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CCP Award Lecture

**Performance of Bimetallic Hydroprocessing Catalysts in Liquid-
Full Reactors**

Speaker: Dr. Hasan Dindi

DuPont (Retired), Engineering Consultant

Studying ZrO₂ Active Sites for Biomass Upgrading

Student Speaker: Mengjie Fan

University of Pennsylvania

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 **Wednesday,**
November 8th 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. Seared Salmon. Dessert:
Limoncella cake

2. Herb Roasted Chicken.
Dessert: Limoncella cake
3. Vegetarian Lasagna.
Dessert: Limoncella cake
4. Vegan – grilled
vegetables. 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 net-
working 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.

The Catalysis Club of Philadelphia

November 15th, 2023

Brandywine Plaza Hotel

630 Naamans Road, Claymont, DE 19703



CCP Award Lecture

Dr. Hasan Dindi

Performance of Bimetallic Hydroprocessing Catalysts in Liquid-Full Reactors

DuPont (Retired), Engineering Consultant

Abstract: Liquid-full hydroprocessing technology IsoTherming[®] is emerging as a cost-effective alternative to the traditional trickle-bed reactors in refinery hydroprocessing applications. Performances of many hydrotreating and hydrocracking catalysts observed to be different in the liquid-full IsoTherming[®] reactors than the traditional trickle-bed reactors. Most of these catalysts are bimetallic and contain nickel or cobalt with molybdenum or tungsten on alumina (hydrotreating) or zeolite (hydrocracking) support.

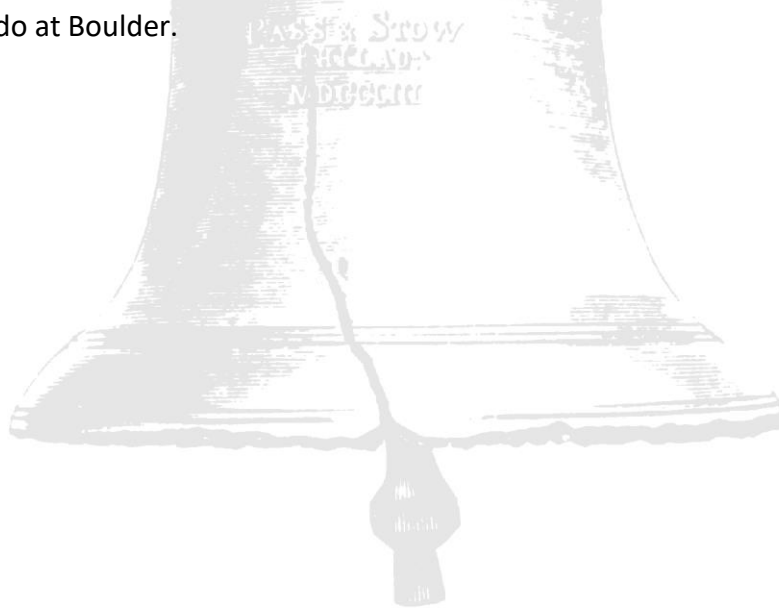
In the refining industry, highly aromatic light cycle oil (LCO) offers a limited market value due to its low cetane value, high density, and high sulfur content. LCO must undergo hydrotreatment in order to meet diesel product specifications, but the highly reactive nature of the hydrocarbon stream causes complications with regards to supplying the necessary hydrogen and managing the considerable exothermic heat release. There are commercial units using conventional trickle-bed technology to process the LCO with the use of hydrotreating and hydrocracking catalysts to meet product specifications, but often with a significant yield loss of the primary diesel product.

Liquid-full IsoTherming[®] technology offers a one- and two-stage process to hydrotreat highly aromatic light cycle oil (LCO) using bimetallic hydrotreating and hydrocracking catalysts to meet the desired product specifications while also maximizing product yield. While commercial trickle-bed processes often result in diesel yields of about 50% (Thakkar et al., AM 05-53, NPRA, pp 1-15, 2005), a one-stage IsoTherming[®] process (Dindi et al. US Patent 8,721,871, 2014), consisting of both hydrotreating and hydrocracking catalysts, may result in diesel yields of up to 75-90%. The efficacy of the zeolitic cracking catalyst may be further increased and yields greater than 90% achieved in two-stage IsoTherming[®] processes (Dindi et al., U.S. Patents 9,139,782; 9,139,783; 9,212,323, and 9,365,782), which includes an intermediate separation step between the hydrotreating and hydrocracking sections to remove ammonia that has a poisoning effect on the reaction.

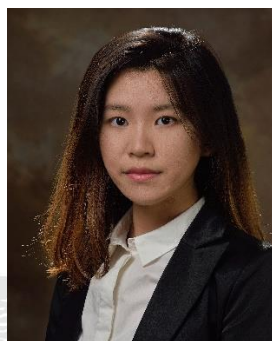
This presentation will discuss pilot plant tests of LCO hydroprocessing in liquid-full IsoTherming® reactors using commercial, bimetallic hydrotreating and hydrocracking catalysts including tests with and without a separation step after hydrotreating (as is the case of a two-stage and one-stage process, respectively). These examples will demonstrate the principles and the advantages of the liquid-full hydroprocessing reactors over the traditional trickle-bed reactors used in refineries today.

Speaker Bio:

Hasan Dindi is an engineering consultant and a Fellow of the American Institute of Chemical Engineers (AIChE). He retired from DuPont in 2021 after 31 years of service. His areas of expertise include catalysis of hydroprocessing and hydrogenation reactions, process scale-up and reaction engineering. He has led the commercialization of the Isotherming Hydroprocessing technology in his last 10 years at DuPont. Before that he has developed Fischer-Tropsch and millisecond contact-time syngas catalysts and processes for Conoco's Gas-to-Liquids Program and led the commercialization of cure-site monomers and chain transfer agents for a new Viton® Elastomer. Hasan has published 29 research articles and has obtained 29 U.S. Patents. He has worked closely for the establishment of the AIChE Rapid Institute and served as an industrial advisor for the Center for Environmentally Beneficial Catalysis at the University of Kansas. He served as an officer in various roles for the Catalysis Club of Philadelphia (Chair, Treasurer and Program Chair). He has received his M.S./Ph.D. Degrees in Chemical Engineering from the University of Colorado at Boulder.



Studying ZrO₂ Active Sites for Biomass Upgrading



Mengjie Fan

Advisor: Prof. John M. Vohs, University of Pennsylvania

Utilizing biomass as a renewable feedstock to produce fuels and chemicals has received much attention in the last few decades. While metal oxides are commonly used as catalysts to promote key reactions in biomass upgrading, the local structure of the active sites in these materials and the mechanisms of the reactions that take place on them are generally not well understood. In our work we are using Atomic Layer Deposition (ALD) to synthesize oxide-based biomass reforming catalysts. This approach provides control of the surface structure and composition which facilitates probing the relationships between structure and activity and identifying specific active sites. In this presentation I will present the results of two studies that have used this approach. The first is a study of how the structure of ZrO₂ surfaces affect the activity for the dehydro-decyclization of cyclic ethers to produce conjugated diene monomers. While Brønsted acid catalysts are known to be active for this reaction, I will show that solid Lewis acids, such as ZrO₂, also exhibit high selectivity. Data for reaction on bulk ZrO₂, ALD grown ZrO₂ ultra-thin films, and ZrO₂ single crystals will be presented and will show that the reaction is highly structure sensitive. Based on these results and DFT calculations the active sites for the dehydro-decyclization reaction will be proposed. I will also present results of a study using ALD to synthesize isolated Zr⁴⁺ sites on both amorphous silica and mesoporous SBA-15 and show that these sites are highly active and selective for the transfer hydrogenation/etherification of hydroxymethylfurfural as well as Diels-Alder cycloaddition/dehydration of dimethyl furan to p-xylene.

Speaker Bio

Mengjie Fan holds a B.S. in Chemical and Biomolecular Engineering from Lafayette College, a M.S. in Chemical Engineering from the University of Michigan and is currently pursuing a Ph.D. at the University of Pennsylvania under the guidance of Prof. John M. Vohs. Mengjie's research focuses on adopting Atomic Layer Deposition (ALD) to understand and improve catalysts for biomass upgrading. By using ALD for near atomic level control of the surface, she can vary the local structure of the active sites in a systematical way and assess how this affects reactivity.