

The Catalysis Club of Philadelphia

(In Person) Thursday, Mar 21st, 2024

Brandywine Plaza Hotel

630 Naamans Road, Claymont, DE 19703

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Membrane Reactor: Coupling Catalytic Reaction and Separation for Dehydrogenation of Light Alkanes

Prof. Dongxia Liu

University of Delaware

Fe₂(MoO₄)₃/ZSM-5 catalysts for methane aromatization to benzene

Gagandeep Dhillon

Johnson Matthey

Meeting Agenda:

Social Hour 5:30 PM

Dinner 6:30 PM

Meeting 7:30 PM

Meeting Registration:

Members: \$45.00

Non-Members: \$55.00

Stud. & Retired Members: \$35.00

Please register online for this In-person meeting by **Thursday, March 14th** at [CCP website](#).

Meal Selection (Included):

Please make one selection for your dinner (included in registration) when you sign up for the meeting from the following options:

1. Maryland Crab Cakes.
Dessert : Limoncella cake.
 2. Herb Roasted Chicken.
Dessert : Limoncella cake.
 3. Vegetarian Lasagna.
Dessert : Limoncella cake
 4. Vegan – Cavatappi Pasta.
Dessert: fruit cup
- Salad comes with any option: Caesar Salad

Membership Registration:

Membership dues for CCP 2023-24 meeting season will be \$25 (\$5 for the local chapter and \$20 for the national club). Dues for students, post-docs and retirees will be \$10 (\$5 for the local club and \$5 for the national club). Please sign-up membership ([Link](#)) for more benefits on meeting registrations and networking events!

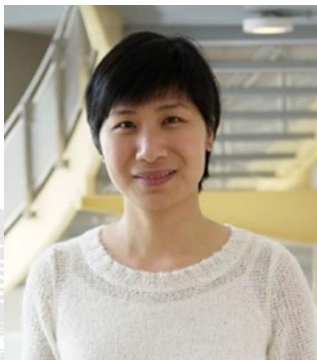
Please contact our Treasurer Steve Hardwick (sjh.wilm.de@gmail.com) or Chair Angela Zheng (angela.zheng@matthey.com) if you need any assistance.

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Prof. Dongxia Liu

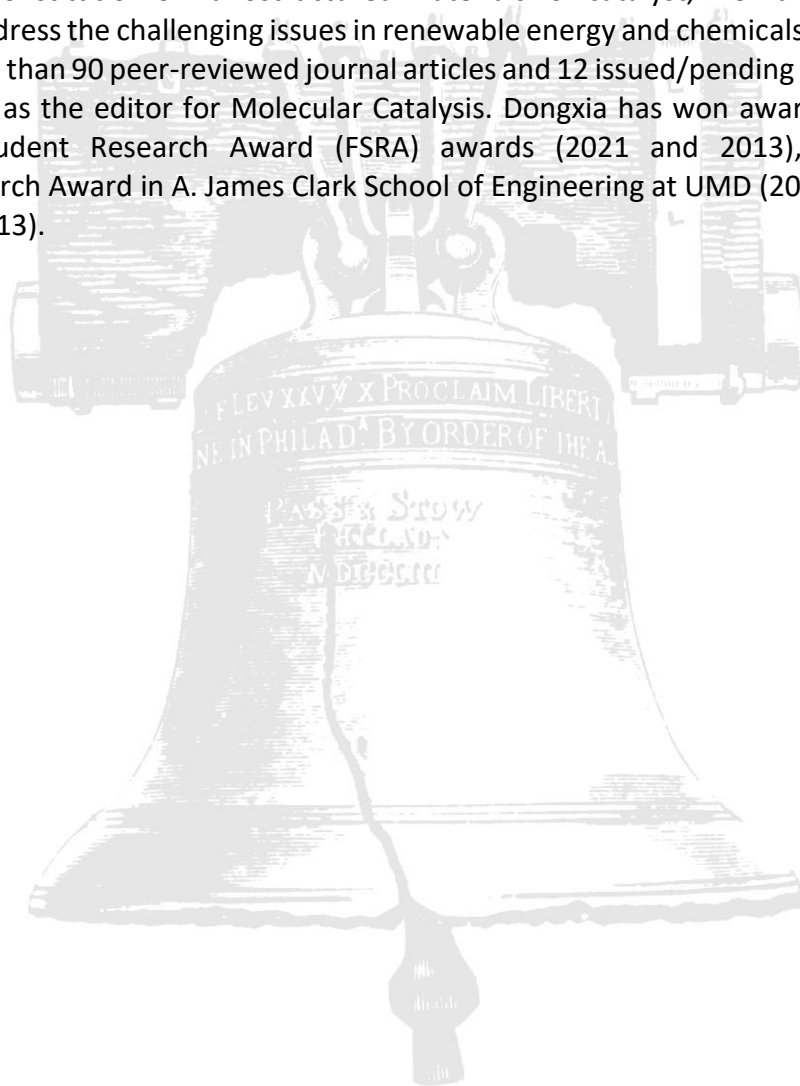
Membrane Reactor: Coupling Catalytic Reaction and Separation for Dehydrogenation of Light Alkanes

Department of Chemical & Biomolecular Engineering, University of Delaware

Abstract: Light alkanes, the main constituent of natural gas and shale gas, are deemed to be alternative sources to replace crude oil to produce chemicals and fuels. Direct non-oxidative alkane conversion has been recognized as a single-step technology that directly convert alkanes to olefins, higher hydrocarbons and hydrogen. Low alkane conversion, high energy input and low catalyst durability, due to endothermic reaction nature and coke formation, are main challenges. In this presentation, I would like to highlight our recent innovations in inorganic membrane reactors that solve the thermodynamic and kinetic challenges in alkane dehydrogenation to achieve high conversion, high product yield, negligible coke formation and system's long-term stability. These consequences originate from the removal of hydrogen co-product by hydrogen separation membranes to right shift the reaction towards high conversion. The elimination of coke formation achieved via design of subnanometer catalysts and lowering operation temperature in the membrane reactor, which enables alkane activation and suppresses the following secondary and following on reaction steps towards coke formation. The developed membrane reactors show great economic viability for practical industrial applications.

Speaker Bio: Dr. Dongxia Liu earned her B.S. in Chemistry from Shandong University in China in 2000, followed by her M.S. degree from the Institute of Chemistry, Chinese Academy of Sciences in 2003. She completed her Ph.D. in chemical engineering at the University of Rochester in 2009. Afterward, she pursued a 2.5-year post-doctoral position at the University of Minnesota. In 2012, she joined the Department of Chemical and Biomolecular Engineering at the University of Maryland (UMD) as an assistant professor and was promoted to an associate professor in 2018 and to a full professor in 2022. In 2023, she joined Department of Chemical and Biomolecular Engineering at the University of Delaware (UD) as a Robert K. Grasselli Professor.

Dr. Liu is leading the Materials Synthesis and Catalysis Lab at UD, targeting for controlling composition and constitution of nanostructured materials for catalyst, membrane and reactor technologies to address the challenging issues in renewable energy and chemicals production. She has authored more than 90 peer-reviewed journal articles and 12 issued/pending patents on these topics, and serves as the editor for Molecular Catalysis. Dongxia has won awards including the UMD's Faculty-Student Research Award (FSRA) awards (2021 and 2013), Junior Faculty Outstanding Research Award in A. James Clark School of Engineering at UMD (2020), and the NSF CAREER award (2013).



Fe₂(MoO₄)₃/ZSM-5 catalysts for methane aromatization to benzene



Gagandeep Dhillon

Johnson Matthey

Abstract: Methane and natural gas feedstocks are important resources for production of commodity chemicals and fuels. Recently, one step conversion of methane to aromatics has gained much attention in this aspect. For the conversion of methane to benzene, Mo/ZSM-5 catalysts have been shown to be active and selective. However, monometallic Mo/ZSM-5 catalysts suffer from rapid deactivation and are limited for industrialization. Addition of promoters such as Fe to Mo/ZSM-5 has been shown to be promising to improve stability and selectivity. In this study, a bimetallic complex Fe₂(MoO₄)₃ is prepared and physically mixed with ZSM-5 to study catalytic activity, selectivity and stability in methane aromatization to benzene. Results indicate that Fe₂(MoO₄)₃/ZSM-5 containing up to 3.7 wt% Mo and 1.4 wt% Fe is optimum. A comparison between optimum Fe₂(MoO₄)₃/ZSM-5 catalyst with an equivalent amount of mixed oxide MoO₃-Fe₂O₃/ZSM-5 is also made. Results show that Fe₂(MoO₄)₃/ZSM-5 is more selective to benzene than its mixed oxide counterpart. Altogether spectroscopic and temperature programmed techniques characterization experiments suggested that using Fe₂(MoO₄)₃/ZSM-5 precursor would fetch higher MoC_x active species inside the zeolite channels, which are responsible for selectivity and stability. Characterization of spent catalysts showed presence of carbon nanotubes in Fe containing catalysts which also promoted the catalyst stability in the reaction.

Speaker Bio: Gagandeep Dhillon holds M.S. and Ph.D. in Chemical Engineering from University of New Hampshire. His M.S. thesis work was focused on heterogeneous catalysts for sustainable diesel fuels production from biomass while a Ph.D. dissertation on CO₂ – Methane reforming over Ni, Co and Fe catalysts. After graduating, Dr. Dhillon joined Texas Tech University as a Post Doctorate Research Associate where he worked on D.O.E project for designing Mo/ZSM-5-based bimetallic catalysts for direct conversion of methane to benzene. After postdoc, he worked as R&D engineer leading catalysts formulation development projects at a climate tech-based startup in Boston, Massachusetts for conversion of CO₂ to sustainable aviation fuels (SAFs). Dr. Dhillon joined as Analytical scientist – Catalyst R&D at Johnson Matthey.