce waste generation during the manufacturing of energy carriers, and (2) the industrial need to develop novel production routes for platform chemicals and fuels. To achieve these goals, catalytic systems must be developed that are able to operate within a multistep reaction network either to achieve complex transformations in a very small number of steps (process intensification) and/or able to tap into renewable feedstocks for the production of energy carriers and/or chemical commodities. These will likely continue framing the next stage of Canadian research work in catalysis, which will undoubtedly incorporate an even stronger focus on sustainability and on the development of technology that not only minimizes the environmental impact of chemical processing, but also proactively remediates past effects of industrial manufacturing in the environment.

Within this context, thermal, chemical and biochemical routes for biomass conversion to platform chemicals and/or energy carriers represents one of the largest sectors of Canadian catalysis research. Canadian scientists and engineers will continue pursuing energy efficient gasification and pyrolysis processes for thermochemical biomass conversion to energy carriers, alongside the development of novel biochemical treatments of cellulose and hemicellulose. These research efforts have strong support from large industrial partners, as they tap into current Federal and Provincial incentives for a transition towards renewable sources of energy

feedstocks. Research in homogenous, heterogenous and enzymatic catalysis can all have an impact in achieving this goal and will likely continue in this area for the next 10-15 years. Simultaneously, as this applied research in the renewable fuels area continues, the pursuit of fundamental structure-property-performance relationships and catalytic activity descriptors for C-H, C-O and C-C bond transformations will be crucial for guiding the rational design of next generation catalyst materials able to tap into these resources. Nevertheless, to offer viable solutions to current energy challenges and proactively tap into an economic model that has put a price on carbon emissions, Canadian researchers will need to look beyond only biomass as the main energy source of a carbon neutral energy infrastructure. Therefore, we anticipate that current research efforts in areas of photocatalysis, carbon dioxide control and conversion as well as electrocatalysis will dramatically expand in the next few years.

Canada offers inexpensive and relatively sustainable low-carbon electricity generation due to the availability of hydro, wind and solar power, which enables the electrification of the chemical industry in the years to come. Canadian research work on the development of electrical to chemical energy conversion technologies (Power to Gas, Power to Chemicals) including the sustainable utilization of CO_2, production of H_2 from H_2O, and storage of surplus electrical energy into denser and easily transportable chemical forms will likely consolidate, in the years to come, into regional research hubs. Research results in this area will provide a new degree of freedom for the Canadian energy and chemical manufacturing industry. At the same time, electrochemical CO_2 conversion into fuels and feedstock chemicals, including C_1-C_3 hydrocarbons and alcohols, is emerging at the forefront of electrocatalysis research in Canada. Though this research has so far largely been fundamental in nature, e.g., discovering new electrocatalyst materials, understanding reaction mechanisms and pathways, and identifying electrocatalyst properties that dictate activity and selectivity; electrochemical CO_2 conversion research has more recently shifted towards electrocatalyst integration into practical devices (donning expertise from the fuel cell and electrolyzer communities), with several groups in Canada on the forefront of technological advances in this area. This trend is expected to continue, and with a strong petrochemical sector and inexpensive/clean sources of electricity (relative to global averages), pilot scale demonstrations of electrochemical CO_2 conversion processes are expected to pop up across the nation.

Reactor engineering research, catalyst design and understanding of catalyzed reaction mechanisms are of primary importance and a common theme in all the aspects described above. Detailed mechanistic insight in the fundamentals of heterogeneous catalyzed reactions can only be acquired by using advanced characterization methods such as spatial and temporal resolved techniques in *in-situ* and *operando* reaction cells. Canada has opportunity to make a global impact in this research space through emerging research on *in-situ* and *operando* characterization of catalyst materials — or in other words, characterization of catalysts under actual reaction conditions. A wide range of opportunities exist for Canadian researchers, using University laboratory-based setups and experimental infrastructure available at facilities such as the Canadian Light Source (CLS), Canada's particle accelerator centre (TRIUMF), the Canadian Centre for Electron Microscopy (CCEM) and the Ontario Centre for the Characterisation of Advanced Materials (OCCAM) to conduct *operando* catalyst characterization studies.

Another aspect that integrates most of these themes and will likely establish a larger footprint on the Canadian catalysis research landscape are combined computational-experimental collaborations, which so far have been crucial in enabling an unprecedented understanding of catalytic processes. It is anticipated that Canadian researchers will develop and further refine

computational models that can predict catalyst composition, structures, and properties that satisfy ‘performance descriptors’, and then experimentally realize/validate these catalyst materials with improved performance capabilities. Advances in computational methods, including artificial intelligence and machine learning lend promise towards this goal, and they will require experimentally collected data sets as input to train the models and guide catalyst discovery algorithms. Catalysis researchers are encouraged to make their data open-access and amenable for use by data scientists. These next generation combined computational-experimental studies will be crucial to refine our understanding of catalysis, and results from *in situ / operando* characterization endeavours will ensure the accuracy of these models and lead to higher probabilities that new catalyst materials with unprecedented performance capabilities can be developed.

On a closing note, it should be highlighted that this discussion is not meant to be an exhaustive account of all research directions in catalysis that lay on the horizon for Canada, and is instead simply the opinion of the small number of researchers tasked with formulating this Chapter. However, it is our hope that this section has been successful in painting a picture (albeit partial) of what a sustainable energy future may look like and what role the Canadian catalysis community can play. It is our hope that this Chapter provides a vision and inspires research scientists, engineers and policy makers to pursue innovative new directions and advance upon our current levels of scientific understanding of catalytic phenomena. All aiming at achieving a fully sustainable energy infrastructure, which will provide benefits that extend well beyond our borders, and perhaps our time.

16 ACKNOWLEDGEMENTS

Many people provided information for this book. In particular, we would like to acknowledge Uschi Graham, NACS archivist, for help with identifying the Kokes award winners, as well as Serge Kaliaguine, Jerry Kriz, David Laycock, Flora Ng, Joyce Rogers, Marten Ternan, and Bohdan Wojciechowski for providing input for the In Memoriam pages.

APPENDIX 1: Charter of The Catalysis Division

CHARTER
OF THE
CATALYSIS SUBJECT DIVISION (the "Division")
OF THE
CHEMICAL INSTITUTE OF CANADA (the "Corporation")

The Division has been established by the Board of Directors of the Corporation (the "Board") for Members of the Corporation who have a common interest, experience and/or training in the advancement of the knowledge and application of both heterogeneous and homogeneous chemical catalysis in Canada by encouragement of appropriate research and development in science and engineering.

The Division shall be comprised of all Members of the Chemical Institute of Canada in good standing who have duly signified their interest in the Division.

The Division is not an entity separate and apart from the Corporation, but a division formed to carry out its purpose under the control of the Board, as determined by the Board or committee of the Board and in compliance with the Articles, By-laws and policies of the Corporation, as established from time to time.

The policies approved by the Board applicable to the Division shall be referred to as the "Catalysis Subject Division Charter" or "Charter". The Board may amend the Charter from time to time and shall provide a copy of the amendment to the Division within ten (10) days of being approved by the Board.

2. Purpose

The purpose of the Division is to further and promote the interests of all of the members of the Division involved in the pursuit of and understanding of catalysis within the Division, in accordance with the Corporation's purposes, its Articles, By-laws, policies and this Charter.

The functions of the Division shall include, among others, the following:

1. a) To arrange through its Executive Committee, meetings of the Division at the time of the annual conferences of either or each of the Societies, at the bi-annual Canadian Symposium on Catalysis, and/or at the bi-annual North American Catalysis Society Meeting.
2. b) To maintain liaison with The Catalysis Society [of North America] and, subject to an agreement with The Catalysis Society, to have one of its members, the Vice-Chair, as a representative to the Board of The Catalysis Society. The Vice-Chair shall report back to the Executive Committee after meetings or communications with The Catalysis Society.
3. c) To maintain liaison with the International Congress on Catalysis and, have the immediate Past Chair and current Chair of the Division be the Canadian representatives to the International Congress on Catalysis. These representatives shall report back to the Executive Committee after meetings or communications with the International Congress on Catalysis.
4. d) Subject to the approval of the Board to undertake any other activities that its Executive Committee consider to be consistent with the purpose of the Division.

3. Appointment and Removal of Division Members

In accordance with the By-laws of the Corporation, the Division and its members shall be established by the Board or a committee of the Board, and shall remain members until such member's resignation or removal. Any Division member, with or without cause, may be removed from the Division by a majority vote of the Board.

4. Division Executive Committee

The Division Executive Committee shall consist of four Officers – Past Chair, Chair, Vice-Chair, and Secretary/Treasurer – and four to six Members-At-Large. The members of the Division, by majority vote, shall designate the Executive Committee at the Annual General Meeting held in conjunction with the Canadian Symposium on Catalysis.

The Officers of the Division shall serve for a period of two years in a specific position (Chair, Vice-Chair or Secretary/Treasurer). The Vice-Chair generally moves to the position of Chair, the Secretary/Treasurer to Vice-Chair, and the Chair to Immediate Past-Chair at the end of each two-year term. The outgoing Chair may not be elected to a second consecutive term as Chair but may be re-elected as a Division Officer after the lapse of two years following the Annual General Meeting at which the member ceased to be Chair.

Alternatively, the Board or a committee of the Board may appoint Officers of the Division.

The Division Chair shall set the agendas for and chair Division meetings. The Chair shall also be the chief manager of the Division and be responsible for implementing the purposes of the Division in a timely manner. The Chair shall be a member ex officio of all committees of the Division.

The Division Vice-Chair shall assist the Division Chair in carrying out his/her duties, as required. The Vice-Chair shall succeed the Chair if he/she leaves office before completing his/her term. The Vice-Chair shall be the Division's representative to the Board of The Catalysis Society [of North America].

In the absence of both the Chair and Vice-Chair, the Immediate Past Chair shall assume their duties and responsibilities. The Immediate Past Chair shall also be the Chair of the Nominating Committee.

The Division Secretary/Treasurer shall attend all Division meetings and record the minutes of such meetings. The Division Secretary/Treasurer shall be responsible for delivering all notices and correspondence to Division members and the Corporation and keeping all of the books, paper, records and other documents of the Division. The Division Secretary/Treasurer shall also be responsible for directing the CIC office to disburse and deposit Division funds, ensuring that proper accounting records are maintained, and reporting finances to the Division and the Board or committee of the Board. The Director of Finance of the Corporation will participate in any review or audit of the Division's accounting records with the accountant/auditor for the Corporation. The Vice-Chair shall assume the role of the Secretary/Treasurer if he/she leaves office before completing his/her term, but a new Secretary/Treasurer shall be sought as soon as possible.

The Division Executive Committee will include four to six Members-at-large who each hold office for four years. The Members-At-Large shall hold office at staggered times so that not all members retire in the same year. The Members-At-Large will provide input on decisions within the Executive, and be responsible for nominating people for the Division Awards. The Members-At-Large will include at least one professor, and one representative from industry. Post-doctoral fellows may also be chosen as Members-At-Large and may continue to serve after they have completed their post-doctoral fellowship.

One of the Members-At-Large will be responsible for maintaining the Division website (http://www.catalysisdivision.ca/).

The Executive Committee members shall be installed and normally take office at the Annual General Meeting at which they are elected.

The Executive should reflect the diversity of the Division in every aspect (age, gender, geographic location across Canada, employment sector, etc.). It is expected that the Officers of the Division will have been members of the Division for at least two years before being put forward as an Executive Committee candidate.

5. Nominating Committee and Elections

The Nominating Committee shall consist of three members including the Immediate Past Chair, who is the Chair of the Nominating Committee. The Nominating Committee shall prepare a slate of Executive Committee members and, having ascertained their willingness to serve, shall arrange through the Secretary/Treasurer for the publication of the slate on the Division website and through an email announcement to all Division members. Such further nominations shall bear the signatures of at least two members of the Division and shall be accompanied by the written consent of the nominee to serve, and shall be mailed to the Chair of the Nominating Committee not later than two weeks prior to the Annual General Meeting.

If no further nominations are received, the slate shall be presented at the Annual General Meeting for adoption. If further nominations are received, the vote shall be by secret ballot at the Annual General Meeting. The Vice-Chair shall prepare the ballot forms.

Any vacancy occurring in the Executive Committee for any reason may be filled by appointment by the Executive Committee, with the appointee to serve until the next Annual General Meeting.

6. Meetings of the Division

The Annual General Meeting of the Division shall be held on at the time of the annual conferences of either or each of the Societies, at the bi-annual Canadian Symposium on Catalysis, and/or at the bi-annual North American Catalysis Society Meeting. The time between successive Annual General Meetings shall not exceed 30 months. Ten members of the Division shall constitute a quorum for the transaction of business.

The agenda shall include provisions for:

1. Minutes of the preceding Annual General Meeting
2. Report by Chair of the Division
3. Financial Report
4. Report by Chair of Nominating Committee
5. Election
6. New Business

Decisions at meetings of the Division members shall be made by a majority vote of the Division members. Any decisions that affect this Charter will be incorporated into an amended Charter within six months.

Any Division member may vote and otherwise participate in the meeting by means of a telephonic, electronic or other communication facility made available by the Division that permits all participants to communicate adequately with each other during the meeting. A person participating in a meeting of members by such means is deemed to be present at the meeting.

There shall be a meeting of the Executive Committee as soon as feasible after the Annual General Meeting. The Chair or Vice-Chair and Secretary/Treasurer, and three other members of the Executive Committee shall constitute a quorum for the transaction of Division business.

As part of its goal to foster open communication, the Division Chair may periodically meet separately with the Executive Director of the Corporation to discuss any matters that the Division considers appropriate to be brought before the Board without delay. In addition, the Chair shall communicate with the Executive Director of the Corporation annually to review the Division's financial statements, funding requirements and governance matters.

The Division may invite to its meetings any Director or officer of the Corporation, and any other person whom it deems appropriate to consult in order to carry out its purposes and responsibilities. The Division may also exclude from its meetings any person it deems appropriate to exclude in order to carry out its responsibilities, save and except for a Director or officer of the Corporation.

The Secretary/Treasurer shall keep a record of the proceedings of the Annual General Meeting of the Division and of the meetings of the Executive Committee, and of all other matters concerning the Division, and shall attend to all correspondence of the Division. The Secretary/Treasurer shall make a financial report at the Annual General Meeting and shall issue minutes of the Annual General Meeting within one month, sending a copy of these to the National Office of the Corporation. The Secretary/Treasurer shall also report to the Executive Committee at such other times as required.

7. Function

The following functions shall be the common recurring duties of the Division in carrying out its purposes. These duties should serve as a guide with the understanding that the Division may fulfill additional duties and adopt additional policies and procedures as may be appropriate in light of changing legislative, regulatory, legal or other conditions.

1. The Division is empowered to study or investigate any matter of interest or concern that the Division deems appropriate for study or investigation by the Division.
2. The Division shall be given access to the Corporation's internal accounting staff, Board, Executive Director and other staff as necessary to assist in fulfilling its duties.
3. While acting within the scope of its stated purpose, the Division shall remain under the direction of the Board and/or committee of the Board.
4. The Division shall comply with any directive given by the Board and perform any functions required to fulfill any directive or policy.

The Division shall also comply with and carry out any other responsibilities and duties delegated to it by the Board from time to time related to the purposes of the Division.

8. Use of Division Monies

The Division may raise monies to fund its operations and those monies, together with any monies received from the Corporation, shall be used to further the Division's purpose as the Division sees fit, provided they are in compliance with the Corporation's Articles, By-laws and policies. In the event the

Division retains monies far in excess of what is required to further its purpose without those monies being earmarked for upcoming projects or extra-ordinary expenses, and in the opinion of the Board retention of those monies may jeopardize the not-for-profit status of the Corporation, the Board shall be entitled to require the Division to spend down these excess monies in order to further the purposes of the Division. Should the Division fail to spend the excess monies in a reasonable time, the Board retains the right to transfer of such excess monies to the Corporation's account, and use the excess monies to further the purposes of the Division and/or the Corporation.

9. Division Banking

In addition to the signing authorities determined by the Division, the Board of the Corporation shall appoint two or more directors of the Corporation or officials employed in the head office of the Corporation who shall have full signing authority on the bank account of the Division. Other than at the request of the Division, the Board shall not issue cheques or withdraw monies from the Division's bank account unless, in the Board's absolute discretion, the use of the monies by the Division contravenes the Corporation's articles or by-laws or this Charter, jeopardizes the Corporation's not-for-profit status, is required to liquidate the Division's bank account after dissolution or suspension of its operations or is required by the Corporation in the event of financial exigency.

The Division shall not be permitted to borrow money.

10. Review and Reporting

The Corporation shall be entitled to review periodically, or at any time at the request of the Board, the financial accounting, activities and governance of the Division, and address and provide direction with respect to any matter that could have an impact on the Corporation.

The Division shall report regularly to the Board with respect to any issues that arise with respect to the quality or integrity of the Division's internal accounting functions, legal or regulatory requirements and with respect to such other matters as are relevant to the Division carrying out its purposes.

The Division shall provide such recommendations to the Board as the Division may deem appropriate. The report to the Board may take the form of a written or oral report by the Division Chair or any other member of the Division designated by the Division to make such report.

11. Use of Intellectual Property of the Corporation

The Division shall be permitted to hold itself out as a Division of the Corporation and may use the Corporation's intellectual property, such as its name, trademarks and logos, in connection with its purpose and in accordance with manner and form approved by the Board. The Division shall maintain the high standard of quality associated with the Corporation's intellectual property. The Division shall cease to use any of the Corporation's intellectual property immediately upon notice from the Board.

12. Amendment

The Charter of the Division may be amended at an Annual General Meeting of the Division by a two-thirds affirmative vote of the members present provided a quorum is present and a notice of motion has been received by the Secretary/Treasurer at least two months in advance of such meeting. A notice of such amendment shall appear on the Division website at least one month before the Annual General Meeting at which the amendment will be discussed. Such amendments shall not be effective until approved by the Board of Directors of the Corporation.

13. Dissolution or Suspension of Division

If in the sole and absolute discretion of the Board, it is determined that the Division is no longer viable or that the Division is no longer carrying out its purposes in accordance with this Charter or the By-laws of the Corporation, the Board shall have the power to suspend or dissolve the Division. The Board shall provide thirty (30) days-notice of its intention to suspend or dissolve the Division and shall receive any written objections or submissions within such thirty (30) day period. Prior to suspension or dissolution, the Division Chair shall be permitted to present written submissions to the Board prior to the Board making a final decision to suspend or dissolve the Division. In the event that the Board does not receive any written submissions within such thirty (30) day period, the Board shall proceed with any decision to suspend or dissolve the Division. The decision of the Board shall be final. On termination, all use of the Corporation’s name, trade-marks and intellectual property shall immediately cease and all records, documentation, monies on account, and such other matters or documents as directed by the Board, shall be delivered to the Corporation.

Date: May 12, 2014
Approved by the Catalysis Division
Date, 2014
Approved by the Board of Directors of the Chemical Institute of Canada

Amendments:

APPENDIX 2: By-Laws of the Canadian Catalysis Foundation

CANADIAN CATALYSIS FOUNDATION

BY-LAW NUMBER 1

Being a General By-Law for regulating the administrative affairs of
CANADIAN CATALYSIS FOUNDATION

BE IT ENACTED as a by-law of the Corporation as follows:

DEFINITIONS

1. In this by-law and all other by-laws of the Corporation, unless the context otherwise specifies or requires:

(a) "Act" means the Canada Corporations Act, Revised Statutes of Canada 1970, c.C-32, as from time to time amended, and every statute that may be substituted therefor and, in the case of such amendment or substitution, any references in the by-laws of the Corporation shall be read as referring to the amended or substituted provisions therefor;

(b) "Board" shall mean the Board of Directors of the Corporation;

(c) "'by-law", "by-laws" means any by-laws of the Corporation from time to time in force and effect;

(d) "Catalysis Division" means a certain organization now known as The Catalysis Division of the Chemical Institute of Canada and composed of members of the Chemical Institute of Canada and its constituent societies, the Canadian Society for Chemistry, the Canadian Society for Chemical Engineering and the Canadian Society for Chemical Technology and includes any successor organization;

(e) All terms contained in the by-laws which are defined in the Act shall have the meanings given to such terms in the Act;

(f) Words importing the singular number only shall include the plural and vice versa; words importing the masculine gender shall include the feminine and neuter genders;

(g) The headings used in the by-laws are inserted for reference purposes only and are not to be considered or taken into account in construing the terms or provisions thereof or to be deemed in any way to clarify, modify or explain the effect of any such terms or provisions.

HEAD OFFICE

2. The directors may from time to time by resolution fix the location of the head office of the Corporation within the place in Canada designated as such by the Corporation's letters patent.

SEAL

3. The seal, an impression whereof is stamped in the margin hereof, shall be the seal of the Corporation.

MEMBERSHIP

ADMISSION TO MEMBERSHIP

4. QUALIFICATION. Any individual whose address is known to the Corporation may be admitted as a member of the Corporation.

5. HONORARY APPOINTMENTS. The Board of Directors may from time to time by resolution appoint one or more Honorary Patrons, Honorary Officers and Honorary Members until a successor is appointed or for a term of one or more membership years, or for life, and in the absence of specification the term of such appointment shall be for one membership year. Persons receiving any such appointment shall be Honorary Members of the Corporation during the term thereof and, unless otherwise stated in the resolution of appointment, shall be entitled to the same rights as those of ordinary members. Honorary Members may attend, without the right to vote, at any regular meeting of the Board.

6. DIRECTORS. All persons who after the date of this by-law are or become directors of the Corporation shall be life members of the Corporation.

7. EX OFFICIO MEMBERS. All persons who, after the date of the by-law, are or become members of the Executive Committee of the Catalysis Division (defined in Section 1) shall, during the time they are members of such Executive Committee, ex officio, be members of the Corporation.

8. ADMITTED. Other members may be admitted from time to time to membership in the Corporation by resolution of the Board. The resolution admitting a member may provide membership shall be during a period of tenure of a particular office, or to be for a period of one or more years, or for life and if no period is indicated membership shall be for a term of one year.

   Each membership for a period of one or more years shall, unless otherwise declared by resolution of the Board, commence at the beginning of the next following annual membership year.

9. ANNUAL MEMBERSHIP YEAR. The annual membership year of the Corporation shall commence on the termination of business of an Annual Meeting of Members of the Corporation and end upon the termination of business of the next following Annual Meeting of the Corporation. Membership in the Corporation for a term of one or more years shall lapse at the end of the respective number of annual membership years next following the date of admission to membership.

10. LAPSE ON DEATH. The interest of a member in the Corporation is not transferable and shall lapse and cease to exist upon death.

11. DEEMED LAPSE OF MEMBERSHIP. Upon receiving the report of the secretary that the present address of any member is not known the Board may by resolution declare such membership to have lapsed.

12. MEMBERSHIP REGISTER. The secretary shall keep as accurately as may reasonably be practical a register of the names and addresses of all members of the Corporation showing the date of admission. Changes of address shall be made in the register upon the request of the member but the secretary is not otherwise required to maintain current addresses of members. The secretary shall, upon satisfying himself that the interest of a member has terminated or lapsed for any reason, delete reference to such member from the current membership lists and enter the particulars so deleted in a separate terminated membership category of the register. Particu1ars of terminated memberships shall be retained at least ten years after termination. The secretary shall report annually to the Board upon the state of the membership register.

13. REINSTATEMENT OF LAPSED MEMBERSHIP. The secretary may replace in the current membership list of the register of members of the Corporation the name of any former member whose membership is deemed to have lapsed upon being satisfied that but for such deemed lapse the former member is entitled to be recognized as a member of the Corporation and the secretary shall do so if such former member requests in writing and appears to be entitled.

14. RESIGNATION. Any member of the Corporation may resign from membership upon notice in writing to

the Corporation and upon acceptance thereof by the Board.

MEETINGS OF MEMBERS

15. ANNUAL MEETING. The annual meeting of the members required by section 102 of the Act shall be held at any place within Canada, on such day in each year and at such time as the directors may by resolution determine. At annual meetings there shall be presented a report of the directors of the affairs of the Corporation for the previous year, a financia1 statement of the Corporation and the auditor's report thereon as required by the Act, and such other information or reports relating to the Corporation's affairs as the directors may determine.

16. SPECIAL MEETINGS. Other meetings of the members whether special or general may be convened by order of the president of the Board at any time and any place within Canada and shall be convened from time to time upon written request therefor signed by five (5) members of the Corporation.

17. NOTICE. A printed, written or typewritten notice stating the day, hour and place of meeting and the general nature of the business to be transacted shall be served either personally or by sending such notice to each member entitled to notice of such meeting and, if required, to the auditor of the Corporation through the post in a prepaid wrapper or letter or by electronic facsimi1e at least fourteen (14) days (exclusive of the day of sending and of the day for which notice is given) before the date of every meeting directed to such address of each such member and of the auditor as appears on the books of the Corporation, or if no address is given therein, then to the last address of each such member or auditor known to the secretary; provided always that a meeting of members may be held for any purpose at any date and time and at any place within Canada without notice if all the members are present in person or represented by proxy at the meeting or if all the unrepresented absent members shall have signified their assent in writing to such meeting being held and such assent may be validly given either before or after the meeting to which such assent relates.

18. OMISSION OF NOTICE. Any accidental omission in the giving of notice of any meeting or the non-receipt of any notice by any member or members or the auditor shall not invalidate any resolution passed or any proceeding taken at any meeting.

19. PROOF OF SERVICE. A certificate of the secretary of the Corporation as to facts in re1ation to the giving of any notice to any member, shall be conc1usive evidence thereof.

20. PERSONS ENTITLED TO THE PRESENT. The only persons entitled to attend a meeting of members shall be those entitled to vote thereat and the auditor of the Corporation. Any other person may be admitted only on the invitation of the chairman of the meeting or with the consent of the meeting.

21. QUORUM. Five members present in person or by proxy shall constitute a quorum for the transaction of all business at any Annual or Special Meeting of the Corporation. No business shall be transacted at any meeting unless the quorum requisite be present at the commencement of the business.

    If within one-half hour from the time appointed for a meeting of the Corporation a quorum of members is not present, the meeting, if convened upon the request of members shall be dissolved. In any other case, it shall stand adjourned without further notice to the same day in the following week, at the same hour and place; and if at such adjourned meeting a quorum of members is not present, it shall be dissolved.

22. CHAIRMAN. In the absence of any director who is president or vice-president of the Board, the members present shall choose another director as chairman and if no director is present and willing to act, the members present shall choose one of their own number to be chairman.

23. SCRUTINEERS. At each meeting of members one or more scrutineers may be appointed by a resolution of the meeting or by the chairman with the consent of the meeting to serve at the meeting. Such scrutineers need not be members of the Corporation.

24. VOTING. Each member entitled to vote shall be entitled to one vote on each question arising at any meeting of members either in person or by proxy. Unless the Act or these by-laws otherwise provide, each question submitted to any meeting of members shall be decided in the first instance by a majority of votes given on a show of hands and in case of an equality of votes the chairman shall, both on a show of hands and at a poll, have a second or casting vote in addition to the vote to which he is entitled as a member. At any meeting, unless a poll is demanded, a declaration by the chairman that a resolution has been carried or carried unanimously or by a particular majority or lost or not carried by a particular majority shall be conclusive evidence of the fact without proof of the number or proportion of votes recorded in favour of or against the motion.

25. PROXY. Every member entitled to vote at a meeting of members may by means of proxy which may, but need not be in the form provided with the notice calling the meeting, appoint a proxyholder or one or more alternate proxyholders, who need not be a member, to attend and act at the meeting in the manner and to the extent authorized by the proxy and with the authority conferred by the proxy.

An instrument appointing a proxy shall be in writing and executed by the member or his attorney authorized in writing and is valid only at the meeting in respect of which it is given or at any adjournment thereof.

26. POLLS. If a poll be required by the chairman of the meeting or be duly demanded by any member and the demand be not withdrawn, a poll upon the question shall be taken in such manner as the chairman of the meeting shall direct.

27. ADJOURNMENT. The chairman of the meeting may with the consent of any meeting, adjourn the same from time to time, and no notice of such adjournment need be given to the members. Any business may be brought before or dealt with at any adjourned meeting which might have been brought before or dealt with at the original meeting in accordance with the notice calling the same.

28. WRITTEN RESOLUTIONS. Subject to the Act, the letters patent and the by-laws, a resolution in writing signed by all the members entitled to vote on that resolution at a meeting of members is as valid as if it had been passed at a meeting of members.

DIRECTORS

29. NUMBER AND POWERS. The affairs of the Corporation shall be managed by a board of directors consisting of not fewer than 3 directors and not more than 12; the number within such range may be changed from time to time by resolution of the Board of Directors of the Corporation; until changed the number of directors shall be 6.

The directors may exercise all such powers and do all such acts and things as may be exercised or done by the Corporation and are not by the by-laws of the Corporation or by statute expressly directed or required to be done by the Corporation at a meeting of members.

30. HONORARY DIRECTORS. The members of the Corporation may elect not more than three Honorary Directors to hold office until the next annual meeting of the Corporation. Honorary Directors may attend, without the right to vote, at any regular meeting of the Board.

31. EX OFFICIO DIRECTORS. The holder from time to time of each of the following offices shall ex officio be a director of the Corporation:

1. the Chairman of the Catalysis Division;

2. the Vice-Chairman of the Catalysis Division.

32. ELECTION OF DIRECTORS. The whole Board (except ex officio directors) shall be elected annually by

the members from among qualified individuals nominated at the meeting.

33. QUALIFICATIONS. No person who is bankrupt, incompetent or a convicted criminal, within the meaning of section 35 hereof shall be eligible to hold the office of director. Any other person shall be eligible to hold the office of director except the following who shall not be eligible for election or appointment as director but nevertheless may be directors ex officio and Honorary Directors:

(a) a person under twenty-one or over seventy-five years of age;

(b) a person who has held the office of director during any part of each of the eight consecutive whole annual terms immediately preceding the end of the meeting at which such election or appointment may be made.

34. TERM OF OFFICE. The first directors shall hold office until the first annual meeting of members of the Corporation. Thereafter a director's term of office shall be from the date of the meeting at which he is elected or appointed until the annual meeting next following or until his successor is elected or appointed.

35. VACATION OF OFFICE. The office of a director of the Corporation shall become vacated:

(a) if he becomes bankrupt or a receiving order is made against him or he makes an assignment under the Bankruptcy Act (Canada) or any statute that may be substituted therefor;

(b) if an order is made declaring him to be a mentally incompetent person or incapable of managing his own affairs; or

(c) if he is convicted of any criminal offence.

36. REMOVAL OF DIRECTORS. The members may, by resolution passed by at least 66 2/3 percent of the votes cast at a special general meeting of members of which notice specifying the intention to pass such resolution was given, remove any director before the expiration of his term of office, and may, by a majority of the votes cast at that meeting, elect any person in his stead for the remainder of his term.

37. RESIGNATION OF DIRECTORS. Any director may at any time resign his office as director by filling his written resignation with the secretary of the Corporation and such resignation shall taken effect immediately upon the filing thereof as aforesaid and shall not require the confirmation of the Board.

38. VACANCIES. Vacancies in the Board may be filled for the remainder of its term of office from among qualified persons, either by the members at a general meeting called for the purpose or, by the remaining directors if constituting a quorum; otherwise such vacancies shall be filled at the next meeting of the members at which directors for the ensuing year are elected. If the number of directors is increased a vacancy or vacancies in the Board of the number of the authorized increase shall thereby be deemed to have occurred which may be filled in the manner above provided.

39. CALLING OF MEETINGS. Meetings of the Board may be held at the head office of the Corporation or such other place in Canada as the president or the Board may determine. Directors' meetings may be called by the president or vice-president or may be called by the secretary upon the direction of the president or vice-president or the direction in writing of any two directors. Notice of such meetings shall be delivered, telephoned or by electronic facsimile to each director not less than one day before the meeting is to take place or shall be mailed to each director not less than fourteen days before the meeting is to take place. The time of giving notice shall be computed excluding the day notice is given and including the day for which notice is given. The certificate of the secretary or the officer calling the meeting that notice has been given pursuant to this by-law shall be sufficient and conclusive evidence of the giving of such notice. The directors may consider or transact any business, either special or general at any meeting of the Board.

40. REGULAR MEETINGS. The Board may appoint a day or days in any month or months for regular meetings at an hour to be named and of such regular meeting no notice need be sent.

41. FIRST MEETING OF NEW BOARD. A directors' meeting may be held without notice immediately following the annual meeting of the Corporation provided a quorum is present.

42. ERRORS IN NOTICE. No error or omission in giving notice for a meeting of directors shall invalidate such meeting or invalidate or make void any proceedings taken or had at such meeting and any director may at any time waive notice of any such meeting and may ratify and approve of any or all proceedings taken or had thereat.

43. QUORUM AND VOTING. A majority of the directors shall constitute a quorum for the transaction of business. Questions arising at any meeting of directors shall be decided by a majority of votes. In case of an equality of votes, the chairman of the meeting, in addition to his original vote, shall have a second or casting vote. All votes at any such meeting shall be taken by ballot if so demanded by any director present, but if no demand be made, the vote shall be taken in the usua1 way by assent or dissent. A declaration by the chairman that a resolution has been carried and an entry to that effect in the minutes shall be admissible in evidence as prima facie proof of the fact without proof of the number of proportion of the votes recorded in favour of or against such resolution.

44. TELEPHONE PARTICIPATION. Where all the directors of the Corporation consent thereto (either before or after the meeting), a director may participate in a meeting of directors or of any committee of directors by means of such telephone, electronic or other communications facilities as permit all persons participating in the meeting to hear each other simultaneously and instantaneously, and a director participating in a meeting by such means shall be deemed for the purposes of the Act to be present at that meeting.

45. ACTION BY UNANIMOUS WRITTEN RESOLUTION. Any action required or permitted to be taken at any meeting of the Board may be taken without a meeting by a resolution in writing signed by all the directors to indicate their consent and filed with the minutes of proceedings of the Board.

46. INTEREST OF DIRECTORS IN CONTRACTS. No contract or arrangement entered into by or on behalf of the Corporation with any director or in which any director is in any way interested shall be liable to be avoided nor shall any director so contracting or being so interested be liable to account to the Corporation for any profit realized by any such contract or arrangement by reason of such director holding that office or of the fiduciary relationship thereby established.

47. DECLARATION OF INTEREST. It shall be the duty, however, of every director of the Corporation who is in any way, whether directly or indirectly, interested in a contract or arrangement or proposed contract or arrangement with the Corporation to declare such interest to the extent, in the manner and at the time required by the applicable provisions of the Act for and to refrain from voting in respect of the contract or arrangement or proposed contract or arrangement if and when prohibited by the Act.

48. REMUNERATION OF DIRECTORS. No director shall receive remuneration for acting as such provided that a director may be paid reasonable expenses incurred by him in the performance of his duties.

OFFICERS

49. ELECTED OFFICERS. At the first meeting of the Board after each election of directors the Board shall elect a president from among its members. In default of election of the president the then incumbent, if a member of the Board, shall hold office until his successor is elected. A vacancy occurring from time to time in such office may be filled by the Board from among its members.

50. APPOINTED OFFICERS. From time to time the Board shall appoint a treasurer and a secretary and may appoint one or more vice-presidents and such other officers as the Board may determine including one or more assistants to any of the officers so appointed. The officers so appointed may, but need not be, directors. One person may hold more than one office.

51. TERM OF OFFICE. No director shall be elected or appointed president or vice-president who has held such respective office as well as the office of director during any part of each of the four (4) consecutive

whole annual terms immediately preceding the end of the meeting at which such election or appointment may be made. In the absence of written agreement to the contrary of the Board may remove at its p1easure any officer of the Corporation.

DUTIES OF OFFICERS

52. RESPONSIBLE TO BOARD. Each officer of the Corporation shall be responsible to the Board. He shall in addition to duties specifically indicated perform all duties incidental to his office and shall have such other powers and duties as may from time to time be assigned to him by the Board. The directors may fix the remuneration (if any) to be paid to officers of the Corporation. All officers in the absence of agreement to the contrary shall be subject to removal by resolution of the board of directors at any time with or without cause.

53. PRESIDENT OF THE CORPORATION. The president shall, when present, preside at the meetings of the Board and meetings of the members of the Corporation and shall, ex officio, be a member of all committees of the Board. The president shall be charged with the general supervision of the business and affairs of the Corporation.

54. VICE-PRESIDENT OF THE CORPORATION. The vice-president, or if there are more than one, the vice-presidents in order of seniority (as determined by the Board) may, during the absence or inability of the president, perform and exercise all the duties and powers of the president save that no vice-president shall preside at a meeting of the Board, or at a meeting of members who is not qualified to attend the meeting as a director, or as a member as the case may be. If a vice-president exercises any such duty or power, the absence or inability of the president shall be presumed with reference thereto. A vice-president shall also perform such duties and exercise such powers as the president may from time to time delegate to him, or the Board may prescribe.

55. SECRETARY OF THE CORPORATION. The secretary shall give, or cause to be given, all notices required to be given to members, directors, auditors and members of committees; he shall attend all meetings of the directors and of the members and shall enter or cause to be entered in the books kept for that purpose minutes of all proceedings at such meetings; he shall be the custodian of the stamp or mechanical device generally used for affixing the corporate seal of the Corporation and of all books, papers, records, documents, and other instruments belonging to the Corporation, and he shall maintain a membership register.

56. TREASURER OF THE CORPORATION. The treasurer shall keep or cause to be kept full and accurate books of account in which shall be recorded all receipts and disbursements of the Corporation; he shall be chairman of the Finance Committee and, under the direction of the Finance Committee and the Board, shall control the deposit of money, the safekeeping of securities and the disbursement of the funds of the Corporation and he shall render to the Board at the meetings thereof, or whenever required of him, an account of all his transactions as treasurer and of the financial position of the Corporation.

57. OTHER OFFICERS. The duties of all other officers of the Corporation shall be such as the terms of their engagement call for or the Board requires of them. Any of the powers and duties of an officer to whom as assistant has been appointed may be exercised and performed by such assistant, unless the Board otherwise directs.

58. VARIATION OF DUTIES. From time to time the Board may vary, add to or limit the powers and duties of any officer or officers.

59. FIDELITY BONDS. The Board may require such officers, employees and agents of the Corporation as the Board deems advisable to furnish bonds for the faithful discharge of their duties, in such form and with such surety as the Board may from time to time prescribe. The cost of any such bond may be paid by the Corporation.

COMMITTEES

60. STANDING COMMITTEES. The Board shall appoint the Finance Committee and the Audit Committee annually at the first meeting of the Board after each election of directors.

61. EXECUTIVE COMMITTEE. The Board of Directors, whenever it consists of more than six may elect from its number an executive committee consisting of not less than three and shall have power to fix its quorum at not less than a majority of its members. Each matter arising at a meeting of the executive committee shall be determined by the majority of votes cast by the members present, each of whom shall be entitled to one vote.

The executive committee may exercise the full powers of the Board to deal with all matters which in its discretion it considers require attention prior to the next regular meeting of the Board and shall report every such action to the Board at its next meeting. The executive committee may at any time receive reports of other committees, authorize such studies and professional guidance as it considers advisable and make recommendations to the Board. The committee shall undertake other duties directed by the Board.

Notice of executive committee meeting stating the day, hour and place of the meeting shall be given to each member of the committee at least two days before the meeting is to take place, provided always that meetings of the executive committee may be held without notice if all committee members are present or those absent in writing waive notice or consent to the holding of the meeting in their absence.

62. OTHER COMMITTEES. The Board may from time to time as deemed necessary, appoint other committees and shall prescribe their duties.

63. COMMITTEE MEMBERS. Except the executive committee, each committee appointed by the Board shall be composed of not fewer than two directors and may include a committee member or members who are not directors. No committee shall have power to add to its number unless so authorized by resolution of the Board.

64. TERM OF OFFICE. Each member of a committee appointed by the Board shall hold office during the pleasure of the Board and shall cease to be a committee member upon acceptance by the Board of his resignation either as such committee member or as a director or upon appointment of his successor or his removal by resolution of the Board.

65. COMMITTEE CHAIRMAN. Each committee appointed by the Board shall have a chairman who shall be a director. The Board shall appoint such committee chairman except that the treasurer shall be chairman of the Finance Committee.

The chairman of a committee shall make or cause to be made a full and sufficient report to the Board without delay, and if practicable at the next following Board meeting, upon all decisions made by the committee and generally all matters considered by the committee in respect of which, in his opinion, the Board ought to be informed.

66. QUORUM. Subject to any regulations imposed from time to time by the Board, committees shall each have power to fix its quorum.

67. VACANCY. If and whenever a vacancy exists in any committee the remaining members of the committee may exercise all its powers. The Board may fill any vacancy in any committee from time to time.

68. PROCEDURE. Committee meetings may be held at the head office of the Corporation or at any other place in Canada. Each standing committee shall keep minutes of its meetings in which shall be recorded all actions taken by it. Other committees shall keep minutes if their terms of reference so provide. Questions

arising at any meeting of a committee shall be decided by a majority of votes and in the case of an equality of votes the chairman shall have the second or casting vote. Subject to any regulations imposed from time to time by the Board, committees may otherwise meet for the transaction of business, adjourn and regulate their meetings as they think fit.

69. AUDIT COMMITTEE. The Audit Committee shall be composed of directors only, not fewer than two, none of whom shall be officers or employees of the Corporation.

The Corporation shall submit the financia1 statement to the Audit Committee for its review and the financial statement shall thereafter be submitted to the Board. The auditor has the right to appear before and be heard at any meeting of the Audit Committee and shall appear before the Audit Committee when required to do so by the committee. Upon the request of the auditor, the chairman of the Audit Committee shall convene a meeting of the committee to consider any matters the auditor believes should be brought to the attention of the directors or members.

70. FINANCE COMMITTEE. The Finance Committee shall be composed of directors only, not fewer than two, one of whom shall be the treasurer who shall be chairman of the committee. The Vice Chairman of the Catalysis Division shall ex officio be a member of the Finance Committee. The Finance Committee shall advise and assist the treasurer in the performance of his duties. The committee shall undertake other duties directed by the Board.

BANKING ARRANGEMENTS AND CONTRACTS

71. CHEQUES, DRAFTS AND NOTES. All cheques, drafts or orders for the payment of money and all notes and acceptances and bills of exchange shall be signed by such officer or officers or person or persons, whether or not officers of the Corporation, and in such manner as the Board may from time to time designate.

72. SECURITIES SAFEKEEPING. The securities of the Corporation shall be deposited for safekeeping with one or more bankers, trust companies or other financial institutions to be selected by the Board. Any and all securities so deposited may be withdrawn, from time to time, only upon the written order of the Corporation signed by such officer or officers, agent or agents of the Corporation, and in such manner, as shall from time to time be determined by resolution of the Board and such authority may be general or confined to specific instances.

73. BORROWING. The Board may from time to time

(a) borrow money on the credit of the Corporation; or

(b) charge, mortgage, hypothecate or pledge all or any of the real or personal property of the Corporation to secure any money borrowed, or other debt, or any other obligation or liability of the Corporation.

From time to time the Board may authorize any director, officer or employee of the Corporation or any other person to make arrangements with reference to the monies borrowed or to be borrowed as aforesaid and as to the terms and conditions of the loan thereof, and as to the securities to be given therefor, with power to vary or modify such arrangements, terms and conditions and to give such additional securities for any monies borrowed or remaining due by the Corporation as the Board may authorize, and generally to manage, transact and settle the borrowing of money by the Corporation.

74. EXECUTION OF INSTRUMENTS. Contracts, documents or any instruments in writing requiring the signature of the Corporation may be signed by one of the president or a vice-president together with the secretary or the treasurer and all contracts, documents and instruments in writing so signed shall be binding upon the Corporation without any further authorization or formality. The Board shall have the power from time to time by reso1ution to appoint any officer or officers or any person or persons on behalf of the Corporation either to sign contracts, documents and instruments in writing generally or to sign specific contracts, documents and instruments in writing.

The seal of the corporation may when required be affixed to contracts, documents and instruments in writing signed as a aforesaid or by any officer or officers, person or persons, appointed as aforesaid by resolution of the Board.

The term "contracts, documents and instruments in writing" as used herein shall include deeds, mortgages, hypothecs, charges, conveyances, transfers and assignments of property real or personal, immovable or movable, agreements, releases, receipts and discharges for the payment of money or other obligations, conveyances, transfers and assignments of shares, stocks, bonds, debentures or other securities and all paper writings.

In particular without limiting the generality of the foregoing one of the president or a vice president together with the secretary or the treasurer shall have authority to sell, assign, transfer, exchange, convert or convey any and all shares, stocks, bonds, debentures, rights warrants or other securities owned by or registered in the name of the Corporation and to sign and execute (under the corporate seal of the Corporation or otherwise) all assignments, transfers, conveyances, powers of attorney and other instruments that may be necessary for the purpose of selling, assigning, transferring, exchanging, converting or conveying any such shares, stocks, bonds, debentures, rights, warrants or other securities.

INVESTMENTS - GRANTS - AWARDS

75. INVESTMENTS. Funds of the Corporation may be invested from time to time in such investments as are determined by the Board from among investments authorized under the laws of Canada.

76. GRANTS - AWARDS. The Board shall seek the advice of the Catalysis Division on proposals for grants and shall establish mechanisms for solicitation of proposals from the catalysis community. The Board may reserve funds for specific commitments and may make grants and awards within the purposes and objects of the Corporation out of the net income of the Corporation. A reservation of funds shall be authorized by resolution of the Board. No grant or award may be made out of capital. Any net income not spent or reserved in any fiscal year shall be added to and form part of the capital of the Corporation. Grants and awards may be made in honour of a specific person, persons or organization.

SUBMISSION OF CONTRACTS OR TRANSACTION TO MEMBERS FOR APPROVAL

77. The Board in its discretion may submit any contract, act or transaction for approval or ratification at any meeting of the members called for the purpose of considering the same and any contract, act or transaction that shall be approved or ratified by a resolution passed by a majority of the votes cast at any such meeting (unless any different or additional requirement is imposed by the Act) shall be as valid and as binding upon the Corporation and upon all the members as if it had been approved or ratified by every member of the Corporation.

PROTECTION OF DIRECTORS, OFFICERS AND OTHERS

78. INDEMNIFICATION. Each person who has been or is threatened to be made a party to any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative or investigative, by reason of the fact that he is or was a director, officer, employee or agent of the Corporation, or is serving or has served at the request of the Corporation as a director, officer, employee or agent of the Corporation, or is serving or has served at the request of the Corporation as a director, officer, employee or agent of another corporation, partnership, joint venture, trust or other enterprise, shall be indemnified by the Corporation against expenses (including attorneys' fees), judgments, fines and amounts paid in settlement actually and reasonably incurred by him in connection with such action, suit or proceeding, and expenses incurred in connection therewith may be advanced by the Corporation, all to the full extent and in the manner permitted by the Act.

The indemnification provided by this section shall be deemed exclusive of any other rights to which those indemnified may be entitled under any by-law, agreement, vote of members or disinterested directors or otherwise, both as to action in his official capacity and as to action in another capacity while holding such office and shall continue as to a person who has ceased to be a director, officer, employee or agent and shall inure to the benefit of the heirs, executors and administrators of such a person.

79. INSURANCE. Subject to the limitations contained in the Act, the Corporation may purchase and maintain such liability insurance for the benefit of its directors and officers, as such, as the Board may from time to time determine.

80. PROTECTION OF DIRECTORS. No director or officer for the time being of the Corporation shall be liable for the acts, receipts, neglects or defaults of any other director or officer or employee or for joining in any receipt or act for conformity or for any loss, damage or expense suffered or incurred by the Corporation through the insufficiency or deficiency of title to any property acquired by the Corporation or for or on behalf of the Corporation or for the insufficiency or deficiency of any security in or upon which any of the monies of or belonging to the Corporation shall be placed out or invested or for any loss or damage arising from the bankruptcy, insolvency or tortious act of any person, firm or corporation, including any person, firm or corporation with whom or which any monies, securities or effects shall be lodged or deposited, or any loss, conversion, misapplication or misappropriation of or any damage resulting from any dealings with any monies, securities or other assets belonging to the Corporation or for any other loss, damage or misfortune whatever which may happen in the execution of the duties of his respective office or trust or in relation thereto unless the same shall happen by or through his own wrongful and wilful act or through his own wrongful and wilful neglect or default.

The directors for the time being of the Corporation shall not be under any duty or responsibility in respect of any contract, act or transaction whether or not made, done or entered into in the name or on behalf of the Corporation, except such as shall have been submitted to and authorized or approved by the Board of Directors. If any director or officer of the Corporation shall be employed by or shall perform services for the Corporation otherwise than as director of officer or shall be a member of a firm or a shareholder, director or officer of a company which is employed by or performs services for the Corporation the fact of his being a director or officer of the Corporation shall not disentitle such director of officer or such firm or company, as the case may be, from receiving proper remuneration for such services.

ENACTMENT AND AMENDMENT OF BY-LAWS

81. By-Laws of the Corporation may be enacted, and such by-laws repealed or amended, by by-laws enacted by a majority of the directors at a meeting of the Board and sanctioned by an affirmative vote of at least 66 2/3 percent of the members present at a meeting of members duly called for the purpose of considering the said by-laws, provided that the repeal or amendment of by-laws not embodied in the letters patent of the Corporation shall not be enforced or acted upon until the approval of the Minister has been obtained.

FINANCIAL YEAR

82. The financial year of the Corporation shall end on the 31st day of December in each year.

AUDITOR

83. The members shall at each annual meeting appoint one or more persons licensed under the Public Accountancy Act as auditors to hold office until the next annual meeting, and if an appointment is not so made the auditor in office shall continue in office until a successor is appointed. The remuneration of an auditor appointed by the members shall be fixed by the Board unless otherwise directed by the members at the time of the auditor's appointment.

PASSED by the Board and sealed with the corporate sea1 this 29 day of June, 1990.

President Secretary

APPENDIX 3: BYLAWS OF THE NORTH AMERICAN CATALYSIS SOCIETY

Version of April 2013 Approved by the Membership

We, the members hereof, associate ourselves for these purposes: to promote and encourage the growth and development of the science of catalysis and those scientific disciplines ancillary thereto; to organize and participate in professional meetings of scientists; to report, discuss and exchange information and viewpoints in the field of catalysis; to serve as a central exchange for the several catalysis club(s)/society(ies) (hereafter referred to as societies) concerning information on their activities; and to provide liaison with foreign catalysis societies, with the International Association of Catalysis Societies, and with other scientific organizations and individuals.

ARTICLE I Name

Section 1. The name of this corporation shall be: The North American Catalysis Society,(NACS).

ARTICLE II Membership

Section 1. Any person from North America associated, directly or indirectly, with the fields of endeavor referred to in the purpose clause of these Bylaws, shall be eligible for full membership.

Section 2. All members of any affiliated North American catalysis society(ies) shall become individual members of the NACS in the event of an appropriate resolution of affiliation enacted by the Executive Board of similar governing body of such catalysis society(ies), as hereinafter provided.

Section 3. Any North American catalysis society(ies) in existence at the time of the adoption of these Bylaws may thereafter affiliate with the NACS by resolution of its Executive board or similar governing body.

Section 4. Any North American catalysis society(ies) founded after the adoption of these Bylaws may affiliate with the NACS by resolution of its Executive Board or similar governing body, but only after being invited to do so by the Board of Directors of the NACS.

Section 5. Nothing herein shall preclude members of any catalysis society(ies) from becoming individual members of the NACS, notwithstanding that such catalysis society(ies) may not have been invited to affiliate with the NACS.

Section 6. Persons from outside North America may indicate their interests in joining NACS as Associate Members. As Associate Members they do not have to pay dues, and they are not eligible to vote on elections and other matters pertaining to the NACS.

Section 7. The local clubs shall be entities that are separate from the NACS.

ARTICLE III
Dues, Finances and Compensation

Section 1. Membership fees shall be paid in such amounts and for such periods as shall be determined by the Board of Directors.

Section 2. The fiscal year of the NACS shall end on December 31.

Section 3. No compensation shall be paid to any officers or directors for their services rendered to the NACS in such capacities; provided, however, that this shall not preclude such officers and directors from being reimbursed for expenses incurred by them in the conduct of their activities in such capacities, at the discretion of the Board of Directors.

ARTICLE IV Location

Section 1. The registered office of the NACS shall be located within the Commonwealth of Pennsylvania, at such place as shall be determined by the Board of Directors. The principal office of the NACS shall be located at such place as shall be determined by the Board of Directors without restriction as to jurisdiction.

ARTICLE V Officers

Section1. The officers of the NACS shall consist of a President, Vice-President, Secretary, Treasurer, Lead Trustee, and Communications Director.

Section 2. No one person shall be entitled to hold two office positions at any one time. Section 3. Only members of the NACS shall be eligible for election to office.

ARTICLE VI Duties of Officers

Section 1. The President shall be the chief executive officer of the NACS and shall preside at all meetings of the membership and/or the directors; he/she shall call all meetings of the directors; he/she shall have general and active management of the business of the NACS and shall, either directly or by delegation, see that all orders and resolutions of the Board of Directors and that all duties of the officers are properly performed; he/she shall submit interim reports of the operation of the NACS to the membership as and when meetings of the membership shall be held and to the Board of Directors at their various meetings as hereinafter provided; he/she shall appoint all committees except as herein otherwise provided, and he/she shall be an ex-officio member of all committees so appointed; he/she may delegate the performance of any of the foregoing; he/she shall execute any and all contracts and other documents in behalf of the NACS pursuant to authority delegated to him/her for such purposes by resolution duly adopted by the Board of Directors, and he/she shall perform such other duties as may be prescribed by the Board of Directors from time to time.

Section 2. The Vice-President shall perform all duties of the office of President in the latter's absence, incapacity or arbitrary refusal to act, and, when so acting, shall have all powers of and be subject to all restrictions upon the office of President. Further, he/she shall perform such other duties as may be prescribed by the Board of Directors or by the President, from time to time.

Section 3. The Secretary shall attend all meetings of the Board of Directors and of the membership and shall perform the following various duties: he/she shall maintain a list of the membership and their addresses; he/she shall record minutes of all meetings in a book to be maintained for that purpose and, when required, shall perform a similar service for all standing committees; he/she shall send to the Board of Directors and/or to the membership all notices as to the business of the NACS and as to the time, date and place of all meetings to be held of the Board of Directors and/or of the membership, respectively; he/she shall engage in, and maintain records of, all correspondence as required by the business of the NACS; he/she shall be the custodian of the corporate seal and of all books and records of the NACS, except as herein otherwise provided; he/she shall attest any and all contracts and other documents, and shall affix the corporate seal as necessary, in behalf of the NACS pursuant to authority delegated to him/her for such purposes by resolution duly adopted by the Board of Directors or by the President, from time to time. In the event of the Secretary's absence, incapacity of arbitrary refusal to act, his/her duties shall be performed by a Secretary Pro Tem appointed by the Board of Directors or by the President.

Section 4. The Treasurer shall be the custodian of all funds as well as financial books and records of the NACS and shall deposit all such funds in the name of the NACS in such depository or depositories as shall be designated by the Board of Directors; he/she shall collect and receive all fees, contributions and grants paid to the NACS; he/she shall pay all vouchers and obligations pursuant to authority duly granted to him/her by the President and Secretary or be resolution of the Board of Directors; he/she shall prepare and submit complete an accurate interim financial reports of the finances of the NACS as and when meetings may be held, as well as to the Board of Directors at any time upon request therefrom, and he/she shall perform such other duties as may be prescribed by the Board of Directors or by the President, from time to time.

Section 5. The Lead Trustee shall monitor and assign variety of investment vehicles with input from trustees; lead sub-committee (of trustees, President and Treasurer) that reviews investment decisions; review investment strategy (biannual); generate annual financial report by March 15 for IRS reporting; and with accountant prepare 990 tax form and submit to IRS by May 15 of each year.

Section 6. The Communications Direction shall maintain and add new content in the NACS website; renew website domain name as scheduled by payments in register.com; publish a Newsletters with a target of four issues per

year; maintain a list of current members from local Clubs; maintain an email distribution list of members; update distribution list in mail server as needed; provide mailing list for rental on a fee per use basis to customers; administer electronic elections for Director-at-Large every 4 years or other events as needed; and arrange contract for electronic website for voting and generate usernames and passwords for electronic ballots.

ARTICLE VII Bonds

Section 1. The Board of Directors may require any of the officers to be bonded at such times and for such amounts as it shall deem necessary.

Section 2. The Board of Directors may require the administrators (trustees) of the Keith Hall Educational Fund and any outside professional who assumes an active role in administering the proceeds of the Fund to be bonded.

ARTICLE VIII Board of Directors

Section 1. The Board of Directors shall consist of members elected by the affiliated catalysis society(ies), one from each, six (6) members elected from the members elected at large by the membership of the NACS, and any officers (elected by the Board) who are not already members of the Board.

Section 2. Only members of the NACS shall be eligible for election to the Board of Directors.

ARTICLE IX
Duties and Powers of the Board of Directors

Section 1. The property and business of the NACS shall be managed by the Board of Directors.

Section 2. In addition to the general powers of the Board of Directors existing by virtue of their office, the powers and authority expressly given by law, by the terms of the Articles of Incorporation of the NACS, and elsewhere in these Bylaws, the following specific powers are expressly conferred on the Board of Directors.

To appoint and/or remove any and all agents, servants or employees of the NACS, other than the members of the Board of Directors and the officers, and to determine their duties and salaries, as well as to delegate such powers to an officer of the NACS; to authorize the negotiating and executing of all contracts, documents and instruments appropriate for the proper operation of the NACS; to delegate any powers of the Board of Directors to any committee of Board members, not less than two (2) in number, for so long and under such terms as the Board may determine; to establish policies of the NACS and to direct the execution of the same, pursuant to the purposes of the NACS, and generally to do all lawful acts and things as are not herein otherwise delegated or directed to be done by the membership or officers of the NACS.

ARTICLE X
Meetings of the Board of Directors

Section 1. The Board of Directors shall meet at least annually at the call of the President. In addition, the Board of Directors shall meet intermittently at such times and places as may be set by resolution duly adopted at duly convened meetings of the Board of Directors.

Section 2. Special meetings of the Board of Directors shall be called by the President and/or Secretary as and when they or either of them shall deem it necessary, or upon the signed written request of any three (3) members of the Board of Directors, the times and places of such special meetings to be determined by the officer calling the same.

Section 3. The Secretary shall send to each member of the Board of Directors, at least one (1) week’s prior written notice of any special meeting and at least ten (10) days prior written notice of any annual or intermittent meeting.

Section 4. Not withstanding Article 20, the Provisions of the ARTICLE may be amended at any regular duly convened meeting by a majority vote of the members of the Board of Directors present and voting at such meeting.

ARTICLE XI Meetings of the Membership

Section 1. Meetings of the membership in general shall be held at such times and places as shall be determined by the Board of Directors.

Section 2. Notices of the meetings of the membership in general shall be given to each member at least thirty (30) days in advance of the date of such meeting, provided that the payment of such member's membership fee is not then in default.

Section 3. Location of national biennial technical meetings of the NACS shall rotate around the membership clubs. For this purpose these meetings shall be operated by the local society. For these meetings the NACS shall be responsible for the selection of the meeting organizers. For this meeting, the operating local society has an "agency" (as defined by the US IRS in 2000) relationship with the NACS for the organization and operation of the meeting.

ARTICLE XII Notices

Section 1. Notices of all meetings of the membership and of the Board of Directors shall be mailed to each member of the NACS or of the Board of Directors, addressed to such members or directors latest addresses, as recorded in the books of the NACS.

Section 2. Attendance by a member or by a Director at any meeting shall constitute a waiver of notice of such meeting, except where attendance at such meeting is for the express purpose of objecting to the transaction of business because said meeting was allegedly not lawfully or duly called or convened, and where such objection is made immediately following the convening of such meeting.

Section 3. Any notice may be waived in writing, signed by the person or persons entitled thereto, either before or after the time and date stated therein, and such waiver shall be entered into the minutes of the meeting held pursuant to such waiver of notice.

Section 4. Neither the business to be transacted at, nor the purpose of any membership meeting, or any annual or intermittent meeting of the Board of Directors, need be stated in any notice or waiver of notice of such meeting unless otherwise specifically required by law or by these Bylaws. Notice of any special meeting of the Board of Directors shall contain the purpose of, and a brief description of the business to be transacted by such meeting.

ARTICLE XIII
Nominations, Elections and Terms of Office

Section 1. The members of the Board of Directors to be elected by the membership at large shall be elected from a slate of not fewer than ten (10) nominees selected by the Nominations Committee, appointed by the President. Election shall be by electronic ballot of the membership of the NACS. Any member of the NACS shall be added to the slate upon receipt by the President of the NACS, no more than one-half of whom shall be members of any one affiliated catalysis society(ies), provided that the petition shall be received by the President prior to the first of January of the year in which new members of the Board of Directors are to be elected. Election shall be by plurality vote. The elected at-large members of the Board of Directors will be seated at the next meeting of the Board of Directors and will be the at-large members who vote for the election of new officers.

Section 2. The one (1) member of the Board of Directors from each affiliated catalysis society(ies) shall be elected by the respective catalysis society(ies) in accordance with its internal procedures.

Section 3. Nominations for the officers shall be made at a Board meeting and elected by the Board of Directors at a meeting of such Board convened with reasonable dispatch after the election of such Board. The officers shall take office on July 1, 2001, and every four years thereafter.

Section 4. The term of office for all officers and members of the Board of Directors shall be four (4) years. All officers and members of the Board of Directors shall continue in their respective capacities until their successors are elected.

Section 5. Any vacancies in the Board of Directors or among the officers arising by reason of death or resignation, shall be filled for the unexpired term by a majority vote of the remaining members of the Board of Directors present and voting at the first meeting held after such death or resignation. In the event that the President is no longer able to serve (for reasons of death or resignation), the Vice-President shall assume his/her duties until a meeting of the Board of Directors within 2 months of the loss of the elected President. In the event that neither the President nor the Vice President is able to serve, the Executive Committee shall elect one of its members to serve as the

operating officer (by majority voting) until an emergency meeting of the Board of Directors can be convened (within 2 months of the vacancies).

Section 6. Election of officers and of members of the Board of Directors shall be by closed, written ballot, whether submitted at a meeting or by mail.

Section 7. Any member who shall have paid his/her dues shall be eligible to hold office in the NACS, whether as an officer or as a member of the Board of Directors.

ARTICLE XIV Quorum

Section 1. A quorum for the purpose of holding a meeting of the membership generally shall consist of such members as shall be in attendance at the time and place when such meeting is to convene.

Section 2. A quorum for the purpose of holding any meeting of the Board of Directors shall consist of a majority of all of the members of the Board, exclusive of any member who may have resigned or died. If a quorum is unavailable for any meeting of the Board of Directors, that meeting shall be adjourned to a new time and place, due notice of which shall be given to the members of the Board of Directors, in which event a quorum, for purposes of the said adjourned meeting, shall consist of such members of the Board of Directors as shall be in attendance at the time and place when such adjourned meeting is to convene.

ARTICLE XV V oting

Section 1. All matters to be voted upon by the general membership, other than election to the Board of Directors, shall be determined by majority vote of the members voting.

Section 2: The act of the majority of the members of the Board of Directors present at a meeting of the directors at which a quorum is present shall be the act of the Board. Members of the Board of Directors may participate in a meeting of the Board by means of conference telephone or similar communications equipment whereby all persons participating in the meeting can hear each other, and participation in a meeting in this manner shall constitute presence in person at the meeting. In the absence of a meeting by a majority of the members of the Board, resolutions can be enacted by a majority written consent of all the members of the Board.

Section 3. Each member of the Board of Directors shall be entitled to one (1) vote in such capacity at the meeting of the Board, and each member of the NACS shall be entitled to one (1) vote in such capacity.

Section 4. Proxy voting at membership shall be permitted, provided that such proxy is executed in writing by the individual entitled to cast such vote and provided such proxy specifies the meeting at, or the duration for which, such proxy shall be effective.

Section 5. Mail balloting at membership meetings shall be permitted, provided that such mail ballot is signed by the member entitled to cast such vote. If the matter being voted upon is to be the subject of a membership meeting, such mail ballot shall be valid only if received no later than the convening of such meeting. If the matter being voted upon is the subject of a general mail ballot only, such mail ballot shall be valid only if received no later than the date specified for such purpose in the material promulgating to the membership the subject to be voted upon.

ARTICLE XVI
Inspection of Books, Accounts and Records

Section 1. The books, accounts and records of the NACS shall be open for inspection at any time by any officer or member of the Board of Directors.

Section 2. The books, accounts and records of the NACS shall be open for inspection by any member of the NACS at such reasonable times and places as may be designated by resolution duly adopted by the Board of Directors; provided, however, that the Board of Directors shall designate a time and place for the examination of such books, accounts and records by the membership immediately prior to, during, or immediately following any membership meeting which may be held.

ARTICLE XVII Committees

Section 1. The President shall appoint the Nominations Committee to suggest candidates for officers of the NACS; at the time of elections of the officers, additional nominations may be received from those attending the Board meeting.

Section 2. In addition to such committees as the President may appoint pursuant to these Bylaws, the Board of Directors may establish and appoint, from time to time, such additional standing and/or special committees as it may deem appropriate.

Section 3. The Executive Committee shall be comprised of elected officers and key functional positions within the NACS. Members of the Executive Committee shall be designated by the President, but should include: the President, Vice-President, Secretary, Treasurer, Lead Trustee of the Keith Hall Educational Fund, Communications Director, Archivist, and the most recent living past President.

Section 4. The President may call a meeting of the Executive Committee to seek its advice.

Section 5. An Awards Committee shall be appointed by the President and led by the Vice President, for the purpose of soliciting suggestions for nominations for the professional award. This committee should be selected in a manner to avoid conflict of interests in the award process.

ARTICLE XVIII Corporate Seal

Section 1. The Secretary shall hold the Corporate Seal

ARTICLE XIX Amendments to Bylaws

Section 1. These Bylaws may be amended by a majority vote of the members voting either (a) in person, by proxy or by mail ballot receive at a duly convened membership meeting of the NACS, or (b) by electronic ballot circulated at the instance of the Board of Directors, provided that notice of the proposed amendment shall be contained in the notice of such duly convened meeting or in such electronic ballot so circulated.

ARTICLE XX Adoption of Bylaws

Section 1. These Bylaws shall be adopted by a majority of votes cast of the general membership as herein provided, and shall become effective immediately thereafter.

ARTICLE XXI Procedural Requirements

Section 1. All meetings of the Board of Directors and all meetings of the membership of the NACS shall be conducted pursuant to Roberts' Rules of Order, these Bylaws, and to any additional rules adopted by such meetings not inconsistent with either of the foregoing.

ARTICLE XXII Professional Awards

Section 1. The NACS has established a series of professional awards for distinction in catalysis. The President is responsible for the selection of a jury for each award, which shall be made up of established technologists in catalysis without having any conflicts of interest in the nominations or award process. Each jury shall be made up of at least 3 persons appointed by the President. Their decisions shall be confidential and reported only to the President, who then tallies the voting, and notifies the winner.

ARTICLE XXIII Keith Hall Educational Fund

Section 1. Within NACS shall be the Keith Hall Educational Fund (Fund), disbursements from only the net income of which shall be made for the support and maintenance of the tax-exempt activities of NACS, including but not limited to national lectureships, seminars and symposia, assistance for attendance at national meetings of NACS for graduate students or post-doctoral fellows, and award recognizing contributions to the furtherance of the field of catalysis. Although the Fund shall be subject to the ultimate administration of the Board of Directors of NACS, it may be administered on a day- to-day basis by "trustees," who shall be appointed by the President of NACS for staggered 6 year terms, with the concurrence of the Executive Committee of NACS. One of these trustees shall be designated by the President as the Lead Trustee, who shall be responsible for reporting the status of the

Fund on a quarterly basis to the President and to the Board on an annual basis. These trustees shall receive, hold, invest, and reinvest the assets of the Fund.

Section 2. The President is empowered to replace an appointed trustee for due cause subject to the approval of a majority of the Executive committee and confirmation by the Board of Directors.

ARTICLE XXIV Restrictions and Interpretation.

Section 1.No part of the net earnings of NACS shall inure to the benefit of, or be distributable to, its members, directors, officers, or other private persons, except that NACS shall be authorized and empowered to pay out of pocket expenses for services rendered and to make payments and distributions in furtherance of the purposes of NACS. Approval of the President is required for such expenses, which are to be reported to the Board at its annual meeting.

Section 2.No substantial part of the activities of NACS shall be the carrying on of propaganda, or otherwise attempting to influence legislation. NACS shall be empowered to make the election provided by IRC § 501(h). NACS shall not participate in, or intervene in (including the publishing or distribution of statements) any political campaign on behalf of or in opposition to any candidate for public office.

Section 3.Notwithstanding any other provisions of these Bylaws or the Articles of Incorporation, NACS shall not carry on any activities not permitted to be carried on (i) by a corporation exempt from federal income tax under IRC § 501(a) by reason of description in IRC §501(c)(3), or (ii) by a corporation, contributions to which are deductible under IRC § 170(c)(2).

ARTICLE XXV Dissolution

Section 1. Upon the dissolution of NACS, the Board of Directors shall, after paying or making provisions for the payment of all of the liabilities of NACS, dispose of all of the assets of NACS exclusively for one or more of the purposes of NACS which may include distribution to an organization or organizations organized and operated exclusively for one or more of such purposes, or shall distribute all of the assets of NACS to the federal government, or to a state or local government, for a public purpose. Any assets not so disposed of shall be disposed of by the Circuit Court of the county in which the principal office of NACS is then located, exclusively for such purposes or to such organization or organizations, as said court shall determine, which are organized and operated exclusively for one or more of the purposes of NACS.

APPENDIX 4: CONSTITUTION OF THE INTERNATIONAL ASSOCIATION OF CATALYSIS SOCIETIES (IACS)

Version adopted by the IACS Council at the 14th ICC, Seoul, *July 13, 2008*
www.iacs-catalysis.org/constitution.html

WHEREAS, the International Congress on Catalysis, Inc., a corporation of Pennsylvania, USA, organised the first International Congress in Philadelphia in 1956 and participated in the planning of subsequent Congresses in Paris in 1960 and Amsterdam in 1964, with the objective of furthering the science and technology of catalysis.

AND WHEREAS, such Congresses have provided:

Means for open exchange of information and knowledge on catalysis and related science and technology;

Opportunities for scientists and engineers of participating countries to make personal contacts.

THEREFORE, in view of the continuing and growing interest in catalysis, it has been agreed to establish an international organisation to further the above objectives. The new organisation was originally called International Congress on Catalysis, but its name has been changed in 1996 to International Association of Catalysis Societies. It has further been agreed that this organisation seeks continued affiliation with the International Union of Pure and Applied Chemistry (IUPAC). In order to assure regularity in all actions and perpetuity thereof, the following Constitution of the International Association of Catalysis Societies has been agreed and approved.

Article 1. General

The name of the organisation shall be International Association of Catalysis Societies. Its objectives shall be generally to promote scientific and technological progress in the field of catalytic chemistry, and specifically to provide a forum for formal and informal discussions amongst scientists and engineers from time to time by promoting the organisation of International Congresses on Catalysis, hereafter referred to as ICC. Attendance at an ICC shall be open to all interested scientists and engineers. The operation of the International Association of Catalysis Societies shall be carried on by a Council and an Executive Committee whose purpose and method of operation are hereinafter described. The International Association of Catalysis Societies represented by its Executive Committee controls the use of its name and that of the International Congress on Catalysis.

Article 2. Objectives of the Council Objectives of the Council shall be:

(a) To coordinate an effective network of relationships between the main associations of catalysis world-wide and in particular:

• to coordinate and make more effective meetings on catalysis, avoiding unnecessary duplication and stimulating discussion in new areas of catalysis science
• to strengthen international relationships and scientific collaboration world-wide and as a reference organisation to stimulate funding agencies to adopt a wide perspective
• to initiate joint actions for more effective integration of research world-wide
• to be a forum for the discussion of common problems within the catalysis community
• to promote the visibility of catalysis outside the catalysis community and emphasise its relevance to society and environment
• to promote educational aspects of catalysis and to assist young researchers by the effective diffusion of knowledge and by facilitating their mobility within the catalysis community
• to create an efficient communication network by whatever means appropriate for the non-commercial distribution of information regarding meetings, appointments, and general information.

(b) To promote discussions of the science and technology of catalysis and related subjects from time to time by inviting appropriate groups in various countries to organise and hold International Congresses on Catalysis at a convenient interval of years, and also to decide upon the dates for holding these ICCs.

(c) To ensure that each ICC shall contribute its full share toward the object (b) above, and to maintain continuity, the Council looks after all matters concerning International Congresses on Catalysis.

Article 3. Membership of the Council

(a) The Council shall be composed of duly accredited delegates of member countries or groups of countries. Each member country or member group of countries shall have two delegates. The Council decides by secret ballot on the admission of new member countries or groups of countries, and the removal of the names of countries that either no longer exist as states represented in IUPAC or no longer fulfil the conditions for admission. A minimum condition for membership is that scientists working in that country, or group of countries, have contributed several papers to recent International Congresses on Catalysis. Admission or removal of a member requires a three-fourths (3/4) majority vote of the Council. Membership of a group of countries excludes each country of that group from direct membership, unless the Council decides on a new definition of the remaining group. Before each Council meeting, the Secretary provides all Council members with a list of the countries and groups of countries that are members of the Council; this list also states explicitly which countries form part of a member group and which countries, if any, have changed their official names since the previous Council meeting. After approval by the Council, this list will be attached to the minutes of the Council meeting.

(b) Appointment of delegates will be made by a national or multinational organisation, competent in the field of catalysis. Problems concerning the appointment of delegates to the Council or the selection of the organisations that make these appointments will be submitted to IUPAC for resolution.

(c) The normal term of office of delegates shall be from the beginning of one ICC to the beginning of the next. If new appointments are made by a national or multinational organisation, competent in the field of catalysis, between two ICCs, the term of office ends with the beginning of the next IACS Council.

(d) A member should not serve more than two consecutive terms unless elected to the of Vice-President.

(e) Officers of the Council shall hold office from the end of each Congress until the end of the next. If any Officer of the Council is not being appointed a delegate for a further period, the new delegate to replace him/her shall be permitted to attend the Council meeting, but without the right to vote.

(f) When a delegate is unable to attend a meeting of the Council, an alternate may serve in his/her stead. Accredited delegates unable to attend such a meeting may each nominate one leading representative of the catalysis community from their country to represent them; such nomination must be received in writing by the Secretary at least one week before the meeting, to ensure circulation of papers.

Article 4. Officers of the Council

The Council at each ICC shall elect by secret ballot a Vice-President, Secretary, Treasurer and a representative chosen from the delegates of the Council. The Vice-President becomes President after the next ICC. On the event of loss of both the President and Vice-President, the Executive Committee shall designate a temporary executive officer until the meeting of the next Council meeting. No more than two of these five Officers may be from the same nation. Election of Officers is by majority vote of the Council.

Article 5. Executive Committee

The Officers of the Council constitute the Executive Committee. The main functions of the Executive Committee are as follows:

(a) The Executive Committee cooperates with the Congress Committee organising the next ICC to ensure that the standard of scientific papers and organisation of the meeting is in line with the tradition of the ICCs.

(b) If unforeseen circumstances force a Congress Committee to relinquish its task, the Executive Committee will take the steps necessary to obtain a decision of the Council in agreement with its Objectives described in Article 2.

(c) The Executive Committee arranges to supply to the press and other news media information concerning activities of the ICC.

(d) The Executive Committee arranges for the financing of the Council and itself.

(e) The Executive Committee is authorised to appoint a Deputy Treasurer who will act in the case of an emergency or if the Treasurer is incapacitated.

Article 6. Officers

(a) The President of the Council, who shall also be Chairperson of the Executive Committee, shall supervise the work of the Council and its Executive Committee, preside at their meetings, and be responsible for the executions of the decisions of these bodies. He or she shall represent the Council at ICCs and between ICCs.

(b) Should the President be absent for any reason, the Vice-President shall take his/her place. Should the President become permanently incapacitated, the Vice-President shall automatically become President and fulfil the President's unexpired term. If a member of the Executive Committee other than the President is permanently incapacitated, the President, after consultation with members of the Executive Committee, will invite a Council member to join the Executive Committee.

Article 7. Secretary

(a) The Secretary shall function for both the Council and the Executive Committee.

(b) The Secretary shall prepare minutes of meetings of the Council and the Executive Committee and distribute these to members of the respective bodies.

(c) The Secretary receives and distributes to members of the Council petitions for admission of new countries to the Council and for changes in bylaws.

(d) The Secretary notifies scientific bodies in countries represented in the Council, at least six months before an ICC, to review and certify their representation on the Council.

(e) The Secretary conducts election for Officers of the Council, unless he/she is a candidate, in which case the President shall appoint an alternate.

Article 8. Treasurer

(a) The Treasurer shall receive funds required for the operation of the Council and its Executive Committee by such means as shall be devised by the Executive Committee. He/she shall hold these funds and disburse them in accordance with the actions of the Executive Committee. He/she shall prepare a financial statement for presentation at the Meeting of the Council during each ICC.

(b) The Treasurer shall advise the Congress Committee on the income from registration fees at previous Congresses and the principal costs of operating them. For this purpose the Treasurer shall maintain a file of non-confidential information on the finances of previous ICCs and hand this file over to the next Treasurer.

Article 9. Meetings

(a) The Council shall meet at the time of each ICC. The business of the Council will be handled, as much as possible, by correspondence. The Executive Committee may call additional meetings of the Council, between two consecutive ICCs, at major international meetings on catalysis. The quorum at such additional meetings shall be not less than four-tens (4/10) of the accredited delegates. Accredited delegates unable to attend such a meeting may each nominate one leading representative of the catalysis community from their country to represent them; such nomination must be received in writing by the Secretary at least one week before the meeting, to ensure circulation of papers. Such nominated persons will enjoy all the responsibilities and privileges of nationally accredited delegates for the purpose and duration of the additional meeting of the Council only. Actions consequent upon resolutions and decisions made at an additional meeting of Council shall be the responsibility of nationally accredited delegates.

(b) The Executive Committee shall meet at least once at the time of each ICC and at such other times as may be deemed necessary by the Executive Committee. A special meeting of the Executive Committee shall be held at the earliest convenient time following the written request of not less than two-thirds (2/3) of the countries represented in the Committee or in the Council.

(c) At each ICC, the Council shall decide on the country in which the next ICC will be held. All invitations received from accredited Council delegates on behalf of their national or multinational scientific organisations will be considered, provided that they contain a written commitment of the inviting organisation that every reasonable effort will be made to distribute extended

abstracts of all papers at least one month before the ICC. In addition, the ICC shall make every effort to publish the Plenary and Award lectures presented at the ICC in an archival publication organ, the choice of which shall be approved by the Executive Committee.

(d) Any delegate of the Council or member of the Executive Committee who is unable to attend a meeting may be represented by another delegate or non-member accredited for the purpose. This representative shall have the voting rights of the absentee delegate.

(e) The majority required for any vote or ballot in the Council and Executive Committee shall be a simple majority, except where otherwise stated in the Constitution.

(f) All Proceedings at the meetings of the Council and Executive Committee shall be conducted in English.

Article 10. Finance

(a) Normal financing of the expenses of the Council and the Executive Committee will be on the basis of a percentage of registration fees.

(b) A set proportion of 10% of the sum of all registration fees is to be turned over to the Executive Committee as a levy to support the organisation.

(c) The financial obligations of the Council and its Executive Committee shall be limited to correspondence, and when required, to providing expenses in relation to the objectives set out in Art. 2a, to providing expenses for Council Meetings whenever called, to providing secretarial help to the Secretary and assistance to the President to ensure his/her attendance at an ICC. The amount of money for secretarial and other assistance shall be determined by the Executive Committee.

(d) The expenses of the Council should as far as possible be paid from funds at the disposal of the Executive Committee. If the need for additional funds arises, the Executive Committee has the power to raise funds by any means that it thinks fit. Each year the Treasurer shall submit to the members of the Executive Committee a financial statement. He/she shall also report on finances at the meeting of the Council during each ICC, including a projection of future income and expenses.

Article 11. Congress Committee

(a) The appropriate scientific organisation(s) of the country hosting an ICC shall appoint a committee, known as the Congress Committee, which shall be subject to approval of the Executive Committee.

(b) The Congress Committee for each ICC, although enjoying every initiative and responsibility for carrying out the work it has undertaken, shall follow the general directions given by the Executive Committee to ensure that the permanent interests and objectives of the International Association of Catalysis Societies are maintained. To this end the Congress Committee shall keep the Executive Committee informed of the work undertaken for the preparation of the ICC. The Executive Committee shall cooperate with the Congress Committee in every possible way.

(c) The Congress Committee appoints a chairperson and such other officers as are required for handling local arrangements, financing, pre-printing, and publication of plenary and award lectures, etc.

(d) The Congress Committee has complete responsibility for all matters concerned with the ICC, with respect to the conduct and financing of the ICC, the final selection of papers on the programme and matters concerned with pre-printing of extended abstracts of papers and publication of Plenary and Award lectures.

(e) The Congress Committee may obtain funds for operating its ICC by registration fees, and by other means such as sponsorship by industry or government.

(f) The Executive Committee can assist in the financial arrangements for the next Congress. Upon written request by the Congress Committee organising the next Congress, the Executive Committee can provide a loan of up to a maximum of 30% of the sum received from the fee levy of the previous Congress. No interest is paid for the part of the loan which does not exceed 10% of the sum received from the fee levy of the previous Congress. The Executive Committee, advised by the Treasurer,

decides on the interest to be paid by the Congress Committee for the part of the loan exceeding this amount. The loan must be repaid within twelve months of the end of the Congress.

(g) The Congress Committee shall provide the Treasurer with a confidential statement, summarising the finances of the ICC, within twelve months of the end of the ICC. The Treasurer will destroy this statement and any copies of it after four years or when his/her term of office has finished.

Article 12.

Alterations of these Articles may be proposed by a member country at any meetings of the Council, but any such proposed alterations must also be seconded by another member country and submitted to the Secretary in writing not less than three months before the date on such a meeting. The proposed alterations shall be quoted in full on the agenda for that meeting and distributed in advance to the members of the Council. Any change in the Constitution shall result from a three- fourths (3/4) majority vote of those present at a meeting of the Council. These alterations are subject to approval by IUPAC.

In case of legal disputes, the law of the country where IUPAC has its permanent office will apply.

APPENDIX 5: Terms of Reference for CIC Catalysis Award

Chemical Institute of Canada
Institut de chimie du Canada

Catalysis Award

Terms of Reference

This award is presented biennially to an individual who, while resident in Canada, has made a distinguished contribution to the field of catalysis.

Deadline

October 1 on odd numbered years (i.e. 2019, 2021, 2023...).

Sponsor

Canadian Catalysis Foundation

Award

A rhodium-plated silver medal* and travel expenses to present the award lecture. The recipient will be required to present an award lecture at the Canadian Symposium on Catalysis or the CSC or CSChE conference. Membership in the Institute is not a prerequisite for receiving this award.

Nominations must include

- Citation (250 word maximum) statement of why the candidate should receive the award. This is the key document in the nomination and this information should be relevant to the achievements for which the award is being offered.
- Biographical Sketch (250 word maximum) This provides background information on the nominee and summarizes past accomplishments. This is a summary of information obtained from a C.V.
- Curriculum Vitae (maximum 9 pages).
- Supporting Letters (3 to 5) At least two letters must be from outside the nominee's organization.

If the nominee has previously received awards by the CIC and/or Societies, the nominator has to differentiate the current achievement from those that have been previously recognized.

The nomination shall remain in force for three consecutive odd years. Nominators are responsible for keeping the record of the nominee up to date and complete.

No award will be given out, if less than 3 nominations for the award are received or if the Committee considers that no suitable candidate has been nominated.

Selection Committee

- Vice-Chair of the Catalysis Division as non-voting chair
- Three most recent winners of the Catalysis Award

• In the event of a conflict of interest, the Division Chair shall designate an alternative member of the Executive to serve on the award jury

The award shall be presented biannually unless the Committee considers that no suitable candidate has been nominated.

*The medals have been purchased from, and engraved by, Rideau Recognition Solutions.