CURRICULUM VITAE- Recent activities

PROFESSOR ROBERT H. MORRIS
CHEMISTRY DEPARTMENT, UNIVERSITY OF TORONTO
rmorris@chem.toronto.ca

Abstract

History: BSc (Coop.) University of Waterloo, 1975 PhD University of British Columbia, 1978. Supervisor Brian James. Rhodium and Iridium Sulfoxide Complexes in Catalysis NATO Postdoctoral work with Prof. Joe Chatt and Dr G. J. Leigh, Nitrogen Fixation Lab, U. of Sussex, 1979. NATO Postdoctoral work with Prof. Greg Geoffroy, Pennsylvania State U., 1980. Assistant Professor, U. of Toronto, 1980-1985 Associate Professor, U. of Toronto, 1985-1989. Professor, U. Toronto, 1989- present. Acting Chair of Chemistry Department July-Dec. 2008. Interim Chair of Chemistry, July 2009 – June 2010. Chair of Chemistry, July 2010-2013. Killam Research Fellow 2015-2017.
Honours: Rutherford Medal in Chemistry from the Royal Society of Canada in 1991. Alcan Lecture Award from the Canadian Society for Chemistry, 1995. Fellow of the Chemical Institute of Canada, 1995. Canadian Society for Chemistry Award for Pure or Applied Inorganic Chemistry, 1998. Advisory boards of Can. J. Chem. (1996-1998) and J. Chem. Soc., Dalton Trans. (1997-2000), Fellow of the Royal Society of Canada, 2005. Dean's Excellence award 2009, 2010-12. Honorary Professor, Beijing University of Chemical Technology. 2013. Killam Research Fellow 2015-2017. RSC Inorganic Mechanisms Award 2017. Canadian Green Chemistry and Engineering Network Awards (Individual) 2017.
Research interests: organometallic and bioinorganic chemistry, homogeneous catalysis, hydride and dihydrogen complexes, green chemistry.
Research Contributions: 277 articles in refereed journals (H index 67 since 1977), 12 book chapters 3 PCT, 5 US, 5 Canadian patents issued, 24 PhD degrees and 21 MSc degrees granted to students supervised, 22 Postdoctoral fellows supervised, 110 Undergraduate students supervised, 192 Invited lectures, 259 Other contributions to conferences.
Research grants from NSERC, PRF, GreenCentre Canada, ORF, CFI, Compute Canada and Contracts from a Fragrance Company.
Courses: Chemistry, Inorganic Chemistry, Bioinorganic Chemistry, Organometallic Chemistry, Undergraduate research. Graduate research.

A. BIOGRAPHICAL INFORMATION

1. PERSONAL

University: Chemistry Department, University of Toronto, Toronto, Ont. M5S 3H6
phone: 416-978-6962
rmorris@chem.utoronto.ca

2. DEGREES

Ph. D. (inorganic chem.)	1978	University of British Columbia "Sulfoxide complexes of rhodium and Iridium" Supervisor: Professor Brian James
B.Sc. (co-op., hon).	1975	University of Waterloo

3. RECENT EMPLOYMENT

University of Toronto, St George Campus:

Chair, Chemistry	July 2010 – Jun 2013
Interim Chair, Chemistry	July 2009 – Jun 2010
Acting Chair, Chemistry	July-Dec 2008
Associate Chair, Graduate Studies in Chemistry	Jan-June 2008
Professor University of Toronto	1995-present.

4. RECENT HONOURS

2021 Special Issue of *Canadian Journal of Chemistry* in my honour.
2015 Killam Research Fellow (2015-2017). (5 awarded among scholars of all disciplines of arts and science in Canada)
2017 Royal Society of Chemistry (UK) Inorganic Mechanisms Award.
2017 Canadian Green Chemistry and Engineering Network Awards (Individual)

5. SELECTED PROFESSIONAL AFFILIATIONS AND ACTIVITIES

Fellow of the Chemical Institute of Canada (since 1995).
Member of the American Chemical Society (since 1980).
Chairman of the Inorganic Chemistry Program of the Canadian Society for Chemistry Conference, May 2010 and May 2017.
Director of the Mathematical and Physical Sciences (MPS) Division of the Academy III of the Royal Society of Canada 2009-2012

B. ACADEMIC HISTORY

6. A. RESEARCH ENDEAVOURS

Organometallic Chemistry. The development of new, green catalytic processes. The preparation of very active catalysts for the hydrogenation of polar bonds, including the first ones based on iron. The chemistry of dihydrogen and hydride complexes of transition metals including the first hydridic-protonic bonds (dihydrogen bonds) and the first dihydrogen complexes of the iron group elements. The acid-base properties of hydride and dihydrogen complexes.

B. SELECTED RESEARCH AWARDS

"Abundant Transition Metals in Catalysis" NSERC Discovery grant. Apr. 2018 – Mar. 2023. $105,000 per year for 5 years.
"Transition Metal Chemistry and Catalysis" NSERC Discovery Grant, 2013-2018, $124,000 per year for five years, total $620,000
"Developing catalysts based on iron" Killam Research Fellowship, Canada Council for the Arts, July 1,2015 to June 30, 2017 $70,000 pa
"Synthesis of iron catalyst for the Strem Chemical Catalog", Contract, Strem Chemical Company, July 1, 2015 to June, 2016, $2000 plus chemicals
"Sustainable iron catalysts for the hydrogenation of esters and carbon dioxide. "Connaught Innovation Award, Connaught Fund, Jan. 1, 2016 to Dec. 1, 2016, $89580
" Catalytic Synthesis of Specialty Chemicals from Sustainable Resources" NSERC Strategic Partnership Grants for Projects. Jan 1, 2017 to Dec 31, 2020. $372,000. Chin, Cathy (PI) with Perovic, D. My part $41,333 per year.
" Synthesizing renewable fuels using enzyme-derived catalysts." ORF Research Excellence 8. Sept. 2017- Aug. 2022. Edward Sargent (PI) with 6 co-applicants. Total funding $2M. My part: $20,000 per year.
"Computational resources for iron catalyst development." Resources for Research Groups, Compute Canada. Apr. 15, 2017 to April 1, 2021. $9,442 + $6067.

6.C. SELECTED PATENTS (3 PCT, 5 US, 5 Canadian patents issued)

166. **A. A. Mikhailine**, C. Sui-Seng, N. Meyer, **F. Freutel**, R. H. Morris "IRON(II) CATALYSTS CONTAINING DIIMINO-DIPHOSPHINE TETRADENTATE LIGANDS AND THEIR SYNTHESIS."*US Provisional Patent Application* **2008**, Filed Nov. 1, 2008. *Can. Patent Application* **2008**, Filed Nov. 1, 2008.. US Patent issued as number 8,716,507 in 2014 "Iron(II) catalysts containing diimino-diphosphine tetradentate ligands and their synthesis" Can. Pat. Appl. (2011), CA 2684197 A1 20110430.
207. **A. Mikhailine, P. Lagaditis, Weiwei Zuo** and R. H. Morris, "Iron Diphosphine Complexes" *US Provisional Patent Application* **2012.** patent issued as number US 9,597,673.

211. P. O. Lagaditis, J. F. Sonnenberg and R. H. Morris, "Iron catalysts containing tridentate PNP ligands, their synthesis and use thereof" *US Provisional Patent Application*, **2014**. Then PCT Patent Application, **2015. 20160326202-A1/ PCT/CA2015/050008**

C. RECENT SCHOLARLY AND PROFESSIONAL WORK.

7. Refereed publications

H index 67 with 18301 citations (Google Scholar) for 341 documents since 1977.
H Index 67 with 16253 citations (ISI) for 274 documents since 1977.
H index 67 with 16169 citations (Scopus) for 233 documents since 2003.

A. Selected Recent Articles (267 in total; Graduate students in bold)

201. **W. W. N. O** and R. H. Morris, "Ester Hydrogenation Catalyzed by a Ruthenium(II) Complex Bearing an N-heterocyclic Carbene Tethered with an "NH_2" Group and a DFT Study of the Mechanism" *ACS Catalysis*, **2013**, *3*, 32–40.
203. **J. F. Sonnenberg** and R. H. Morris. "Evidence for Iron Nanoparticles Catalysing the Rapid Dehydrogenation of Ammonia-Borane" *ACS Catalysis,* **2013,** 3, 1092–1102.
208. A. M. Appel, J. E. Bercaw, A. B. Bocarsly, H. Dobbek, et al. "Frontiers, Opportunities, and Challenges in Biochemical and Chemical Catalysis of CO_2" *Chem. Rev.* **2013**, *113*, 6621-6658.
210. W.W. Zuo, A. J. Lough, **Y. Li**, and R. H. Morris. "Amine(imine)diphosphines Activate Iron Catalysts in the Asymmetric Transfer Hydrogenation of Ketones and Imines" *Science*, **2013**, *342*, 1080-1083.
212 **P. O. Lagaditis**, **P. E. Sues**, **J. F. Sonnenberg**, **K. Y. Wan**, A. J. Lough and R. H. Morris, "Iron(II) Complexes Containing Unsymmetrical P-N-P′ Pincer Ligands for the Catalytic Asymmetric Hydrogenation of Ketones and Imines" *J. Am. Chem. Soc.*, **2014**, *136*, 1367–1380.
215. R. H. Morris, "Estimating the acidity of transition metal hydride and dihydrogen complexes by adding ligand acidity constants" *J. Am. Chem. Soc.*, **2014**, *136*, 1948–1959.
221. **J. F. Sonnenberg** and R. H. Morris, "Perspective: Distinguishing Homogeneous from Nanoparticle Asymmetric Iron Catalysis" Catalysis Science & Technology, 2014, *4*, 3426 – 3438. (invited for themed issue on Mechanistic Studies in Catalysis).
222. **D. E. Prokopchuk, B. T. H. Tsui**, A. J. Lough and R. H. Morris, " Intramolecular C-H/O-H Bond Cleavage with Water and Alcohol using a Phosphine-Free Ruthenium Carbene NCN Pincer Complex " *Chem. - Eur. J.*, **2014**, *20,* 16960–16968.
223. **P. E. Sues**, K. Cai, D. F. McIntosh and R. H. Morris, "Template Effect and Ligand Substitution Methods for the Synthesis of Iron Catalysts: A Two Part Experiment for Inorganic Chemistry" *J. Chem. Ed.*, *92*, 378-381.
225. W. Zuo and R. H. Morris, "Synthesis and use of an asymmetric transfer hydrogenation catalyst based on iron(II)" *Nature Protocols*, **2014**, 10, 241-257 (reviewed, invited, impact factor 13).
229. R. H. Morris, "Exploiting metal-ligand bifunctional reactions in the design of iron asymmetric hydrogenation catalysts" *Accounts of Chemical Research*, **2015**, 48, 1494–1502 (Special issue on Earth-Abundant Metals in Homogeneous Catalysis).
230. F. W. Zuo, D. E. Prokopchuk, A. J. Lough and R. H. Morris, "Details of the Mechanism of the Asymmetric Transfer Hydrogenation of Acetophenone Using the Amine(imine)diphosphine Iron Precatalyst: The Base Effect and The Enantiodetermining Step" *ACS Catalysis*, **2016**, *6*, 301-314.
231. R. H. Morris, "Brønsted−Lowry Acid Strength of Metal Hydride and Dihydrogen Complexes" *Chemical Reviews*, **2016**, 8588–8654 (invited for special issue on Transition Metal Hydrides).
233. **K. Y. Wan**, A. J. Lough and R. H. Morris, "Transition Metal Complexes of an (S,S)-1,2-Diphenylethylamine Functionalized N-Heterocyclic Carbene: a New Member of the Asymmetric NHC Ligand Family" *Organometallics*, **2016**, *35*, 1604-1612.
235. **K. Z. Demmans** and R. H. Morris, "Aqueous Biphasic Iron-Catalyzed Asymmetric Transfer Hydrogenation of Aromatic Ketones." *RSC Advances*, **2016**, 6, 88580 – 88587.
238. **M. M. H. Sung** and R. H. Morris, "DFT Calculations Support the Additive Nature of Ligand Contributions to the pKa of Iron Hydride Phosphine Carbonyl Complexes" *Inorg. Chem.*, **2016**, *55*, 9596−9600.237.
242 **S. A. M. Smith**, P. O. Lagaditis, **A. Lüpke**, A. J. Lough and R. H. Morris, "Unsymmetrical iron P-NH-P' complexes for the asymmetric hydrogenation of aryl ketones" *Chem. Eur. J.*, 2017, *23*, 7212-7216.

243 **K. Z. Demmans, C. S. G. Seo**, A. J. Lough, R. H. Morris, "From Imine to Amine: an Unexpected Left Turn. Cis-β Iron (II) PNNP' Precatalysts for the Asymmetric Transfer Hydrogenation of Acetophenone" *Chem. Sci.* 2017, *8*, 6531-6541.

245 **S. A. M. Smith, D. E. Prokopchuk,** A. J. Lough, R. H. Morris. "Asymmetric Transfer Hydrogenation of Ketones Using New Iron(II) (P-NH-N-P') Catalysts: Changing the Steric and Electronic Properties at Phosphorus P'" Israel J. Chem. 2017, *57*, 1204-1215, invited for special issue on Base Metal Catalysis.

246 **K. W. Yang, M. M. Sung**, A. J. Lough and R. H. Morris, "Half-Sandwich Ruthenium Catalyst Bearing an Enantiopure Primary Amine Tethered to an N-Heterocyclic Carbene for Ketone Hydrogenation" *ACS Catal.* 2017, *7*, 6827-6842.

247 R. H. Morris, "A capped trigonal pyramidal molybdenum hydrido complex and an unusually mild sulfur-carbon bond cleavage reaction" *Chem. Commun.*, **2017**, *53*, 11032 – 11035.

248. K. Y. Wan, F. Roelfes, A. J. Lough, F. E. Hahn and R. H. Morris, "Iridium and Rhodium Complexes Containing Enantiopure Primary Amine-Tethered N-Heterocyclic Carbenes: Synthesis, Characterization, Reactivity, and Catalytic Asymmetric Hydrogenation of Ketones" *Organometallics*, **2018**, *37*, 491–504.

250. R. H. Morris, "Mechanisms of the H_2- and transfer hydrogenation of polar bonds catalyzed by iron group hydrides" *Dalton Transactions*, **2018**, *47*, 10809–10826.

260 **D. Schnieders, B. T. H. Tsui, M. M. H. Sung,** M. R. Bortolus, G. J. Schrobilgen, J. Neugebauer and R. H. Morris, "Metal-Hydride Vibrations: the trans-Effect of the Hydride" *Inorg. Chem.*, **2019**, *18,* 12467-12479.

261. R. H. Morris, "Physical Insights into Mechanistic Processes in Organometallic Chemistry: an Introduction" *Faraday Discussions*, **2019**, *220*, 10-27. Invited for special issue.

265. **C.S. G. Seo, T. Tannoux, S. A. M. Smith,** A. J. Lough, R. H. Morris, " Enantioselective hydrogenation of activated aryl imines catalyzed by an iron(II) P-NH-P' complex." J. Org. Chem. **2019**, *84*, 12040-12049. 10.1021/acs.joc.9b01964

268. **M. V. Gradiski**, A. N. Kharat, **M. S. E. Ong**, A. J. Lough, **S. A. M. Smith** and R. H. Morris, "A One-Step Preparation of Tetradentate Ligands with Nitrogen and Phosphorus Donors by Reductive Amination and Representative Iron Complexes" *Inorg. Chem.*, **2020**, *59*, 11041-11053.

269. R. M. Bullock, J. G. Chen, L. Gagliardi, P. J. Chirik,et al., "Using Nature's Blueprint to Enable Catalysis with Earth-Abundant Metals" *Science*, **2020**, *369*, eabc3318 1-10.

272. **B. E. Rennie**, **R. G. Eleftheriades** and R. H. Morris, "Systematic Trends in the Electrochemical Properties of Transition Metal Hydride Complexes Discovered by Using the Ligand Acidity Constant Equation" *J. Am. Chem. Soc.*, **2020**, *142*, 17607–17629.

275. **C. S. G. Seo**, **B. T. H. Tsui**, **M. V. Gradiski, S. A. M. Smith** and R. H. Morris, "Enantioselective direct, base-free hydrogenation of ketones by a manganese amido complex of a homochiral, unsymmetrical P-N-P' ligand" *Catal. Sci. Technol.*, **2021**. DOI:10.1039/D1CY00446H.

B. Recent Book Chapter (10 in total)

237. Prokopchuk, D. E.; Smith, S. A. M.; Morris, R. H. "Ligands for Iron -based Homogeneous Catalysts for the Asymmetric Hydrogenation of Ketones and Imines" In *Ligand Design in Metal Chemistry: Reactivity and Catalysis*; Stradiotto, M.; Lundgren, R. J., Ed.; VCH Wiley: 2016, pp 205-236.

10. Papers presented at meetings and symposia (220 in total)

11. Selected Recent Invited Lectures (175 in total)

160-163. "Catalysis enabled by metal-ligand cooperation." Brock University, Oct. 2015. Princeton University, Nov. 2015. University of Winnipeg, Feb. 2016. University of Manitoba, Feb. 2016 (50 min).
164-165. "Catalysis enabled by metal-ligand cooperation." Pacific Northwest National Labs. May 2016. University of Washington, May 2016 (50 min).
166. "Catalysis enabled by metal-ligand cooperation." ACS Conference, Philadelphia, Aug. 2016.
167. "Catalytic asymmetric hydrogenation enabled by iron-ligand cooperation" Base Metal Catalysis Workshop, Princeton U. Sept. 2016.

168-171. "Catalysis enabled by metal-ligand cooperation." University of Strasbourg, University of Meunster, ETH Zuerich, Sep., University of Karlsruhe, Sep. 2016.
172. "Catalysis enabled by metal-ligand cooperation." University of Regina, Oct. 2016
173. "Catalysis enabled by metal-ligand cooperation." Laval University, Feb. 2017.
174. "Developing sustainable catalysts." University of Toronto, Ask a Laureate Lectures. May 2017.
177-179 "Mechanisms of the H_2- and transfer hydrogenation of polar bonds catalyzed by iron group hydrides" Dalton Conference, Warwick U., UK, plenary award lecture, U. Bath, UK, U. Leicester, UK, Apr 2018.
180. "2017 CGCEN Award Lecture: The use of abundant metals in homogeneous catalysts for asymmetric hydrogenation." CSC2018 Edmonton, May 2018.
181. "The use of the abundant metals iron and manganese in homogeneous catalysts for asymmetric hydrogenation" University of Ottawa, June 2018.
182. "Catalytic Asymmetric Hydrogenation. Practice and Theory." International Conference on Theoretical Aspects of Catalysis, ICTAC. UCLA, CA. Plenary Lecture. June 2018.
183. "The use of the abundant metals iron and manganese in homogeneous catalysts for asymmetric hydrogenation" University of Rochester, August 2018.
184. "Mechanisms of the asymmetric hydrogenation of ketones and imines catalyzed by iron- and manganese-group hydrides." R. H. Morris, 8th IRTG Symposium, Toronto, September 2018.
185. "The use of the abundant metals iron and manganese in homogeneous catalysts for asymmetric hydrogenation" Columbia University, New York. Nov. 2018.
188. "Vibrational spectroscopy as an indicator of the nucleophilicity of the hydride ligand" 102nd Canadian Chemistry Conference, Quebec City, Symposium on Inorganic Reaction Mechanisms. R. Morris*, D. Schnieders, M. Sung, B. Tsui, J. Neugebauer, 20 min. June 2020
189. "Physical insights into mechanistic processes in organometallic chemistry – an introduction" RSC Faraday Discussion Conference plenary lecture. September 2, 2019.
190. "Discovering sustainable catalysts." UTM, Jan. 22. 2020. 50 min. new.
192. "Sustainable catalysis using hydrides of earth-abundant metals", York U. (virtual) Oct. 1, 2020.

C. Theses supervised. MSc theses (21 in total) and PhD theses (23 in total)

Current PhD students

Ben Rennie, "Acid tolerant catalysts for imine and carbon dioxide hydrogenation." Started Sept 2017.
Matthew Gradiski "Iron catalysts for difficult hydrogenation processes." Started. Sept 2016.
Brian Tsui: "Asymmetric hydrogenation using iron catalysts with NHC ligands. "Started Sept. 2016.
Chris (Sang) Seo "New routes to homochiral phosphine-amine ligands." Started. Sept 2015.

Recent postdoctoral Fellows and Research Associates:

16. Christine Sui-Seng, 2006-2008. 17. Nils Meyer, 2008-2010. 18. Weiwei Zuo, 2011-2014. 19. Alexandre Mikhailine, 2012 (4 months). 20. Paraskevi Lagaditis 2013 (4 months) 21. Afrooz Zirakzadeh 2015 22. Paraskevi Lagaditis 2016.

Current Undergraduate researchers (more than 100 in total)

Max Olson, 2017-2018, Nina Farac, 2017-2018.

E. SELECTED ADMINISTRATIVE POSITIONS

Member of the Graduate Studies Committee 2017-present.
Coordinator of student exchanges with Johannes Guttenberg U. Mainz (since 2005).
Chair, Inorganic Program, Canadian Society for Chemistry Conference 2017, Toronto Convention Centre.
Chair, Chemistry Department. July 2010-2013.
Chair of Departmental Advisory Committee 2008-2013
Associate Chair of Graduate Studies in Chemistry 2008
Acting Chair, then Interim Chair, Chemistry Department July-Dec 2008
Director, Math, Physics and Chemistry Fellow Selection Committee, Academy III, Royal Society of Canada (2009-2012)