

# Monte L. Helm

Senior Scientist

Center for Molecular Electrocatalysis

Pacific Northwest National Laboratory

Richland, WA United States



## Profile

---

As a scientist, my professional development revolves around pursuing research to advance our understanding of the natural world. As an educator, I seek to share my knowledge and inspire the next generation of scientists. As a leader I aim to build collaborative teams who's group effort accomplishes more than the sum of the individual contributions.

## Qualifications Summary

---

- **Demonstrated ability to conduct world class, energy related science at a National Laboratory**
  - 30 publications from PNNL in top rated chemistry journals (2012 - present)
  - Co-PI on a \$14M funded Dept. of Energy - Energy Frontier Research Center proposal
- **Outstanding record in teaching, scholarship and service in an academic setting**
  - Maintained teaching excellence and an externally recognized research program and assumed leadership roles both within the department (Chair 2011-2012) and among various campus-wide committees.
- **Demonstrated ability in forming collaborative partnerships, leadership abilities and communication skills**
  - Coordinates synergist efforts in the Center for Molecular Electrocatalysis between more than 30 researchers located at Pacific Northwest National Lab, Yale University, University of Wisconsin and University of Illinois at Urbana-Champaign

## Experience and Education

---

**Senior Scientist, Physical Sciences Division, Pacific Northwest national Laboratory (PNNL); Richland, WA — 2012-pres.**

Provides scientific leadership for the electrocatalysis H<sub>2</sub> production and oxidation subtask within the Center for Molecular Electrocatalysis, including mentorship of young scientific staff members and postdocs.

**Deputy Director, Center for Molecular Electrocatalysis, PNNL; Richland, WA — 2012-15**

Provides scientific and operational oversight for the Center for Molecular Electrocatalysis (CME) at Pacific Northwest National Laboratory (PNNL) a Department of Energy funded Energy Frontier Research Center — \$3.5M/year budget.

**Associate Professor, Fort Lewis College (FLC); Durango, CO — 2008-12**

Maintained teaching excellence and an externally recognized research program, as an associate professor at Fort Lewis College I assumed leadership roles both within the department and among various campus-wide committees.

**Visiting Scientist, PNNL; Richland, WA — 2010-11**

Project Title: Synthesis of New Ligand Platforms and Study of their Nickel(II) Complexes for Hydrogen Production Catalysis

**Assistant Professor, Fort Lewis College; Durango, CO — 2003-2008**

As an assistant professor, my focus revolved around excellence in teaching and establishing an externally funded research program.

**Dreyfus Fellow, University of Tennessee (UTC); Chattanooga, TN — 2001-2003**

Project Title: Late Transition Metal Coordination Involving Crown Thioethers

**Postdoc Fellow, University of Sussex; Brighton, UK — 2000-2001**

Project Title: Synthesis and Reactivity of Heterosubstituted Diphospholes

**Ph.D. (Inorganic Chemistry), University of Colorado (CU); Boulder, CO — 1995-2000**

Project Title: Late Transition Metal Coordination Involving Crown Thioethers

**B.Sc., University of Minnesota (MSUM); Moorhead, MN — 1991-1995**

Major in Chemistry, minor in Philosophy

## Teaching Qualifications (evaluations available upon request)

---

General and introductory chemistry lectures and laboratories

Inorganic and Advanced Inorganic lectures and laboratories

Organometallic Catalysis and Electrocatalysis

Special topic courses: X-ray Crystallography, Main Group Chemistry, Heteronuclear FT-NMR Spectroscopy, Electrochemistry/Electrocatalysis

## Research Interests and Experience

---

My research interests revolve around synthetic and structural main group chemistry, as well as exploring structure/reactivity relationships. Emphasis is placed on the synthesis of new main-group phosphorus containing ligands, with a view towards selective metal coordination, activation and catalysis for energy related applications.

My current research at Pacific Northwest National Laboratory focuses on the development of electrocatalysts for the storage of energy generated from renewable sources. The research involves using pendant amines attached to phosphine ligands to serve as proton relays to and from a metal's primary coordination sphere.

As a faculty member at Fort Lewis College I ran a nationally recognized undergraduate research program revolving around the synthesis and metal coordination of new phosphacrown ligands. Among other phosphorus crown compounds, the research resulted in synthesis and report of the first facially capping tridentate 9-membered phosphorus crown analog to the known 9O3, 9N3 and 9S3 crown compounds.

As a Dreyfus Fellow under the direction of Dr. Greg Grant my project included synthesis of heavy metal complexes of crown thioethers. The research established heteronuclear NMR (<sup>113</sup>Cd, <sup>199</sup>Hg and <sup>207</sup>Pb) data for the new complexes and studied of how structural changes in the various crown rings influence the coordination behavior.

While a postdoctoral research fellow at the University of Sussex, working under Professor John Nixon, I was involved in the synthesis and metal coordination of cyclopentadienyl analogues containing unsaturated phosphorus atoms. My project involved the incorporation of other heteroatoms, such as sulfur and selenium, into these rings, and their effects on various metal coordination reactions.

My graduate student work under Dr. Arlan Norman focused on the study of linear- and cyclophosphazanes. I conducted spectral and reactivity studies on linear triphosphazanes, and synthesized a new class of cyclotriphosphazane ligands. The reactivity and metal coordination of the cyclotriphosphazanes was also studied, with an aim for their potential uses as host-guest molecules and in asymmetric catalysts.

During my undergraduate education I did research for Dr. Gary Edverson on the synthesis of organoborane polymers, namely, incorporating pentaborane units into organic molecules which can then be polymerized.

## Research Grants and Awards

---

### **Pacific Northwest National Laboratory**

Department of Energy – Center for Molecular Electrocatalysis an Energy Frontier Research Center - \$14,000,000 (\$3.5M/year FY15-18)

### **Fort Lewis College: \$931,000 awarded between 2003-12**

NSF – Research at Undergraduate Institutions (RUI) - \$292,000 – 2/2012 (declined by MLH)

American Chemical Society-Petroleum Research Fund - \$65,000 5/2011 – 9/2014

Pacific Northwest National Laboratory – Release Time - \$25,000 – 8/2011 – 5/2012

Nation Science Foundation – FaST Program - \$19,250 – 5/2011 – 7/2011

Fort Lewis College Faculty Development Grant - \$1,200 – 12/2010 – 9/2011

Pacific Northwest National Laboratory – Sabbatical Funding - \$88,000 7/2010 – 6/2011

Fort Lewis College Faculty Development Grant - \$1,600 – 12/2009 – 9/2010

Fort Lewis College Faculty Development Grant - \$1,500 – 12/2008 – 9/2009

Fort Lewis College Faculty Development Grant - \$1,500 – 12/2007 – 9/2008

Research Corporation Cottrell College Science Award - \$44,148 – 5/2008 – 5/2010

American Chemical Society – Summer Minority Supplement - \$4,250 – 5/2007 - 9/2007

Fort Lewis College Faculty Development Grant - \$1,500 – 12/2006 – 9/2007

Fort Lewis College Faculty Development Grant - \$2,500 – 12/2005 – 9/2006

National Science Foundation – Major Research Instrumentation - \$310,000 8/1/2005 – 8/1/2007

American Chemical Society-Petroleum Research Fund - \$35,000 5/2005 – 9/2007

Fort Lewis College Faculty Development Grant - \$3,000 – 12/2004 – 9/2005

Fort Lewis College Faculty Development Grant - \$3,500 – 12/2003 – 9/2004

Dreyfus Foundation Supplementary Award for Dreyfus Fellows - \$10,000 - 12/2003 –

12/2005 Research Corporation Startup Fund Match - \$25,000 - 9/2003 – 12/2005

Fort Lewis Startup Fund - \$25,000 - 9/2003 – 9/2004

## **Administrative and Community Service**

---

### **Executive Committee Member, Center for Molecular Electrocatalysis, PNNL 2012-pres.**

Define the vision and strategic direction for the CME; provide executive and organizational support for project efforts; review and approve major project decisions; and provide overall project oversight to evaluate progress against goals.

**Management Skills Development Program, PNNL 2012-pres.** A two year program designed to enhance knowledge, skills, and abilities to manage and develop staff. The program increase your self awareness and effectiveness as a manager and leader and to enhance the participant's knowledge, skills and abilities to manage, develop and lead staff.

**Summer Undergraduate Laboratory Intern (SULI) Program, PNNL 2012-pres.** During the summers of 2012-2015 I have hosted 1-2 undergraduate research interns that conducted research in the CME under my supervision. The program is designed to give undergraduate students a summer research experience at a National Laboratory.

**Department Chair; FLC Chemistry Department 2011-2012** My fundamental goal during this brief time was to establish a collegial environment where my faculty members felt valued and that they had a stake in the departmental goals. This three-year term was cut short by my job relocation to PNNL.

**FLC Campus-wide Committees 2003-2012** Served as an active member on a variety of campus wide committees including: Course Management Software committee; Instructional Technology Committee; and multiple faculty new-hire committees.

**Board of Directors; San Juan Biodiesel; Durango, CO; 2004-2010** Served as a board member and Secretary (2005-2009) of the San Juan Biodiesel initiative. Responsible for selecting, appointing, supporting and reviewing the performance of the chief executive; ensuring the availability of adequate financial resources; and approving annual budgets.

**Chemistry Club Advisor; FLC 2003-2012** Served as advisor for the FLC student-run chemistry club.

**Webmaster; FLC 2003-2012** Redesigned, implemented and maintained the FLC chemistry department's home page.

**Webmaster; UTC 2001-03** Redesigned, implemented and maintained the UTC chemistry department's home.

**Course Fees Committee Member; CU 1996-99** Handled fees collected for improvement of undergraduate and graduate courses.

**Teaching Assistant Training; CU 1996-99** Trained incoming graduate students on teaching techniques and methods.

**Student Advisor; MSUM 1992-1994** Coordinator 1993-1994; advised incoming freshman; trained campus wide student advisors.

## Research Skills

---

Air-Sensitive Techniques – Throughout my career the research I have conducted has required manipulation of air and moisture sensitive compounds. Hence, I am proficient in standard Schlenk and vacuum-line chemical manipulations, as well as working in and maintaining inert atmosphere glove boxes.

Electrochemistry – I have experience with basic electrochemical techniques such as cyclic, square wave and differential pulse voltammetry and bulk electrolysis. I am also versed using electrochemistry to determine turn over frequencies and overpotentials of electrocatalysts.

Nuclear Magnetic Resonance - I am well versed in homo- and hetero-nuclear 1D and 2D techniques as well as basic instrument maintenance and troubleshooting.

X-ray Crystallography – I am versed in current X-ray crystallography techniques, including crystal mounting and data collection, through solution of the structure using SHELX and Olex2.

Computing – I am well versed in all aspects of computing on Macintosh and PC computers, including networking, cross platform data sharing, Microsoft PowerPoint software for lecture presentations and the use of HTML for website design and maintenance. I have also acquired basic Unix programming skills to enhance my NMR operation and maintenance abilities.

## Academic Honors

---

Featured Scholar Award, 2007; recognition for outstanding contributions for scholarship (FLC)

Outstanding Young Alumni Award, 2005; recognition of outstanding achievement in scholarship (MSUM)

Sewall Fellowship Award, 2000; outstanding graduate research (CU).

Teaching Assistant Effectiveness Award, 1998; yearly university wide competition recognizing outstanding teaching ideas of graduate students (CU).

Edward L. King Scholarship, 1997 and 1998; excellence in graduate research (CU).

Theodore S. Gilman Award, 1996-97 and 1998-99; excellence in teaching and development for the General Chemistry program (CU).

General Chemistry Teaching Award, 1995-96 and 1997-98; excellence in teaching general chemistry (CU).

Shaw Award, 1994; excellence in undergraduate research (MSUM).

## Affiliations

---

American Chemical Society, member, 1994 - present

Council on Undergraduate Research, member, 2001 - present

Phi Kappa Phi Honor Society, member, 1994-1996

Phi Sigma Kappa Fraternity, member, 1992-1995; President, 1993-1994 (MSUM)

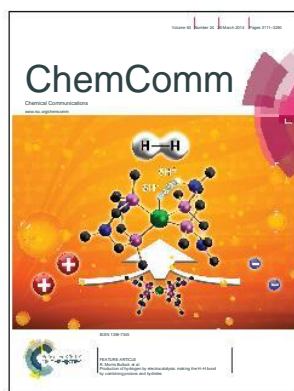
---

# HELM PUBLICATIONS

---

## Total of 58 Publications 1997-2014

- My research at Pacific Northwest National Laboratory has yielded 32 publications since 2012 revolving around molecular electrocatalysis development for the interconversion of renewable energy and fuels.
- My undergraduate research program at Fort Lewis College resulted in 16 publications over 8 years on phosphine ligand development (\* indicates undergraduate coauthor).



Journal covers that feature work referenced below.

---

1. Darmon, J. M.; Kumar, N.; Hulley, E. B.; Weiss, C. J.; Raugei, S.; Bullock, R. M.; Helm, M. L. Increasing the Rate of Hydrogen Oxidation Without Increasing the Overpotential: a Bio-Inspired Iron Molecular Electrocatalyst with an Outer Coordination Sphere Proton Relay. *Chem. Sci.* **2015**, *6*, 2737–2745. DOI:10.1039/C5SC00398A. [Featured as Cover Art]

- Cheng, Y.; Stolley, R. M.; Han, K. S.; Shao, Y.; Arey, B. W.; Washton, N. M.; Mueller, K. T.; Helm, M. L.; Sprenkle, V. L.; Liu, J.; Li, G. Highly Active Electrolytes for Rechargeable Mg Batteries Based on a  $[\text{Mg}_2(\mu\text{-Cl})_2]^{2+}$  Cation Complex in Dimethoxyethane. *Phys. Chem. Chem. Phys.* **2015**, *17*, 13307–13314. DOI:10.1039/C5CP00859J.
- Brown, H. J. S.; Wiese, S.; Roberts, J. A. S.; Bullock, R. M.; Helm, M. L. Electrocatalytic Hydrogen Production by  $[\text{Ni}(\text{7P}^{\text{Ph}}\text{N}^{\text{H}})_2]^{2+}$ : Removing the Distinction Between Endo- and Exo-Protonation Sites. *ACS Catal.* **2015**, 2116–2123. DOI:10.1021/cs502132y.
- Peterson, S. M.; Helm, M. L.; Appel, A. M. Nickel Complexes of a Binucleating Ligand Derived From an SCS Pincer. *Dalton Trans.* **2015**, *44*, 747–752. DOI:10.1039/C4DT02718C.
- Stolley, R. M.; Helm, M. L. Light-Harvesting Materials: Soft Support for Energy Conversion. *Nat. Chem.* **2014**, *6*, 949–950. DOI:10.1038/nchem.2088.
- Hou, J.; Fang, M.; Cardenas, A. J. P.; Shaw, W. J.; Helm, M. L.; Bullock, R. M.; Roberts, J. A. S.; O'Hagan, M. J. Electrocatalytic  $\text{H}_2$  Production with a Turnover Frequency  $>10^7 \text{ s}^{-1}$ : The Medium Provides an Increase in Rate but Not Overpotential. *Energy Environ. Sci.* **2014**, *7*, 4013–4017. DOI:10.1039/C4EE01899K.
- Jeletic, M. S.; Helm, M. L.; Hulley, E. B.; Mock, M. T.; Appel, A. M.; Linehan, J. C. A Cobalt Hydride Catalyst for the Hydrogenation of  $\text{CO}_2$ : Pathways for Catalysis and Deactivation. *ACS Catal.* **2014**, *4*, 3755–3762. DOI:10.1021/cs5009927.
- Hulley, E. B.; Helm, M. L.; Bullock, R. M. Heterolytic Cleavage of  $\text{H}_2$  By Bifunctional Manganese(I) Complexes: Impact of Ligand Dynamics, Electrophilicity, and Base Positioning. *Chem. Sci.* **2014**, *5*, 4729–4741. DOI:10.1039/C4SC01801J.
- Weiss, C. J.; Das, P.; Miller, D. L.; Helm, M. L.; Appel, A. M. Catalytic Oxidation of Alcohol via Nickel Phosphine Complexes with Pendant Amines. *ACS Catal.* **2014**, *4*, 2951–2958. DOI: 10.1021/cs500853f.
- Das, P.; Stolley, R. M.; van der Eide, E. F.; Helm, M. L. A Ni(II)–Bis(Diphosphine)–Hydride Complex Containing Proton Relays – Structural Characterization and Electrocatalytic Studies. *Eur. J. Inorg. Chem.* **2014**, *2014*, 4611–4618. DOI:10.1002/ejic.201402250.
- Weiss, C. J.; Egbert, J. D.; Chen, S.; Helm, M. L.; Bullock, R. M.; Mock, M. T. Protonation Studies of a Tungsten Dinitrogen Complex Supported by a Diphosphine Ligand Containing a Pendant Amine. *Organometallics* **2014**, *33*, 2189–2200. DOI:10.1021/om401127v.
- Galan, B. R.; Wiedner, E. S.; Helm, M. L.; Linehan, J. C.; Appel, A. M. Effects of Phosphine–Carbene Substitutions on the Electrochemical and Thermodynamic Properties of Nickel Complexes. *Organometallics* **2014**, *33*, 2287–2294. DOI:10.1021/om500206e.



13. Darmon, J. M.; Raugei, S.; Liu, T.; Hulley, E. B.; Weiss, C. J.; Bullock, R. M.; Helm, M. L. Iron Complexes for the Electrocatalytic Oxidation of Hydrogen: Tuning Primary and Secondary Coordination Spheres. *ACS Catal.* **2014**, *4*, 1246–1260. DOI:10.1021/cs500290w.
14. Stolley, R. M.; Darmon, J. M.; Helm, M. L. Solvent and Electrolyte Effects on Ni(P<sup>R</sup><sub>2</sub>N<sup>R'</sup><sub>2</sub>)<sub>2</sub>-Catalyzed Electrochemical Oxidation of Hydrogen. *Chem. Commun.* **2014**, *50*, 3681–3684. DOI: 10.1039/C4CC00295D.
15. Wiedner, E. S.; Helm, M. L. Comparison of [Ni(P<sup>Ph</sup><sub>2</sub>N<sup>Ph</sup><sub>2</sub>)<sub>2</sub>(CH<sub>3</sub>CN)]<sup>2+</sup> And [Pd(P<sup>Ph</sup><sub>2</sub>N<sup>Ph</sup><sub>2</sub>)<sub>2</sub>]<sup>2+</sup> As Electrocatalysts for H<sub>2</sub> Production. *Organometallics* **2014**, *33*, 4617–4620. DOI:10.1021/om4010669.
16. Bullock, R. M.; Appel, A. M.; Helm, M. L. Production of Hydrogen by Electrocatalysis: Making the H-H Bond by Combining Protons and Hydrides. *Chem. Commun.* **2014**, *50*, 3125–3143. DOI:10.1039/C3CC46135A. [Featured as Cover Art]
17. Das, P.; Ho, M.-H.; O'Hagan, M. J.; Shaw, W. J.; Bullock, R. M.; Raugei, S.; Helm, M. L. Controlling Proton Movement: Electrocatalytic Oxidation of Hydrogen by a Nickel(II) Complex Containing Proton Relays in the Second and Outer Coordination Spheres. *Dalton Trans.* **2014**, *43*, 2744–2754. DOI:10.1039/C3DT53074D. [Featured as Cover Art]
18. Fang, M.; Engelhard, M. H.; Zhu, Z.; Helm, M. L.; Roberts, J. A. S. Electrodeposition From Acidic Solutions of Nickel Bis(Benzenedithiolate) Produces a Hydrogen-Evolving Ni-S Film on Glassy Carbon. *ACS Catal.* **2014**, *4*, 90–98. DOI:10.1021/cs400675u.
19. Appel, A. M.; Helm, M. L. Determining the Overpotential for a Molecular Electrocatalyst. *ACS Catal.* **2014**, *4*, 630–633. DOI:10.1021/cs401013v.
20. Franz, J. A.; O'Hagan, M. J.; Ho, M.-H.; Liu, T.; Helm, M. L.; Lense, S.; DuBois, D. L.; Shaw, W. J.; Appel, A. M.; Raugei, S.; Bullock, R. M. Conformational Dynamics and Proton Relay Positioning in Nickel Catalysts for Hydrogen Production and Oxidation. *Organometallics* **2013**, *32*, 7034–7042. DOI:10.1021/om400695w.
21. Wiese, S.; Kilgore, U. J.; Ho, M.-H.; Raugei, S.; DuBois, D. L.; Bullock, R. M.; Helm, M. L. Hydrogen Production Using Nickel Electrocatalysts with Pendant Amines: Ligand Effects on Rates and Overpotentials. *ACS Catal.* **2013**, *3*, 2527–2535. DOI:10.1021/cs400638f.
22. Hoffert, W. A.; Roberts, J. A. S.; Bullock, R. M.; Helm, M. L. Production of H<sub>2</sub> At Fast Rates Using a Nickel Electrocatalyst in Water-Acetonitrile Solutions. *Chem. Commun.* **2013**, *49*, 7767–7769. DOI:10.1039/C3CC43203C. [Featured as Cover Art]
23. Stewart, M. P.; Ho, M.-H.; Wiese, S.; Lindstrom, M. L.; Thogerson, C. E.; Raugei, S.; Bullock, R. M.; Helm, M. L. High Catalytic Rates for Hydrogen Production Using Nickel Electrocatalysts with



- Seven-Membered Cyclic Diphosphine Ligands Containing One Pendant Amine. *J. Am. Chem. Soc.* **2013**, *135*, 6033–6046. DOI:10.1021/ja400181a. [Featured as Cover Art]
24. Shaw, W. J.; Helm, M. L.; DuBois, D. L. A Modular, Energy-Based Approach to the Development of Nickel Containing Molecular Electrocatalysts for Hydrogen Production and Oxidation. *Biochim. Biophys. Acta, Bioenerg.* **2013**, *1827*, 1123–1139. DOI:10.1016/j.bbabi.2013.01.003.
25. van der Eide, E. F.; Helm, M. L.; Walter, E. D.; Bullock, R. M. Structural and Spectroscopic Characterization of 17- and 18-Electron Piano-Stool Complexes of Chromium. Thermochemical Analyses of Weak Cr–H Bonds. *Inorg. Chem.* **2013**, *52*, 1591–1603. DOI:10.1021/ic302460y.
26. Jain, A.; Helm, M. L.; Linehan, J. C.; DuBois, D. L.; Shaw, W. J. Biologically Inspired Phosphino Platinum Complexes. *Inorg. Chem. Commun.* **2012**, *22*, 65–67. DOI:10.1016/j.inoche.2012.04.039.
27. Jain, A.; Reback, M. L.; Lindstrom, M. L.; Thogerson, C. E.; Helm, M. L.; Appel, A. M.; Shaw, W. J. Investigating the Role of the Outer-Coordination Sphere in  $[\text{Ni}(\text{P}^{\text{Ph}}_2\text{N}^{\text{Ph-R}}_2)_2]^{2+}$  Hydrogenase Mimics. *Inorg. Chem.* **2012**, *51*, 6592–6602. DOI:10.1021/ic300149x.
28. Weiss, C. J.; Groves, A. N.; Mock, M. T.; Dougherty, W. G.; Kassel, W. S.; Helm, M. L.; DuBois, D. L.; Bullock, R. M. Synthesis and Reactivity of Molybdenum and Tungsten Bis(Dinitrogen) Complexes Supported by Diphosphine Chelates Containing Pendant Amines. *Dalton Trans.* **2012**, *41*, 4517–4529. DOI:10.1039/c2dt12224c.
29. Waggoner, N. W.; Spreer, L. S.; Boro, B. J.; DuBois, D. L.; Helm, M. L. Group 10 Complexes Containing Phosphinomethylamine Ligands: Synthesis, Structural Analysis and Electrochemical Studies. *Inorg. Chim. Acta* **2012**, *380*, 14–21. DOI:10.1016/j.ica.2011.07.001.
30. Wiedner, E. S.; Yang, J. Y.; Chen, S.; Raugei, S.; Dougherty, W. G.; Kassel, W. S.; Helm, M. L.; Bullock, R. M.; Rakowski DuBois, M.; DuBois, D. L. Stabilization of Nickel Complexes with  $\text{Ni}^0 \cdots \text{H}-\text{N}$  Bonding Interactions Using Sterically Demanding Cyclic Diphosphine Ligands. *Organometallics* **2012**, *31*, 144–156. DOI:10.1021/om200709z.
31. Cosimbescu, L.; Wang, L.; Helm, M. L.; Polikarpov, E.; Swenson, J. S.; Padmaperuma, A. B. Electron Transport Materials: Synthesis, Properties and Device Performance. *Int. J. Org. Chem.* **2012**, *02*, 101–110. DOI:10.4236/ijoc.2012.22016.
32. Kilgore, U. J.; Stewart, M. P.; Helm, M. L.; Dougherty, W. G.; Kassel, W. S.; Rakowski DuBois, M.; DuBois, D. L.; Bullock, R. M. Studies of a Series of  $[\text{Ni}(\text{P}^{\text{R}}_2\text{N}^{\text{Ph}}_2)(\text{CH}_3\text{CN})]^{2+}$  Complexes as Electrocatalysts for  $\text{H}_2$  Production: Substituent Variation at the Phosphorus Atom of the  $\text{P}_2\text{N}_2$  Ligand. *Inorg. Chem.* **2011**, *50*, 10908–10918. DOI:10.1021/ic201461a.

33. Helm, M. L.; Stewart, M. P.; Bullock, R. M.; Rakowski DuBois, M.; DuBois, D. L. A Synthetic Nickel Electrocatalyst with a Turnover Frequency Above 100,000 s<sup>-1</sup> For H<sub>2</sub> Production. *Science* **2011**, *333*, 863–866. DOI:10.1126/science.1205864.
- Chemical and Engineering News (page 6 of Aug. 15, 2011 issue; <http://cen.acs.org/articles/89/i33/Nickel-Unites-Protons-Rapidly.html>)
  - Chemistry World from the Royal Society of Chemistry (<http://www.rsc.org/chemistryworld/News/2011/August/11081103.asp>)
  - BBC News (<http://www.bbc.co.uk/news/science-environment-14494972>)
34. Galan, B. R.; Schöffel, J.; Linehan, J. C.; Seu, C.; Appel, A. M.; Roberts, J. A. S.; Helm, M. L.; Kilgore, U. J.; Yang, J. Y.; DuBois, D. L.; Kubiak, C. P. Electrocatalytic Oxidation of Formate by [Ni(P<sup>R</sup><sub>2</sub>N<sup>R'</sup><sub>2</sub>)<sub>2</sub>(CH<sub>3</sub>CN)]<sup>2+</sup> Complexes. *J. Am. Chem. Soc.* **2011**, *133*, 12767–12779. DOI:10.1021/ ja204489e.
35. Lowry, D. J.; Helm, M. L. Synthesis of 1,4,7-Triphenyl-1,4,7-Triphosphacyclononane: The First Metal-Free Synthesis of a [9]-aneP<sub>3</sub>R<sub>3</sub> Ring. *Inorg. Chem.* **2010**, *49*, 4732–4734. DOI:10.1021/ ic100274m.
36. Carroll, G. M.; Miller, S. M.; Helm, M. L. Synthesis, Characterization and Crystal Structure of (*cis*-*P,P'*-Diphenyl-1,4-Diphospha-Cyclohexane)Molybdenum(0)Tetracarbonyl. *Inorg. Chem. Commun.* **2010**, *13*, 534–536. DOI:10.1016/j.inoche.2010.01.030.
37. Sussman, J. E.; Morey, T. S.; Miller, S. M.; Helm, M. L. Group 9 Half-Sandwich Complexes Containing the Unique *P,P'*-Diphenyl-1,4-Diphospha-Cyclohexane Ligand: Synthesis, X-Ray Structure Analyses and Spectroscopic Studies. *J. Organomet. Chem.* **2009**, *694*, 3506–3510. DOI:10.1016/j.jorganchem.2009.06.023.
38. Heston, S. A.; Noll, B. C.; Helm, M. L. {Bis[2-(Diphenylphosphino)Ethyl]Phenylphosphine-[ $\kappa$ ]<sup>3</sup>*P, P', P''*}Chloridoplatinium(II) Hexafluoridophosphate. *Acta Crystallogr., Sect. E* **2009**, *65*, m793–m793. DOI:10.1107/S1600536809022405.
39. Vorce, P. R.; Miller, S. M.; Helm, M. L. {Bis[2-(Diphenylphosphino)Ethyl]Phenylphosphine-[ $\kappa$ ]<sup>3</sup>*P, P', P''*}Chloridopalladium(II) Hexafluoridophosphate. *Acta Crystallogr., Sect. E* **2009**, *65*, m792. DOI:10.1107/S1600536809022417.
40. Rooney, C. P.; Wade, J. L.; Hinkle, A. C.; Stolley, R. M.; Miller, S. M.; Helm, M. L. Group 6 Metal Carbonyl Complexes of a Family of Bulky Phosphines: Spectroscopic and Structural Studies of Chromium(0)-, Molybdenum(0)- and Tungsten(0)-Pentacarbonylsilylphosphines. *Main Group Chem.* **2008**, *7*, 155–165. DOI:10.1080/10241220802376535.
41. Mason, L. J.; Moore, A. J.; Carr, A.; Helm, M. L. Lithium Bis(2-Phenylphosphidoethyl)Phenyl-Phosphine: a Reactive Phosphorus Intermediate. *Heteroat. Chem.* **2007**, *18*, 675–678. DOI: 10.1002/hc.20351.

42. Morey, T. S.; Miller, S. M.; Helm, M. L. Bis(Cis-1,4-Diphenyl-1,4-Diphosphacyclohexane- $[\kappa^2 P, P']$ Platinum(II) Bis(Tetrafluoridoborate). *Acta Crystallogr., Sect. E* **2007**, 63, m1983–m1983. [DOI:10.1107/S1600536807030115](https://doi.org/10.1107/S1600536807030115).
43. Mason, L. J.; Perrault, E. M.; Miller, S. M.; Helm, M. L. Group 10 Metal Complexes of a Cyclic Diphosphine: the Crystal Structures of Bis(Cis-  $P, P'$ -Diphenyl-1, 4-Diphospha-Cyclohexane) M (II) Chloride, M= Palladium, Platinum. *Inorg. Chem. Commun.* **2006**, 9, 946–948. [DOI:10.1016/j.inoche.2006.06.003](https://doi.org/10.1016/j.inoche.2006.06.003).
44. Helm, M. L.; Hill, L. L.; Lee, J. P.; Van Derveer, D. G.; Grant, G. J. Cadmium-113 NMR Studies on Homoleptic Complexes Containing Thioether Ligands: the Crystal Structures of  $[Cd([12]aneS_4)_2](ClO_4)_2$ ,  $[Cd([18]aneS_4N_2)](PF_6)_2$  and  $[Cd([9]aneS_3)_2](PF_6)_2$ . *Dalton Trans.* **2006**, 3534–3543. [DOI: 10.1039/b601665k](https://doi.org/10.1039/b601665k).
45. McCampbell, T. A.; Kinkel, B. A.; Miller, S. M.; Helm, M. L. Group 6 Metal Carbonyl Complexes of a Bulky Phosphine: The Crystal Structures of Tris(Trimethylsilyl)Phosphine-M(0)Pentacarbonyl, M = Chromium, Molybdenum, and Tungsten. *J Chem Crystallogr* **2006**, 36, 271–275. [DOI:10.1007/s10870-005-9022-z](https://doi.org/10.1007/s10870-005-9022-z).
46. Helm, M. L.; Helton, G. P.; Vanderveer, D. G.; Grant, G. J. Mercury-199 NMR Studies of Thiacycrown and Related Macrocyclic Complexes: the Crystal Structures of  $[Hg(18S_6)](PF_6)_2$  and  $[Hg(9N_3)_2](ClO_4)_2$ . *Inorg. Chem.* **2005**, 44, 5696–5705. [DOI:10.1021/ic050500z](https://doi.org/10.1021/ic050500z).
47. Grant, G. J.; Lee, J. P.; Helm, M. L.; Vanderveer, D. G.; Pennington, W. T.; Harris, J. L.; Mehne, L. F.; Klinger, D. W. Synthetic, Structural, Spectroscopic, and Electrochemical Studies of Mixed Sandwich Rh(III) and Ir(III) Complexes Involving  $Cp^*$  and Tridentate Macrocycles. *J. Organomet. Chem.* **2005**, 690, 629–639. [DOI:10.1016/j.jorganchem.2004.10.010](https://doi.org/10.1016/j.jorganchem.2004.10.010).
48. Denker, M. W.; Helm, M. L. Synthesis and Spectroscopic Studies of Group 6 Metal Carbonyl Complexes with a Novel Cyclotriphosphazane Ligand. *Synth. React. Inorg., Met.-Org., Nano-Met. Chem.* **2005**, 35, 227–231. [DOI:10.1081/SIM-200052654](https://doi.org/10.1081/SIM-200052654).
49. Grant, G. J.; Patel, K. N.; Helm, M. L.; Mehne, L. F.; Klinger, D. W.; Vanderveer, D. G. Heteroleptic Platinum(II) Complexes with Crown Thioethers and Diimine Ligands: the Crystal Structures of  $[Pt(9S_3)(2,2' -Bipy)](PF_6)_2$  and  $[Pt(9S_3)(4,4-Dimethyl-2,2' -Bipy)](PF_6)_2 \cdot 2.5CH_3NO_2$ . *Polyhedron* **2004**, 23, 1361–1369. [DOI:10.1016/j.poly.2004.02.023](https://doi.org/10.1016/j.poly.2004.02.023).
50. Tarassoli, A.; Sedaghat, T.; Helm, M. L.; Norman, A. D. Synthesis, Spectroscopic Characterization and X-Ray Studies of New Complexes of Organotin(IV) Chlorides with N-Alkylated 2-Amino-1-Cyclopentene-1-Carbodithioic Acids. *J. Coord. Chem.* **2003**, 56, 1179–1189. [DOI:10.1080/00958970310001628939](https://doi.org/10.1080/00958970310001628939).

51. Helm, M. L.; Loveday, K. D.; Combs, C. M.; Bentzen, E. L.; Vanderveer, D. G.; Rogers, R. D.; Grant, G. J. Heavy Metal Complexes of Macrocyclic Trithioethers. *J Chem Crystallogr* **2003**, *33*, 447–455. DOI:10.1023/A:1024294417454.
52. Helm, M. L.; Vanderveer, D. G.; Grant, G. J. Mercury Complexes with Thiocrowns: the Crystal Structure of Bis(1,4,7-Trithiacyclodecane) Mercury(II) Hexafluorophosphate. *J Chem Crystallogr* **2003**, *33*, 625–630. DOI:10.1023/A:1024954028516.
53. Helm, M. L.; Hitchcock, P. B.; Nixon, J. F.; Nyulászi, L.; Szieberth, D. Synthetic, Structural and Theoretical Studies on the New 2,3-Dihydro-1,2,4-Thia-, Selena- and Tellura-Diphospholes, P<sub>2</sub>EC<sub>2</sub>Bu<sup>t</sup><sub>2</sub>(H)Me, (E=S, Se, Te) and Their [M(CO)<sub>5</sub>] Complexes (M=Cr, Mo, W). *J. Organomet. Chem.* **2002**, *659*, 84–91. DOI:10.1016/S0022-328X(02)01706-0.
54. Helm, M. L.; Combs, C. M.; Vanderveer, D. G.; Grant, G. J. Homoleptic Group 12 Metal Complexes of Macrocyclic Thioethers: the Crystal Structures of Bis(1,4,7-Trithiacyclodecane)M(II) Perchlorate: M(II)=Zinc(II), Cadmium(II), Mercury(II). *Inorg. Chim. Acta* **2002**, *338*, 182–188. DOI:10.1016/S0020-1693(02)01016-2.
55. Caliman, V.; Helm, M. L.; Hitchcock, P. B.; Jones, C.; Nixon, J. F. The First 2,3-Dihydro-1H-[1,2,4] Triphosphole. *J. Organomet. Chem.* **2002**, *650*, 198–201. DOI:10.1016/S0022-328X(02)01227-5.
56. Helm, M. L.; Katz, S. A.; Imiolczyk, T. W.; Hands, R. M.; Norman, A. D. Synthesis, Characterization, and Solution Properties of Skeletally Stabilized Triphosphazanes. *Inorg. Chem.* **1999**, *38*, 3167–3172. DOI:10.1021/ic981408o.
57. Helm, M. L.; Noll, B. C.; Norman, A. D. New Cleft-Containing Heterosubstituted Cyclophosphazanes. *Inorg. Chem.* **1998**, *37*, 4478–4479. DOI:10.1021/ic971583p.
58. Hands, R. M.; Helm, M. L.; Noll, B. C.; Norman, A. D. Skeletal Stabilization: a Basis for New Classes of Cyclophosphazanes. *Phosphorus Sulfur Silicon Relat. Elem.* **1997**, *124*, 285–293. DOI:10.1080/10426509708545633.

## Publication Statistics (Web of Science, Updated June 22, 2015)

