

Matthew F. Cain, Ph.D.

Associate Professor of Chemistry
University of Hawai'i at Mānoa, Department of Chemistry
2545 McCarthy Mall, Honolulu, HI 96822
Phone: (808)-956-2705 Email: mfcain@hawaii.edu
Homepage: synthesisinparadise.org

Professional Appointments

- 8/2020 - Present Associate Professor of Chemistry, University of Hawai'i at Mānoa, Honolulu, HI.
7/2014 - 7/2020 Assistant Professor of Chemistry, University of Hawai'i at Mānoa, Honolulu, HI.
1/2012 - 5/2014 Postdoctoral Researcher, Massachusetts Institute of Technology, Cambridge, MA.
Research Advisor: Professor Richard R. Schrock
Project: Synthesis of New TREN ligands for Mo-Catalyzed Dinitrogen Reduction

Education

- 7/2007 - 12/2011 Ph.D., Chemistry, Dartmouth College, Hanover, NH.
Research Advisor: Professor David S. Glueck.
Thesis: Cu(I)-Catalyzed P-C Bond Formation and the Synthesis of C_3 - and C_1 -Symmetric P-Stereogenic Triphosphine Ligands. Diploma formally received at June 2012 Commencement.
8/2003 - 5/2007 B.S. Chemistry: American Chemical Society Certified, *Magna Cum Laude*, State University of New York College at Geneseo, Geneseo, NY.
Research Advisor: Professor David K. Geiger

Awards and Honors

- 2020 New Talent: Americas (RSC, *Dalton Transactions*)
2019 NSF CAREER Award Winner
2018 Nominated for 2018 Excellence in Teaching Award, College of Natural Sciences, University of Hawai'i at Mānoa
2012 Hannah Croasdale Award (for academic excellence, all disciplines, Dartmouth College)
2011 ACS Division of Inorganic Chemistry Travel Award
2011 Reaxys PhD Prize Finalist
2010 - 2011 Department of Education Graduate Assistance in Areas of National Need (GAANN) Fellowship
2010 Selected for CENTC Summer School, "Emerging Perspectives in Catalysis"
2007 Phi Beta Kappa (National Honor Society)
2007 Gamma Sigma Epsilon (Chemistry Honor Society)
2006 - 2007 American Chemical Society's Chemistry Achievement Award (Rochester, NY Section)

Awarded Research Support

From Major Funding Agencies

- 2022 American Chemical Society – Petroleum Research Fund (ACS-PRF), PI: Matthew F. Cain, 2 years / \$110,000
"Limitations with Carbenes, Solved with Phospheniums for the Oxidative Addition of Small Molecules and Functionalization of Petroleum Relevant Substrates"
2019 NSF CAREER Award, PI: Matthew F. Cain, 5 years / \$675,000
"Roadmaps for Developing Hypervalent Phosphorus-Based Main Group Catalysts and Bridging Gaps in STEM Education in Hawaii"

From Internal Sources or for Outreach Purposes

- 2021 American Chemical Society, PI: Matthew F. Cain, \$1000
“Building a Virtual Component into ChemClub Outreach”
- 2019 - 2024 Undergraduate Research Opportunities Program (UROP), University of Hawai‘i at Mānoa, PI: Matthew F. Cain, ~\$5000/each
Researcher: Yuri Ah-Tye (2024, *Pending*): “Benzaza- and Benzoxaphosphole-based Phosphonium Ions (PR₂⁺)”
Researcher: Nils Melbourne (2022): “Polymer Upcycling with Benzazaphospholes”
Researcher: Jazmyne Guittap (2021): “Do Benzazaphospholes Behave as Aromatics? Potential Supporting Ligands to Enhance Catalysis”
Researcher: Celeste Guiles (2020): “New Phosphorus-Based Transmetalating Agents”
Researcher: Cyrus Ma (2019): “Synthesis of a Mes-Substituted 1,2-Benzoazaphosphole as a Potential Transfer Hydrogenation Candidate”

Publications

As an Independent Researcher

20. Howard, M.P.; Miura-Akagi, P.M.; Chapp, T.W.; Ah-Tye, Y.J.H.; Kitano, T.; Zhou, D.Y.; Yoshida, W.Y.; Rheingold, A.L.; Borosky, G.L.; Laali, K.K.; Cain, M.F. Synthesis and Reactivity of a P–H Functionalized Benzazaphosphole. *Submitted (10/10/23) to Polyhedron Special Issue: Emerging Investigators in Inorganic Chemistry.*
19. Miura-Akagi, P.M.; Chapp, T.W.; Yoshida, W.Y.; Yap, G.P.A.; Rheingold, A.L.; Hughes, R.P.; Cain, M.F. Synthesis and Structure of Dearomatized and P-Halogenated Benzazaphospholes and Their Reactivity toward Pt(0) Sources. *Organometallics* **2023**, *42*, 672-688. DOI: 10.1021/acs.organomet.3c00070
18. Chinen, B.L.; Hyvl, J.; Brayton, D.F.; Riek, M.M.; Yoshida, W.Y.; Chapp, T.W.; Rheingold, A.L.; Cain, M.F. Trimerization and Cyclization of Reactive P-Functionalities Confined Within OCO Pincers. *RSC Adv.* **2021**, *11*, 28602-28613. DOI: 10.1039/d1ra05926b
17. Zhou, D.Y.; Miura-Akagi, P.M.; McCarty, S.M.; Guiles, C.H.; O’Donnell, T.J.; Yoshida, W.Y.; Krause, C.E.; Rheingold, A.L.; Hughes, R.P.; Cain, M.F. P-Alkynyl Functionalized Benzazaphospholes as Transmetalating Agents. *Dalton Trans.* **2021**, *50*, 599-611. DOI: 10.1039/D0DT01367F (special issue featuring New Talent: Americas, 2020)
16. Cain, M.F. 1,2-(Benz)Azaphospholes: A Slow Beginning to a Bright Future. *Comments on Inorganic Chemistry* **2020**, *40*, 25-51. DOI: 10.1080/02603594.2019.1701447
15. Nakashige, M.L.; Loristo, J.I.P.; Wong, L.S.; Gurr, J.R.; O’Donnell, T.J.; Yoshida, W.Y.; Rheingold, A.L.; Hughes, R.P.; Cain, M.F. E-Selective Synthesis and Coordination Chemistry of Pyridine-Phosphaalkenes: Five Ligands Produce Four Distinct Types of Ru(II) Complexes. *Organometallics* **2019**, *38*, 3338-3348. DOI: 10.1021/acs.organomet.9b00425
14. Kremláček, V.; Hyvl, J.; Yoshida, W.Y.; Růžička, A.; Rheingold, A.L.; Turek, J.; Hughes, R.P.; Dostál, L.; Cain, M.F. Heterocycles Derived from Generating Monovalent Pnictogens within NCN Pincers and Bidentate NC Chelates: Hypervalency vs. Bell-Clappers vs. Static Aromatics. *Organometallics* **2018**, *37*, 2481-2490. DOI: 10.1021/acs.organomet.8b00290
13. Hyvl, J.; Yoshida, W.Y.; Moore, C.E.; Rheingold, A.L.; Cain, M.F. Unexpected Detours and Reactivity Encountered During the Planned Synthesis of Hypervalent 10–Pn–3 Species (Pn = P or As). *Polyhedron* **2018**, *143*, 99-104. DOI: 10.1016/j.poly.2017.08.039 (special issue on pincer ligands)

12. Hyvl, J.; Yoshida, W.Y.; Rheingold, A.L.; Hughes, R.P.; Cain, M.F. A Masked Phosphinidene Trapped in a Fluxional NCN Pincer. *Chem. Eur. J.* **2016**, *22*, 17562-17565. DOI: 10.1002/chem.201604415
11. Miura-Akagi, P.M.; Nakashige, M.L.; Maile, C.K.; Oshiro, S.M.; Gurr, J.R.; Yoshida, W.Y.; Royappa, A.T.; Krause, C.E.; Rheingold, A.L.; Hughes, R.P.; Cain, M.F. Synthesis of a Tris(phosphaalkene)phosphine Ligand and Fundamental Organometallic Reactions on Its Sterically Shielded Metal Complexes. *Organometallics* **2016**, *35*, 2224-2231. DOI: 10.1021/acs.organomet.6b00250
This article was highlighted in the July 18, 2016 issue of Chemical & Engineering News.
10. Magnuson, K.W.; Oshiro, S.M.; Gurr, J.R.; Yoshida, W.Y.; Gembicky, M.; Rheingold, A.L.; Hughes, R.P.; Cain, M.F. Streamlined Preparation and Coordination Chemistry of Hybrid Phosphine-Phosphaalkene Ligands. *Organometallics* **2016**, *35*, 855-859. DOI: 10.1021/acs.organomet.6b00101

As a Postdoctoral/Graduate Researcher

9. Gibbons, S.K.; Valteau, C.R.D.; Peltier, J.L.; Cain, M.F.; Hughes, R.P.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. Diastereoselective Coordination of P-Stereogenic Secondary Phosphines in Copper(I) Chiral Bis(phosphine) Complexes: Structure, Dynamics, and Generation of Phosphido Complexes. *Inorg. Chem.* **2019**, *58*, 8854-8865.
8. Xu, Z.; Cain, M.F.; Rupert, A.V.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. Selective Formation of a C_3 -Symmetric P-Stereogenic Tris(phosphine) via Platinum-Catalyzed Asymmetric Alkylation of a Tris(Secondary Phosphine). *Tetrahedron: Asymmetry* **2015**, *26*, 1459-1468.
7. Emerson, E.W.; Cain, M.F.; Sanderson, M.D.; Knarr, C.B.; Glueck, D.S.; Ahern, J.C.; Patterson, H.E.; Rheingold, A.L. Synthesis, Structure, and Luminescence of the "Octahedral" Cluster $Cu_4I_4(rac\text{-}IsMePCH_2PMeIs)_2$ ($Is = 2,4,6\text{-}(i\text{-}Pr)_3C_6H_2$). *Inorg. Chim. Acta* **2015**, *427*, 168-172.
6. Cain, M.F.; Forrest, W.P.; Peryshkov, D.V.; Schrock, R.R.; Müller, P. Synthesis of a TREN in Which the Aryl Substituents are Part of a 45 Atom Macrocyclic. *J. Am. Chem. Soc.* **2013**, *135*, 15338-15341.
5. Cain, M.F.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. Asymmetric Synthesis and Metal Complexes of a C_3 -Symmetric P-Stereogenic Triphosphine, (*R*)- $MeSi(CH_2PMe(t\text{-}Bu))_3$ (MT-Siliphos). *Organometallics* **2012**, *31*, 775-778.
4. Cain, M.F.; Reynolds, S.C.; Anderson, B.J.; Glueck, D.S.; Golen, J.A.; Moore, C.E.; Rheingold, A.L. Synthesis, Structure and Spectroscopic Properties of 2,3-bis(diphenylphosphino)quinoxaline (dppQx) and Its Copper(I) Complexes. *Inorg. Chim. Acta* **2011**, *369*, 55-61 (special issue in honor of Robert G. Bergman).
3. Seibert, A.R.; Cain, M.F.; Glueck, D.S.; Nataro, C. Electrochemistry of $P(CH_2Fc)_3$ and Derivatives. *J. Organomet. Chem.* **2011**, *696*, 2259-2262.
2. Cain, M.F.; Hughes, R.P.; Glueck, D.S.; Golen, J.A.; Moore, C.E.; Rheingold, A.L. Synthesis and Structure of Intermediates in Copper-Catalyzed Alkylation of Diphenylphosphine. *Inorg. Chem.* **2010**, *49*, 7650-7662 (cover picture).
1. Pet, M.A.; Cain, M.F.; Hughes, R.P.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. Synthesis and Structure of Ferrocenylmethylphosphines, Their Borane Adducts, and Some Related Derivatives. *J. Organomet. Chem.* **2009**, *694*, 2279-2289.

Invited Lectures

As an Independent Researcher

10. “Progress toward Isolable 10–P–3 Species and Offshoot Applications with Functionalized Benzazaphospholes” Department of Chemistry and Biochemistry, Florida Atlantic University, Boca Raton, FL, August 19, 2022.
9. “Progress toward Isolable 10–P–3 Species: A Long Detour into New PN Heterocycles” Department of Chemistry – Ångström Laboratories, Uppsala University, Uppsala, Sweden, May 26, 2021 via Zoom.
8. “Progress toward Isolable 10–P–3 Species: A Long Detour into New PN Heterocycles” Department of Chemistry, Case Western Reserve University, Cleveland, OH, April 1, 2021 via Zoom.
7. “Progress toward Isolable 10–P–3 Species: A Long Detour into New PN Heterocycles” Department of Chemistry and Biochemistry, Texas Tech University, Lubbock, TX, October 28, 2020 via Zoom.
6. “1,2-Benzazaphospholes as Transition Metal Surrogates” Department of Chemistry, University of Idaho, Moscow, ID, October 29, 2019.
5. “1,2-Benzazaphospholes as Transition Metal Surrogates” Department of Chemistry, Washington State University, Pullman, WA, October 28, 2019.
4. “1,2-Benzazaphospholes as Transition Metal Surrogates” Department of Chemistry and Biochemistry, University of Oregon, Eugene, OR, October 25, 2019.
3. “All Things P: New Investigations into Multidentate, Non-Innocent, and/or Chiral Phosphine- and Phosphaalkene-Based Ligands” American Chemical Society - Hawai‘i Chapter, Kapi‘olani Community College, Honolulu, HI, November 2014 (Keynote Speaker).

As a Postdoctoral Researcher

2. “Synthesis and Development of New Multidentate Ligands for Challenging Catalytic Processes” Department of Chemistry, University of New Hampshire at Durham, Durham, NH, December 2013 (Junior Faculty Candidate Seminar).
1. “Synthesis and Development of New Multidentate Ligands for Challenging Catalytic Processes” Department of Chemistry, University of Hawai‘i at Mānoa, Honolulu, HI, December 2013 (Junior Faculty Candidate Seminar).

Contributed Presentations

As an Independent Researcher

17. Oral: Cain, M.F.; Zhou, D.Y.; Miura-Akagi, P.M. 2021 International Chemical Congress of Pacific Basin Societies, Pacifichem 2021 (Virtual), Honolulu, HI, December 16-21, **2021**. P-Alkynyl Functionalized Benzazaphospholes as Transmetalating Agents.
16. Poster: Cain, M.F.; Hyvl, J.; Riek, M.M.; Chinen, B.L.; Rheingold, A.L. 2021 International Chemical Congress of Pacific Basin Societies, Pacifichem 2021 (Virtual), Honolulu, HI, December 16-21, **2021**. Progress toward Stabilizing 10–P–3 Species Utilizing NCN and OCO Pincers.
15. Poster: Cain, M.F. Gordon Research Conference: Organometallic Chemistry, Newport, RI, July 7-12, **2019**. 1,2-Benzoazaphospholes as Transition Metal Surrogates.

14. Oral: Cain, M.F. The 13th International Conference on Heteroatom Chemistry (ICHAC 2019), Prague, Czech Republic, June 30-July 5, **2019**. 1,2-Benzoazaphospholes as Transition Metal Surrogates.
13. Oral: Cain, M.F.; Miura-Akagi, P.M. 257th ACS National Meeting, Orlando, FL, March 31-April 4, **2019**. INOR-0081: 1,2-Benzoazaphospholes as Transition Metal Surrogates.
12. Oral: Cain, M.F.; Nakashige, M.L. 257th ACS National Meeting, Orlando, FL, March 31-April 4, **2019**. INOR-0595: Synthesis and Coordination Chemistry of Pyridine-Phosphaalkene Ligands: An Entry Point into New Dearomatized Ru(II) Complexes?
11. Oral: Cain, M.F. The 12th International Conference on Heteroatom Chemistry (ICHAC-12), Vancouver, British Columbia, Canada, June 11-16, **2017**. Hypervalency and Bell-Clappers: Recent Developments in Stabilizing Singlet Phosphinidenes and Hypervalent Nitrogen Species.
10. Oral: Cain, M.F. The International Chemical Congress of the Pacific Basin Societies 2015, Pacificchem 2015, Honolulu, HI, December 15-20, **2015**. INOR-2026: All Things P: New Investigations into Multidentate, Non-Innocent, and/or Chiral Phosphine- and Phosphaalkene-Based Ligands.

As a Postdoctoral/Graduate Researcher

9. Poster: Cain, M.F.; Hughes, R.P.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. 14th Asian Chemical Congress, Bangkok, Thailand, September 5-8, **2011**. Reaxys Prize Poster Session: Synthesis of C₃- and C₁-Symmetric Tripodal Triphosphines as Potential Ligands for Cu(I)-Catalyzed Asymmetric P-C Bond Formation.
8. Oral: Cain, M.F.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. 242nd ACS National Meeting, Denver, CO, August 28-September 1, **2011**. INOR-496: Synthesis of C₃-Symmetric P-Stereogenic Triphosphine Ligands.
7. Poster: Cain, M.F.; Hughes, R.P.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. 242nd ACS National Meeting, Denver, CO, August 28-September 1, **2011**. INOR-443: Synthesis of C₃- and C₁-Symmetric Tripodal Triphosphines as Potential Ligands for Cu(I)-Catalyzed Asymmetric P-C Bond Formation.
6. Poster: Cain, M.F.; Glueck, D.S. Gordon Research Conference: Organometallic Chemistry, Newport, RI, July 9-15, **2011**. Synthesis of C₃- and C₁-Symmetric Tripodal Triphosphines as Potential Ligands for Cu(I)-Catalyzed Asymmetric P-C Bond Formation.
5. Poster: Cain, M.F.; Reynolds, S.C.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. 240th ACS National Meeting, Boston, MA, August 22-26, **2010**. INOR-561: Synthesis, Structure, and Spectroscopic Properties of 2,3-bis(diphenylphosphino)quinoxaline (dppQx) Cu(I) Complexes.
4. Poster: Cain, M.F.; Glueck, D.S. 240th ACS National Meeting, Boston, MA, August 22-26, **2010**. INOR-234: Approaches to the Synthesis of C₃-Symmetric P-Stereogenic Triphosphine Ligands.
3. Poster: Cain, M.F.; Hughes, R.P.; Glueck, D.S.; Golen, J.A.; Moore, C.E.; Rheingold, A.L. 240th ACS National Meeting, Boston, MA, August 22-26, **2010**. INOR-232: Synthesis and Structure of Intermediates in Copper-Catalyzed Alkylation of Diphenylphosphine.

2. Poster: Cain, M. F.; Pet, M.A.; Hughes, R.P.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. 237th ACS National Meeting, Salt Lake City, UT, March 22-26, **2009**. INOR-549: Synthesis and Structure of Ferrocenylmethylphosphines and Their Borane Adducts.
1. Poster: Cain, M.F.; Glueck, D.S.; Golen, J.A.; Rheingold, A.L. 237th ACS National Meeting, Salt Lake City, UT, March 22-26, **2009**. INOR-553: Cationic Cu(I) Complexes of Primary and Secondary Phosphines: Potential Precursors to Phosphido Complexes.

Teaching Experience

- Spring 2023 **Assistant/Associate Professor of Inorganic Chemistry**, University of Hawai'i at Mānoa
Spring 2020 Chem 161, General Chemistry I
Spring 2018 *The most fundamental aspects of chemistry were explained. Atoms, Elements and Molecules, Stoichiometry, the Ideal Gas Law, Thermochemistry, Quantum Mechanical Model of the Atom, Periodic Trends, Lewis Structures, Molecular Shapes, VSEPR and MO Theory, Intermolecular Forces and the Solid State*
Fall 2015 - 2017 Overall Rating: 3.84 / 5 (2023), 3.79 / 5 (2020, Online), 4.17 / 5 (2018), 4.40 / 5 (2017), 4.04 / 5 (2016), 3.77 / 5 (2015)
- Fall 2018 - 2023 **Assistant/Associate Professor of Inorganic Chemistry**, University of Hawai'i at Mānoa
Spring 2016 Chem 425/427, Advanced Inorganic Chemistry
Spring 2015 *The fundamentals of coordination chemistry were introduced. Bonding and molecular orbital theory, coordination number and geometry, isomerism and chirality, reaction mechanisms and kinetics, the effect of ligands, organometallic processes, and catalysis were among the topics discussed. A primary focus was centered on understanding the "hows and whys" of inorganic and organometallic chemistry with the ultimate goal of comprehending published research.*
Overall Rating: TBD (2023), 4.92 / 5 (2022), 4.84 / 5 (2021), 4.57 / 5 (2020, Online), 5.0 / 5 (2019), 5.0 / 5 (2018), 4.89 / 5 (2016), 4.88 / 5 (2015)
- Spring 2022 **Assistant/Associate Professor of Inorganic Chemistry**, University of Hawai'i at Mānoa
Spring 2019 Chem 622, Organometallics I
Spring 2017 *The structure, reactivity, and bonding of Main Group Compounds and Transition Metal Complexes were discussed with a dual emphasis placed on the fundamental principles and application to new and relevant literature.*
Fall 2014 Overall Rating: 5.0 / 5 (2022), 5.0 / 5 (2019), 4.50 / 5 (2017), 3.83 / 5 (2014)
- Fall 2017 - 2023 **Assistant/Associate Professor of Inorganic Chemistry**, University of Hawai'i at Mānoa
Chem 425L, Preparation and Analysis of Inorganic Compounds
The laboratory component of the Chem 425/427 sequence, involving the synthesis of several organometallic species and their subsequent characterization by NMR and IR spectroscopy.
- 2007 - 2009 **Teaching Assistant**, Dartmouth College
Supervised and evaluated undergraduates in the laboratory, graded their data sheets, formal lab reports, and exams in four different courses: General I, General II, Honors General, and Inorganic Chemistry
- 2005 - 2007 **Undergraduate Teaching Assistant**, SUNY Geneseo
Supervised and evaluated undergraduates in the laboratory, graded their data sheets and formal lab reports in General Chemistry I and II
- 2002 - 2004 **Private Tutor**, Congers, NY
Tutored high school students for the NYS Chemistry Regents Exam; all passed with above-average grades

Outreach Efforts

2022 - Present	Kaimuki Middle School Science Fair: Chemistry Judge
2022 - Present	Partnering with Girl Scouts for their STEM day
2022	Partnering with Wai‘anae High School (Public high school, West Oahu)
2022	Partnering with HUGS Hawaii (an organization for seriously ill children and their families)
2022	Partnering with Hawaii Baptist Academy (Private high school)
2021 - Present	Partnering with SparkYou, LLC (Science Summer Camp/Enrichment Program)
2/2019 - 20	Honolulu District Science and Engineering Fair: Chemistry Judge
12/2018 - 19	Niu Valley Middle School Science Fair: Chemistry Judge
11/2018	Center for Tomorrow’s Leaders: Guest Speaker
11/2018 - 19	Pearl City High School College and Career Fair: STEM Guest Speaker
Fall 2016 - Present	University of Hawai‘i at Mānoa Chemistry Club Advisor
2015 - Present	Chemistry Department Liaison for the Mānoa Experience/Discover Mānoa, the University Preview Days