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Promoting Catalytic Science and Technologies

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The Catalysis Club of Philadelphia

(In Person) Thursday, Feb 20th, 2025

Doubletree by Hilton Hotel Wilmington – Wilmington, Delaware

4727 Concord Pike, Wilmington, DE 19803

Novel Rare Earth Technology in Fluid Catalytic Cracking

Speaker: Dr. Yuying Shu

Catalysis Technologies, W.R. Grace & Co., Columbia MD

Two-Dimensional (2D) MXene Supported Metal Catalysts for Plastic Waste Hydrogenolysis

Student Speaker: Ali Kamali

University of Delaware

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 ***Friday, February 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. Boneless beef short rib with peppercorn demi glace. Dessert: Brownie with anglaise sauce.
2. Apple cider glazed chicken with toasted pecans. Dessert: Brownie with anglaise sauce.
3. Winter vegetable stew (vegan). Dessert: Brownie with anglaise sauce.

Starter: Butternut squash bisque, toasted pumpkin seeds, dried cranberry
Side: Fingerling potatoes with broccoli

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 net-working events!

Please contact our Treasurer Steve Hardwick (sjh.wilm.de@gmail.com) or Chair Zhuonan (Nick) Song (zsong@wlgore.com) or Program Chair Brandon Bukowski (bbukows1@jhu.edu) if you need any assistance

The Catalysis Club of Philadelphia

Thursday, February 20th, 2025

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Dr. Yuying Shu

Novel Rare Earth Technology in Fluid Catalytic Cracking

Catalysts Technologies, W. R. Grace & Co., Columbia MD

In this lecture, Dr. Shu will cover two main topics.

1) Novel rare earth technology in fluid catalytic cracking (FCC)

The USY zeolite in fluid catalytic cracking catalyst is commonly stabilized by ion-exchange with rare earth (RE) cations. The RE-exchange provides hydrothermal stability, resulting in higher surface area retention, less dealumination of the zeolite, and greater preservation of acid sites. Though La and Ce are commonly used in FCC catalysts, we have observed that the stability of REUSY catalysts improves as the ionic radius of the RE cation decreases. In our study, we compare the activity and selectivity of REUSY catalysts, stabilized with light (La) and heavy (Ho, Er, and Yb) rare earth cations—the latter having a smaller ionic radius, due to the well-known phenomenon of lanthanide contraction. The experimental data shows that when lanthanide elements having a smaller ionic radius are used to make the REUSY catalyst, a significant improvement in catalytic activity is achieved. The data also shows that yttrium is even more effective than the heavier lanthanides in stabilizing Y-zeolite. Under a variety of deactivation conditions, yttrium stabilized USY catalysts show higher cracking activity and higher gasoline selectivity than similar catalysts formulated with lanthanum. The results may be explained by the greater Brønsted acidity and hydrocarbon adsorption capacity of the yttrium-stabilized catalysts. Based on this novel rare earth technology (GSI-Grace Stable Activity Improvement), Grace has commercialized Alcyon®, Alcyon®M, Impact®-Prime, ResidUltra™-Prime, and Fusion®-Prime catalyst technologies.

2) Novel catalytic approach towards higher C4 olefins in FCC units

Many refiners in North America have an economic incentive to produce more butylene within the FCC product streams for alkylation unit to increase the octane value of the gasoline. In this section, we will discuss the reaction networks involved in acid-catalyzed light olefins formation, the variables that determine gasoline octane, and the ways by which Grace can exploit such pathways using novel catalytic solutions that increase butylene yield and octane value. In recent years, Grace has commercialized several ACHIEVE®400 catalyst families to increase butylene yield. ACHIEVE®400 incorporates isomerization activity within the catalyst particle by using two different types of zeolites – a traditional Y zeolite and a specially tuned ZSM-5 zeolite. Incorporation of

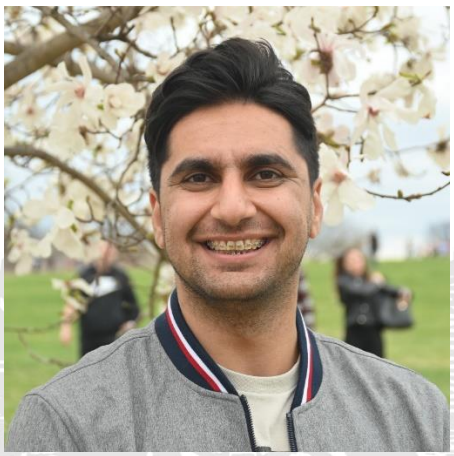
isomerization activity into the particle itself results in a more desirable yield pattern than the use of a traditional ZSM-5 additive. Third generation ACHIEVE®400 Prime is formulated with Grace GSI proprietary zeolite stabilization technology, to further limit undesired H-transfer reactions.

Speaker Bio:

Dr. Yuying Shu is a Senior Principal Scientist at W. R. Grace, located at Columbia in Maryland. Before joining Grace, she had been an Associate Professor and group leader at Dalian Institute of Chemical Physics (2005-2006), a Visiting Scientist at Chemical Engineering Department of University of Delaware (2004-2005), a Research Associate at Chemical Engineering Department of Virginia Tech (2002-2004), a COE (Center of Excellence) Research Fellow and a NEDO Post-doctoral Researcher at Catalysis Research Center of Hokkaido University Japan (2000-2002). She received her Ph.D. in 2000 at Dalian Institute of Chemical Physics, Chinese Academy of Sciences. Her major research interest is the development of new catalysts and new chemical reactions.

Dr. Shu has worked in developing FCC catalysts and additives for many years and is an expert in this field. She has filed 30 patents application from her discovery. She has published over 70 peer-reviewed journal articles and has given many conferences and invited lectures. She has received many awards including 2020 “GATE” (the Grace Award for Technical Excellence, Grace's most prestigious scientific award), 2018-2020 “Premier Awards” (Grace's most prestigious company-wide recognition of performance excellence), "Top Innovator of The Year for 2010 in Maryland”. She has made many significant contributions to Grace Catalysts Technologies and successfully led the efforts to the discovery of ten commercial catalyst platforms.

Two-Dimensional (2D) MXene Supported Metal Catalysts for Plastic Waste Hydrogenolysis



Ali Kamali

Advisor: Prof. Dongxia Liu, University of Delaware

Abstract: The exponential increase in global plastic production has significantly outpaced our current waste management capabilities, leading to severe environmental, energy, and economic impacts. The reliance on landfilling and incineration as major methods of managing plastic waste does decrease the volume of discarded materials but creates substantial negative impacts in terms of energy utilization and greenhouse gas emissions. The alternative method of recycling is a promising solution, however the rate of utilization in the United States is dismally low at only 5-6%. Furthermore, the strong C-C backbone of polyolefins makes them particularly challenging to depolymerize and recycle with existing chemical recycling methods such as pyrolysis and gasification which have low product selectivity and high energy consumption. This situation underscores the critical need to develop sustainable recycling methods to address the rapid growth of plastic production and subsequent waste.

Recent advancements in the hydrogenolysis of plastic waste using ruthenium (i.e., Ru) have shown significant potential for upcycling polyolefins into valuable fuels. Due to their high activity, Ru nanoparticles have been extensively utilized in the plastic hydrogenolysis process, demonstrating the ability to rapidly break C-C bonds in polyolefins such as polyethylene. Despite these promising aspects, one major flaw of this process is the tendency of Ru-based catalysts to break terminal C-C bonds, leading to the formation of low-value methane gas which diminishes the overall yield of valuable hydrocarbon products. Additionally, the high density of polyolefin macromolecules creates significant external mass transport diffusion limitations which can adversely affect the efficiency of depolymerization reaction.

MXenes are a class of two-dimensional materials derived from MAX phases that exhibit exceptional chemical, physical, and mechanical properties, making them promising candidates for catalytic applications including plastic depolymerization. MXenes' high surface area in combination with the presence of functional groups on their nanosheets enable the dispersion of metal active sites as well as modification of their electronic charges, thereby enhancing catalytic activity. This structure allows for higher accessible active sites and the incorporation of ionic

crosslinkers (like Ru) during synthesis can prevent MXene nanosheets from re-stacking or aggregating, further enhancing their catalytic capability. In this talk, we discuss an innovative approach to enhance the hydrogenolysis of plastic waste by leveraging the unique properties of MXene materials supported with Ru nanoclusters. To address the mass transfer diffusion problem of plastics, we modified the interlayer spacing of MXene nanosheets to enhance the efficient contact between polymer substrates and catalytic sites. The use of this material in polyolefins hydrogenolysis demonstrated a remarkable conversion rate and selectivity under mild conditions. These findings highlight the potential of MXene materials in addressing the challenges associated with the catalytic depolymerization of plastics.

Speaker Bio: Ali Kamali is a fifth-year PhD candidate at the University of Delaware, working under the guidance of Prof. Dongxia Liu. His research primarily focuses on the development of two-dimensional catalysts for the deconstruction of plastic waste into high-value products such as fuels, and olefins. Additionally, his work explores the effects of defective metal oxides on Aniline hydrogenation and plastic upcycling. Ali earned his Master's degree in chemical engineering from the University of Tehran, in Iran before joining UD.