

## Jeffrey T. Miller

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## Purdue University

2015-present **Davidson School of Chemical Engineering**

Professor of chemical engineering with research interests in the heterogeneous catalysis synthesis for production of energy and environmental protection. Catalytic reactions include alkane dehydrogenation with alloy metal nano-particles, zeolite conversions of light alkanes to olefins, and olefin oligomerization by novel Lewis acids. The group also has expertise in characterization of catalysts under realistic reaction conditions of high temperature and pressure, especially X-ray absorption spectroscopy and X-ray diffraction at the Advanced Photon Source, in situ infrared, atomic resolution STEM, in situ X-ray photoelectron spectroscopies.



## Argonne National Laboratory

2008-2014 **Chemical Science and Engineering**

Senior Scientist and group leader of the heterogeneous catalysis group developing, testing and characterizing new catalytic materials for energy production. Catalytic reactions include conversion of biomass and natural gas to transportation fuels. Catalytic materials include supported nano-particles and alloys; single site, supported heterogeneous catalysts, colloidal nano-particles and homogenous catalysts. Special interest in characterization of catalysts under realistic reaction conditions of high temperature and pressure, especially X-ray absorption spectroscopy at the Advanced Photon Source.



## Industrial Chemical Engineering Experience

### BP Chemicals Company

2007-2008 **Aromatic Technology Development**

Team leader for development of new selective oxidation catalyst: responsible for lab-scale preparation, optimization and intermediate scale-up. Additional responsibilities include analytical characterizations of the new catalyst.

1998-2006 **Para-Xylene Business Unit**

Team leader for development of proprietary catalysts: responsibilities include material synthesis, pilot plant evaluations, transfer of proprietary methods to catalyst manufacturer and plant demonstrations. Additional responsibilities include development of advanced separation processes.



## AMOCO Oil Company



### 1994-1997 **Residual Oil Process Division**

Lead catalyst team for developed a new catalyst for conversion of asphalt to transportation fuels

### 1992-1994 **Fluid Catalytic Cracking Process Division**

Team leader for commercialization of a process for disposal of waste plastics to fuels

### 1988-1992 **Naphtha Reforming Process Division**

Team leader for the developed a new catalyst and process for conversion of light paraffins to aromatics

### 1985-1988 **Hydrotreating Process Division**

Commercialized catalyst and process improvements for a distillate hydrocracking process

### 1982-1985 **Synthetic Fuels Division**

Developed a catalyst and process to convert CO + H<sub>2</sub> to iso-paraffins or higher alcohols

### 1980-1982 **Synthetic Fuels Division**

Developed a two-stage, shale oil hydrocracking catalyst and process for production of jet fuel

## Education

1980 **Oregon State University**, Corvallis, OR

Ph. D., Inorganic Chemistry

Advisor: C.W. DeKock

1973 **University of New Mexico**, Albuquerque, NM

M. S., Inorganic Chemistry

1971 **Memphis State University**, Memphis, TN

B. S., Chemistry

## Professional Activities and Awards

2023 Purdue College of Engineering Outstanding Mentor Award

2022 Most Impactful Inventors from Purdue University

2021 Seed for Success Research Award from Purdue University

2020 Excellence in Research Award from Purdue University

2020 CISTAR Faculty Mentor Award

2018 Seed for Success Research Award from Purdue University

2012-14 Adjunct Professor of Chemical Engineering, Purdue University

2012 Pierre et Marie Curie Lectureship in Catalysis from the University of Paris

2010 F.G. Ciapetta Award in Catalysis from the North American Catalysis Society

2009 Excellence in Catalysis Award from the Metropolitan Catalysis Society of NY

2007 Member of NSF-DOE International Catalysis Assessment Committee

2006 Herman Pines Award in Catalysis from the Chicago Catalysis Society

2000-08 Officer in Chicago Catalysis Club

1998 Adjunct Professor, Department of Chemical Engineering, Univ. of Illinois at Chicago

1997-2004 Editorial Board, Applied Catalysis A: General

1997 Secretary of the North American Catalysis Society Meeting in Chicago

## Publications (475)

### Selected Publications Since 2020

1. C. Ye, M. Peng, Y. Wang, N. Zhang, D. Wang, M. Jiao, J.T. Miller, "Surface Hexagonal Pt<sub>1</sub>Sn<sub>1</sub> Intermetallic on Pt Nanoparticles for Selective Propane Dehydrogenation," *ACS Applied Materials & Interfaces*, **12** (23), 25903-25909 (2020).
2. S. H. Krishna, C. B. Jones, J. T. Miller, F. H. Ribeiro, R. Gounder, "Combined Kinetic and Spectroscopic Interrogation of Cu-Zeolites In-Operando: Insights into the Mechanism and Site Requirements of NO<sub>x</sub> Selective Catalytic Reduction with NH<sub>3</sub>," *J. Phys. Chem. Lett.* **11**, 5029-5036 (2020).
3. S.D. Deshmukh, L.F. Easterling, J.M. Manheim, N.J. LiBretto, K.G. Weideman, J.T. Miller, H.I. Kenttämä, R. Agrawal, "Analyzing and Tuning the Chalcogen-Amine-Thiol Complexes for Tailoring of Chalcogenide Syntheses," *Inorg. Chem.*, **59**, 12, 8240–8250 (2020).
4. J. ZhuChen, J. Gao, P.R. Probus, W. Liu, X. Wu, E.C. Wegener, A.J. Kropf, D. Zemlyanov, G. Zhang, X. Yang, J.T. Miller, "The Effect of Strong Metal-Support Interaction (SMSI) on Pt-Ti/SiO<sub>2</sub> and Pt-Nb/SiO<sub>2</sub> Catalysts for Propane Dehydrogenation," *Catal. Sci. & Tech.*, **10**, 5973–5982 (2020).
5. C.B. Jones, I. Khurana, S.H. Krishna, A.J. Shih, W.N. Delgass, J.T. Miller, F.H. Ribeiro, W.F. Schneider, R.P. Gounder, "Effects of Dioxygen Pressure on Rates of NO<sub>x</sub> Selective Catalytic Reduction with NH<sub>3</sub> on Cu-CHA Zeolites," *J. Catal.*, **389**, 140-149 (2020).
6. G.M. Mitchell, K.D. Sabnis, F.G. Sollberger, Y. Cui, C.W. Han, P. Majumdar, Z. Zeng, J.T. Miller, J.P. Greeley, V. Ortolan, C. Wang, W.N. Delgass, F.H. Ribeiro, "Effect of Cobalt Addition on Platinum Supported on Multi-Walled Carbon Nanotubes for Water-Gas Shift," *J. Catal.*, **391**, 25-34 (2020).
7. J. Ko, J.A. Muhlenkamp, Y. Bonita, N.J. LiBretto, J.T. Miller, J.C. Hicks, W.F. Schneider, "Experimental and Computational Investigation of the Role of P in Moderating Ethane Dehydrogenation Performance over Ni-based Catalysts," *Ind. & Eng. Chem. Res.*, **59** (28), 12666-12676 (2020).
8. N.J. Escorcia, N.J. LiBretto, J.T. Miller, C.W. Li, "Colloidal Synthesis of Well-Defined Bimetallic Nanoparticles for Alkane Dehydrogenation," *ACS Catalysis*, **10**, 9813-9823 (2020).
9. R. Ma, T. Yang, J. Gao, J. Kou, J. ZhuChen, Y. He, J.T. Miller, D. Li, "Composition Tuning of Ru-Based Phosphide for Enhanced Propane Selective Dehydrogenation," *ACS Catal.*, **10**, 17, 10243-10252 (2020).
10. L. Qi, Y. Zhang, M.A. Conrad, C.K. Russell, J.T. Miller, A.T. Bell, "Ethanol Conversion to Butadiene over Isolated Zinc and Yttrium Sites Grafted onto Dealuminated Beta Zeolite," *JACS*, **142**, 14674–14687 (2020).
11. S.R. Kim, E.C. Wegener, M.C. Yang, M. O'Reilly, S. Oh, C. Hendon, J.T. Miller, Y. Surendranath, "Rapid electrochemical methane functionalization involves Pd–Pd bonded intermediates," *JACS*, **142** (49), 20631-20639 (2020).
12. R. Alcala, A. DeLaRiva, E.J. Peterson, X.P. Hernandez, H. Brongersma, Rik Ter Veen, J.T. Miller, Y. Wang, A. Datye, "Atomically Dispersed Dopants for Stabilizing Ceria Surface Area," *Appl. Catal. B, Env.*; **284**, 119722 (2021).
13. G. Pauletto, N.J. LiBretto, D.C. Boffito, J.T. Miller, A. Jentys, G.S. Patience, J.A. Lercher, "Ni/CeO<sub>2</sub> Promoted Ru and Pt Supported on FeCrAl Gauge for Cycling Methane Catalytic Partial Oxidation-CPOX," *Appl. Catal. B, Env.*, **286**, 119849 (2021).
14. J. ZhuChen, A. Talpade, G. Canning, P.R. Probus, F.H. Ribeiro, A.K. Datye, J.T. Miller, "Strong Metal-Support Interaction (SMSI) of Pt/CeO<sub>2</sub> and its Effect on Propane Dehydrogenation," *Catal. Today*, **371**, 4-10 (2021).

15. M.J. Cordon, J. Zhang, M. Zhou, K.A. Unocic, S.C. Purdy, E.C. Wegener, L.F. Allard, R.S. Assary, J.T. Miller, T.R. Krause, A.J. Kropf, C. Yang, D. Liu, Z. Li, "Selective Butene Formation in Direct Ethanol to C<sub>3</sub>+ Olefin Valorization Over Zn-Y/Beta and Single-Atom Alloy Composite Catalysts Using In-Situ Generated Hydrogen," *ACS Catal.*, **11**, 7193-7209 (2021).
16. N.J. LiBretto, Y. Xu, A.E. Quigley, E.Y. Edwards, R. Nargund, J.C. Vega-Vila, A. Saxena, R.P. Gounder, J.P. Greeley, G. Zhang, J.T. Miller, "Olefin Oligomerization on Main Group Ga<sup>3+</sup> and Zn<sup>2+</sup> Single Site Catalysts," *Nature Commun.*, **12**, 2322 (2021); doi: 10.1038/s41467-021-22512-6.
17. T.M. Lardinois, J.S. Bates, H.H. Lippie, C.K. Russell, J.T. Miller, H. Meyer III, K. Unocic, V.Y. Prikhodko, X. Wei, C.K. Lambert, A.G. Getsoian, R.P. Gounder, "Structural Interconversion Between Agglomerated Palladium Domains and Mononuclear Pd(II) Cations in Chabazite Zeolites," *Chem. Mater.*, **33** (5), 1698-1713 (2021).
18. J. Guo, K.J. Sawant, J.T. Miller, Z. Zheng, D. Zemlyanov, J.P. Greeley, "Structural Chemical Transformations of Zinc Oxide Ultrathin Films on Pd (111) Surfaces," *ACS Appl. Mater. & Interfaces*, **13** (29), 35113-35123 (2021).
19. R.R. Seemakurthi, G. Canning, Z. Wu, J.T. Miller, A.K. Datye, J.P. Greeley, "Identification of a Selectivity Descriptor for Propane Dehydrogenation through Density Functional and Microkinetic Analysis on Pure Pd and Pd Alloys," *ACS Catal.*, **11** (15) 9588-9604 (2021); DOI: 10.1021/acscatal.1c01916.
20. J. Zhang, E.C. Wegener, R. Samad, J. Harris, K.A. Unocic, L.F. Allard, S.C. Purdy, S. Adhikari, M. Cordon, J.T. Miller, T.R. Krause, S. Cheng, D. Liu, M. Li, X. Jiang, Z. Wu, Z. Li, "Isolated Metal Sites Over Cu-Zn-Y/Beta for Direct and Selective Butene-Rich C<sub>3</sub>+ Olefin Formation from Ethanol," *ACS Catal.*, **11** (15), 9885-9897, (2021).
21. G. Pauletto, M. Mendil, N.J. LiBretto, P. Mocellin, J.T. Miller, G.S. Patience, "Short Contact Time CH<sub>4</sub> Partial Oxidation Over Ni Based Catalyst at 1.5 MPa," *Chem. Eng. J.*, **414** (15) 128831 (2021); <https://doi.org/10.1016/j.cej.2021.128831>.
22. H. Xiong, D. Kunwar, D. Jiang, C.E. García-Vargas, H. Li, C. Du, G. Canning, X.I. Pereira Hernandez, Q. Wan, S. Lin, H. Guo, S.C. Purdy, J.T. Miller, K. Leung, S.S. Chou, H.H. Brongersma, R. ter Veen, J. Huang, H. Guo, Y. Wang, A.K. Datye, "Engineering Catalyst Supports to Stabilize 2D Pd Metal Oxide Rafts for Water-Tolerant Methane Oxidation," *Nature Catalysis*, **4** 830-939 (2021); doi: 10.1038/s41929-021-00680-4.
23. J. Kou, J. ZhuChen, J. Gao, W. Liu, J. Zhu, X. Zhang, J. Zhu, A. Ghosh, W. Liu, A.J. Kropf, D. Zemlyanov, R. Ma, X. Guo, A.K. Datye, G. Zhang, L.J. Guo, J.T. Miller, "The Structural and Catalytic Properties of Isolated Pt<sup>2+</sup> Sites in Platinum Phosphide (PtP<sub>2</sub>)," *ACS Catalysis*, **11**(21), 13496-13509 (2021).
24. J. Zhang, E.C. Wegener, N.R. Samad, J.W. Harris, K.A. Unocic, L.F. Allard Jr., S.P. Purdy, S. Adhikari, M.J. Cordon, J.T. Miller, T.R. Krause, S. Cheng, D. Liu, M. Li, X. Jiang, Z. Wu, Z. Li, "Isolated Metal Sites in Cu-Zn-Y/Beta for Direct and Selective Butene-Rich C<sub>3</sub>+ Olefin Formation from Ethanol," *ACS Catal.*, **11**, 9885-9897 (2021).
25. C.-W. Chang, H.N. Pham, R. Alcalá, A.K. Datye, J.T. Miller, "Dehydroaromatization Pathway of Propane on PtZn/SiO<sub>2</sub> + ZSM5 Bifunctional Catalyst," *ACS Sustainable Chem. & Eng.*, **10**(1), 394-409 (2022), doi:10.1021/acssuschemeng.1c06579.
26. Z. Li, Y. Xiao, P.R. Chowdhury, Z. Wu, T. Ma, J. Z.C., G. Wan, T.-H. Kim, D. Jing, P. He, P.J. Potdar, L. Zhou, Z.. Zeng, X. Ruan, J.T. Miller, J.P. Greeley, Y. Wu, A. Varma, "Direct Methane Activation by Atomically Dispersed Platinum Nanolayers on Two-Dimensional Metal Carbides (MXenes)," *Nature Catalysis*, **4**, 882-891 (2021).

27. C. Ye, M. Peng, T. Cui, X. Tang, M. Jiao, D. Wang, J.T. Miller, Y. Li, "Identifying Surface Atomic Arrangement of Reduced Noble Metal Nanoparticles by Surface Oxidation," *Nano Res.*, **16**(4), 4499-4505 (2021); DOI: 10.1007/s12274-021-3636-0.
28. Y. Xu, N.J. LiBretto, G. Zhang, J.T. Miller, J.P. Greeley, "First Principles Analysis of Ethylene Oligomerization on Single-site Ga catalysts Supported on Amorphous Silica," *ACS Catalysis*, **12**(9), 5416-5424, (2022).
29. C.-W. Chang, J.T. Miller, "Catalysts and Processes Development Strategies for Propane to Liquid Hydrocarbons," *Appl. Catal. A, Gen.*, **643**, 118753 (2022); doi: 10.1016/j.apcata.2022.118753.
30. W. Zhang, X. Zhang, J. Wang, A. Ghosh, J. Zhu, N.J. LiBretto, G. Zhang, A.K. Datye, W. Liu, J.T. Miller, "The Structural Evolution of the Catalytic Surface of Pd<sub>3</sub>Bi Intermetallic Alloy Nanoparticles with Increasing Bi Loading," *ACS Catal.*, **12** (17), 10531-10545 (2022).
31. C.A. Milligan, R.R. Seemakurthi, J. Gao, J.P. Greeley, J.T. Miller, F.H. Ribeiro, D.Y. Zemlyanov, "Structure-Controlled Properties of PdZn Near-Surface Alloys," *J. Phys. Chem. C*, **126** (32), 12660-13674 (2022); doi: 10.1021/acs.jpcc.2c01637.
32. G. Wan, G. Zhang, J. ZhuChen, M.F. Toney, J.T. Miller, C.J. Tassone, "Toward Tailoring Working Catalysts in Reaction-mediated Transformation," *ACS Catal.*, **12** (13), 8007-8018 (2022); doi: 10.1021/acscatal.2c01838.
33. J.A. Muhlenkamp, N.J. LiBretto, J.T. Miller, J.C. Hicks, "Ethane Dehydrogenation Performance and High Temperature Stability of Silica Supported Cobalt Phosphide Nanoparticles," *Catal. Sci. & Tech.*, **12**, 976-985 (2022); doi: 10.1039/D1CY01737C.
34. R. Zelinsky, D.P. Dean, C.J. Breckner, J.T. Miller, W.S Epling, "Pd/BEA Hydrocarbon Traps: Effect of Hydrothermal Aging on Trapping Properties and Pd Speciation," 2022, *Appl. Catal. B: Env.* **320**, 121938 (2023); DOI: 10.1016/j.apcatb.2022.121938.
35. R. Ma, J. Gao, J. Kou, D.P. Dean, C.J. Breckner, K. Liang, B. Zhou, J.T. Miller, G. Zou, "Insights into the Nature of Selective Nickel Sites in Ni/Al<sub>2</sub>O<sub>3</sub> Catalysts for Propane Dehydrogenation," *ACS Catal.*, **12**(20), 12607-12616 (2022); doi: 10.1021/acscatal.2c03240
36. M.A. Conrad, A. Shaw, G. Marsden, L.J. Broadbelt, J.T. Miller, "Insights into the Chemistry of the Homogeneous Thermal Oligomerization of Ethylene to Liquid-Fuel Range Hydrocarbons," *Ind. & Eng. Chem. Res.*, **62**, 2202-2216 (2022); doi: 10.1021/acs.iecr.2c02172.
37. C.J. Breckner, K. Zhu, M. Wang, G. Zhang, C.W. Li, J.T. Miller, "Controlled site coverage of strong metal-support interaction (SMSI) on Pd NP catalysts," *Catal. Sci. Tech.*, **13**, 157 - 169 (2023); doi: 10.1039/D2CY01707E.
38. M.A. Conrad, J.E. DeLine, J.T. Miller, "High Temperature Conversion of Ethylene to Liquid Hydrocarbons using  $\gamma$ -Al<sub>2</sub>O<sub>3</sub>," *Ind. & Eng. Chem. Res.*, **62**, **12**, 4849-4850 (2023); doi: 10.1021/acs.iecr.2c02759.
39. S.H. Krishna, C.B. Jones, Y. Wang, D.P. Dean, J.T. Miller, W.F. Schneider, R. Gounder, "Influence of Framework Al Density in Chabazite Zeolites on Copper Ion Mobility and Reactivity During NO<sub>x</sub> Selective Catalytic Reduction with NH<sub>3</sub>," *Nature Catalysis*, 2023; doi: 10.1038/s41929-023-00932-5.
40. G. Zhang, N.J. LiBretto, L.G. Cesar, S.C. Purdy, J.T. Miller, "Surface Structure Determination in Catalytic Alloy Nano-Particles by X-ray Absorption Spectroscopy," accepted *Springer Handbook of Advanced Catalyst Characterization*, Springer Handbooks, eds. I. Wachs, M. A. Bañares, Springer Nature Switzerland AG, ch. 30, 659-

- 669 (2023); doi: 10.1007/978-3-031-07125-6\_30; <https://link.springer.com/978-3-031-07125-6>.
41. R. Alcala, D.P. Dean, Isha Chavan, C.W. Chang, B. Burnside, H. Pham, E.J. Peterson, J.T. Miller, A.K. Datye, "Strategies for Regeneration of Pt-Alloy Catalysts Supported on Silica for Propane Dehydrogenation," *Appl. Catal. A: General*, **658**, 119157 (2023); doi: 10.1016/j.apcata.2023.119157.
  42. S. Porter, A. Ghosh, C.H. Liu, D. Kunwar, C. Thompson, R. Alcala, D.P. Dean, J.T. Miller, A. DeLaRiva, H. Pham, E.C. Peterson, A. Brearley, J. Watt, E. Kyriakidou, A.K. Datye, "Biphasic Janus Particles Explain Self-Healing in Pt-Pd Diesel Oxidation Catalysts," *ACS Catal.*, **13**, 5456-5471 (2023); doi: 10.1021/acscatal.3c00360.
  43. B.C. Bukowski, S.C. Purdy, E.C. Wegener, Z. Wu, A.J. Kropf, G. Zhang, J.T. Miller, J.P. Greeley, "Intermetallic Alloy Structure-Activity Descriptors Derived from Inelastic X-ray Scattering," *PCCP*, **25**, 11216-11226 (2023); doi: 10.1039/D3CP00330B.
  44. C.J. Breckner, H.N. Pham, M.G. Dempsey, M.A. Perez-Ahuatl, A.C. Kohl, C.N. Lytle, A.K. Datye, J.T. Miller, "The Role of Lewis Acid Sites in  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> Olefin Oligomerization," *ChemPhysChem*, **24**, e202300244 (2023); doi 10.1002/cphc.202300244.
  45. C.K. Russell, A. Saxena J.T. Miller, "Influence of Bifunctional PtZn/SiO<sub>2</sub> and H-ZSM-5 Catalyst on the Rates and Selectivity of Propene Aromatization, *Catal. Res.*, **3** (2), 018 (2023); doi:10.21926/cr.2302018.
  46. R. Bardool, D.P. Dean, H.N. Pham, A.K. Datye, S. Raeissi, M.R. Rahimpour, J.T. Miller, "Secondary Reactions of Propylene on Single Site Ga(III) on Alumina Propane Dehydrogenation Catalysts," *J. Catal.*, **428**, 115201 (2023); doi: 10.1016/j.jcat.2023.115201.
  47. H.P. Jacobs, W.C. Elias, K.N. Heck, D.P. Dean, J.J. Dodson, W. Zhang, K. Hong, J.H. Arredondo, C.J. Breckner, L. Chen, S.G. Mueller, S.R. Alexander, J.T. Miller, M.S. Wong, "Promotional Role of Acid Sites on Aluminosilicate-Supported PdAu for Vinyl Acetate Synthesis," *ACS Catal.*, **14**, 221-226 (2024); doi: 10.1021/acscatal.3c04335.
  48. D. Wu, S. Zhou, C. Du, J. Li, J. Huang, H.-X. Shen, A.K. Datye, S. Jiang, J.T. Miller, S. Lin, H. Xiong, "The Proximity Between Hydroxyl and Single Atom Determines the Catalytic Reactivity of Rh<sub>1</sub>/CeO<sub>2</sub> Single-Atom Catalysts," *Nano Research*, **17**, 397-406 (2024); doi: 10.1007/s12274-023-6333-3.
  49. G. Marsden, A. Shaw, M.A. Conrad, Matthew, J.T. Miller, L.J. Broadbelt, Linda, "Microkinetic Modeling of the Homogeneous Thermal Oligomerization of Ethylene to Liquid-Fuel Range Hydrocarbons," accepted *React. Chem. & Eng.*, 2024.
  50. D.P. Dean, D. Leshchev, E. Stavitski, C.K. Russell, K. Zhu, J.T. Miller, "Valence-to-Core X-ray Emission Spectroscopy to Resolve the Size-Dependent Valence Electronic Structure of Pt Nanoparticles," submitted *Catal. Sci & Tech.*, 2024.