Catalysis Club of Philadelphia

Thursday, March 21st, 2018

Crowne Plaza Wilmington North

630 Naamans Road, Claymont, DE 19703

Speaker: Prof. Eric D. Wachsman

University of Maryland

Mixed Protonic-Electronic Membrane Reactors; Converting Hydrocarbon Resources and CO2 to Fuels

Student Speaker: Boris Sheludko

Rutgers University

Design and Use of Supported Pincer-Iridium Complexes for Heterogeneous, Continuous-Flow Alkane Dehydrogenation and *in situ* Characterization of Surface Species

Meeting Schedule:

Social Hour .... 5:30 PM
Dinner .... 6:30 PM
Meeting .... 7:30 PM

Meeting Fees:

Members: $40.00
Non-Members: $45.00
Stud. & Retired Members: $25.00

Menu

Potato leek soup, served with a mixed salad, lemoncello cake and your choice of 3 entrees:

1) Chicken Champagne – *Sautéed chicken breast with champagne cream sauce*
2) Slow Roasted Prime Rib – *With Au Jus and horseradish*
3) Eggplant Parmigianino – *Layered with mozzarella cheese and bread crumbs*

catalysisclubphilly.org

Meal reservations – Please register online by ***Friday, March 15th*** at http://catalysisclubphilly.org/ or notify your company representative or our Treasurer Lifeng Wang (Lifeng.Wang@pqcorp.com) or Chair Eric Sacia (Eric.R.Sacia@dupont.com)

Membership - Dues for the 2018-19 season will be $25.00 ($5.00 for the local chapter and $20.00 for the national club). Dues for students, post-docs and retirees will be $10.00 ($5.00 for local club and $5.00 for national club).

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Prof. Eric D. Wachsman

Director, Maryland Energy Innovation Institute
William L. Crentz Centennial Chair in Energy Research
University of Maryland, College Park, MD

Mixed Protonic-Electronic Membrane Reactors; Converting Hydrocarbon Resources and CO2 to Fuels

Abstract: Membrane reactor technology holds the promise to circumvent thermodynamic equilibrium limitations by *in-situ* removal of product species, resulting in improved chemical yields. Recent advances in mixed-conducting oxide-membrane technology present the possibility for a dramatic reduction in the cost of converting petroleum, coal and biomass derived feed stocks to hydrogen and other "value added" hydrocarbons. We have developed novel membrane reactor technology, based on high temperature proton conductors, that can convert a wide range of hydrocarbons to pure H_2, and syngas for synthesis of liquid fuels and chemical feed stocks. By simultaneous H_2 permeation and catalysis, we have demonstrated the ability to increase water gas shift yields >70% over thermodynamic limitations. Similarly, we have demonstrated increases in steam reforming yields, and the ability to reform CH_4 with CO_2.

More recently we have developed single-step gas to liquid reactors that convert natural gas to C_{2+} products with high yields and no unwanted oxidation byproducts. The direct utilization of CH_4 and CO_2 to simultaneously produce C_{2+} hydrocarbons (C_2 and aromatics) and syngas (CO and H_2) on opposite sides of a mixed protonic-electronic conducting $SrCe_{0.7}Zr_{0.2}Eu_{0.1}O_{3-\delta}$ membrane reactor is demonstrated. On one side (interior) of the membrane reactor, direct non-oxidative methane conversion (DNMC) over an iron/silica catalyst produces C_{2+} hydrocarbons and H_2. On the other side (outer surface) of the membrane, permeated H_2 (driving the DNMC reaction) reacts with a CO_2 sweep gas to form CO and water via the reverse water gas shift (RWGS) reaction. This novel single H_2-permeable membrane reactor simultaneously addresses both reduction of greenhouse gas (CO_2 and CH_4) emissions as well as production of value-added hydrocarbon products (C_{2+}, CO, and H_2) with *in situ* gas separation.

Speaker Details: Dr. Eric D Wachsman, Director of the Maryland Energy Innovation Institute, is the William L. Crentz Centennial Chair in Energy Research with appointments in both the Department of Materials Science and Engineering, and the Department of Chemical Engineering at the University of Maryland. He received his Ph.D. in Materials Science & Engineering from Stanford University, and his B.S. in Chemical Engineering from the University of California at Berkeley.

Dr. Wachsman is Vice President of The Electrochemical Society (ECS), Editor-in-Chief of *Ionics*, on the Editorial Board of *Scientific Reports*, *Energy Systems*, and *Energy Technology*, and a member of the American Chemical Society, the International Society for Solid State Ionics, and the Materials Research Society.

He is a Fellow of both ECS and the American Ceramic Society (ACerS); the recipient of the 2017 Carl Wagner Award from ECS; the 2014 Sir William Grove Award from the International Association for Hydrogen Energy; the 2014 Pfeil Award from The Institute of Materials, Minerals, and Mining; the Outstanding Invention of 2013 award from the University of Maryland Office of Technology Licensing; the 2012 Fuel Cell Seminar & Exposition Award; and the 2012 HTM Outstanding Achievement Award from ECS.

His research is focused on solid ion-conducting materials and electrocatalysts, and includes the development of solid oxide fuel cells (SOFC), solid-state batteries, ion-transport membrane reactors, solid-state gas sensors, and the electrocatalytic conversion of CH_4, CO_2, and NO_x, using advanced ion conducting materials. He has more than 250 publications and 24 patents on ionic and electronic transport in materials, and their catalytic properties, and device performance.

Boris Sheludko
Rutgers University – Celik and Goldman groups

Design and Use of Supported Pincer-Iridium Complexes for Heterogeneous, Continuous-Flow Alkane Dehydrogenation and in situ Characterization of Surface Species

Abstract: Pincer-ligated iridium complexes have for decades been studied as highly active alkane dehydrogenation catalysts in solution phase. They are capable of transfer dehydrogenation efficiently at or below 240 °C and, with some ligand backbones, can produce terminal olefin selectively. More recently, they have been observed to be active toward dehydrogenation in absence of solvent, prompting interest in their use as strictly heterogeneous catalysts.

Our research focuses on the implementation of a continuous-flow alkane dehydrogenation system based on supported pincer-ligated iridium complexes. The activity and selectivity of several complexes are observed at various temperatures, indicating catalyst stability in the supported phase up to an unprecedented 340 °C, at which catalyst activity is observed to remain stable for several days. Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) is used to characterize surface species under reaction conditions, indicating the presence of various carbonyl species at increasing temperatures, with complementary information obtained from post-mortem X-ray Absorption Spectroscopy (XAS) analysis as well as Scanning Transmission Electron Microscopy (STEM). Interestingly, carbonyl-containing starting material, a species previously considered inert toward dehydrogenation, has been shown to be viable at higher temperatures (300 °C).

Speaker Details: Boris Sheludko attended Wesleyan University as part of a five-year BA/MA program, during which time he performed research under the guidance of Professor Albert J. Fry. His thesis research focused on elucidating the mechanism and scope of the electrochemical oxidation of diphenyl ketones in the presence of alcohols to generate benzhydryl ethers. Upon graduating in 2012, he was recruited for the position of Senior Research Technician at ExxonMobil Research & Engineering Corporate Strategic Research. He worked there for three years prior to returning to academia to obtain his Ph.D. and is currently in his fourth year at Rutgers University – New Brunswick. He is co-advised by Professors Fuat E. Celik (Chemical & Biochemical Engineering) and Alan S. Goldman (Chemistry & Chemical Biology), and his research focuses on the development of a continuous gas-flow alkane dehydrogenation system making use of immobilized pincer-iridium complexes.