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The Catalysis Club of Philadelphia

Thursday, March 16th, 2023

Brandywine Plaza Hotel

630 Naamans Road, Claymont, DE 19703

Catalytic Oxidation of Ventilation Air Methane

Speaker: Dr. Yuliana Lugo-José

Johnson Matthey Inc.

Direct Conversion of Ethylene to Propylene Through Simultaneous Ethylene Dimerization and Olefin Metathesis

Student Speaker: Eli Ream

Lehigh University

Meeting Schedule:

Social Hour 5:30 PM

Dinner 6:30 PM

Meeting 7:30 PM

Meeting Fees:

Members: \$45.00

Non-Members: \$55.00

Stud. & Retired Members: \$35.00

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Meeting and Meal reservations –

Please register online by **Thursday,
March 9th** at

[http://catalysisclubphilly.org/meeting-
registration-with-paypal/](http://catalysisclubphilly.org/meeting-registration-with-paypal/)

Or contact our Treasurer Steve
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Membership – Dues for the 2022-23
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).

The Catalysis Club of Philadelphia

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Dr. Yuliana Lugo-José

Johnson Matthey Inc.

Catalytic Oxidation of Ventilation Air Methane

*Yuliana Lugo-José², Hai-Ying Chen¹, Joseph Fedeyko², Todd Toops¹, and Jacqueline Fidler³

¹Oak Ridge National Laboratory, ²Johnson Matthey Inc., ³CONSOL Energy Inc.,

Abstract:

Johnson Matthey, Oak Ridge National Laboratory and CONSOL Energy are partnering on a DOE ARPA-E funded project to develop a catalytic oxidation technology for the abatement of methane from ventilation air methane (VAM) sources of underground coal mines. The project consists of developing a cost-effective methane oxidation catalyst; design a commercial-scale and a field test unit with capacities of handling approximately high and low VAM flow; generate one year field data to assess technology reliability and guide the commercial unit design for meeting <\$40/ton CO₂e Levelized Cost of Carbon Abatement (LCCA). Pd-based catalysts were selected as they exhibit the highest intrinsic activity at low temperatures (~450-600 °C) with Pd supported on Al₂O₃ and on high SAR zeolite as two leading candidates. Even though Pd/Al₂O₃ catalysts are one of the few catalyst technologies that have been commercialized for methane oxidation, catalyst deactivation is still observed especially when operating at low temperatures (<550 °C). DRIFTS studies using CO as a probe molecule reveals that, under methane oxidation conditions, Pd surfaces become fully oxidized, leaving no coordination unsaturated Pd sites on the surface to activate CH₄. The presence of water in the feed further accelerates the process. Because of the hydrophobic nature of siliceous zeolites (SAR>1200), Pd/Si-zeolite catalysts are more tolerant to water. This type of catalysts, however, are more susceptible to sulfur poisoning. Therefore, regeneration capacity from sulfur poisoning under VAM operating conditions become critical. This presentation will also cover the work of testing site selection and the measurement of VAM gas compositions.

Speaker Bio:

Dr. Yuliana Lugo-José received a BSc degree in Chemical Engineering from the University of Puerto Rico, Mayagüez campus and a Ph.D. degree in Heterogeneous Catalysis and Reaction Engineering from the University of South Carolina. She joined Johnson Matthey in 2015 as an application engineer supporting customers in the automotive HD/LD industry. She currently is a Technical Account Manager supporting JM SEC (Stationary Emission Control) business. In this role, Dr. Yuliana Lugo-José manages methane abatement projects to provide advanced catalyst solutions to help decarbonize the mining and oil/gas industry.



Direct Conversion of Ethylene to Propylene Through Simultaneous Ethylene Dimerization and Olefin Metathesis



Eli Ream

*Advisor: Prof. Israel E. Wachs
Lehigh University*

Propylene is a major petrochemical building block used to generate a variety of important chemicals. Historically, propylene has been produced as a byproduct of steam cracking. With an increase in shale gas production, however, steam cracking processes are switching to lighter feedstocks that produce less propylene. [1] Thus, there is a need for the development of “on-purpose” methods for producing propylene. The direct conversion of ethylene to propylene (ETP) through simultaneous ethylene dimerization and olefin metathesis is a promising method for propylene production that is currently in development. In ethylene dimerization, two ethylene molecules dimerize to form butene molecules and through olefin metathesis, ethylene and 2-butene form two propylene molecules. Many catalysts have been proposed for this reaction. One method for designing a catalyst for ETP is to combine elements of catalysts for ethylene dimerization and catalysts for olefin metathesis. Ethylene dimerization catalysts are typically Ni-based and olefin metathesis catalysts are typically Mo-, W-, or Re-based. [2,3] In this work, a supported $\text{NiSO}_4/\text{ReO}_4/\gamma\text{-Al}_2\text{O}_3$ catalyst was synthesized for the direct conversion of ethylene to propylene in which NiSO_4 performs ethylene dimerization to butenes and ReO_4 performs olefin metathesis to propylene. The catalyst was extensively characterized at the molecular level.

The $\text{C}_2\equiv\text{TPSR}$ and $\text{C}_3\equiv\text{TPSR}$ spectroscopy studies revealed that there is a synergy between NiO_x and SO_4 that allows for ethylene dimerization and that ReO_4 performs olefin metathesis. Additionally, TPSR experiments revealed that ReO_4 promotes ethylene dimerization and NiSO_4 promotes olefin metathesis. A combination of *in situ* XAS and *in situ* UV-vis spectroscopy were used to characterize the Ni sites and a combination of *in situ* XAS and *in situ* Raman spectroscopy were used to characterize Re sites. *In situ* IR-spectroscopy was used to determine the hydroxyl anchoring sites of NiO_x , SO_4 , and ReO_4 . *In situ* Ammonia adsorption IR-spectroscopy experiments probed the nature of the surface acid sites and revealed the presence of both Lewis and Bronsted acid sites. HS-LEIS surface analysis of $\text{NiO}/\text{ReO}_4/\text{Al}_2\text{O}_3$ revealed that the ReO_4 sites are present on the outermost surface layer while the NiO sites are present in the subsurface layer of a dehydrated catalyst. Steady-state performance tests show that the catalyst reaches over 90% propylene selectivity. This presentation will discuss new insights about the structure-function relationship of the catalyst system that arise from these results.

References

1. Blay, V., Epelde E., Miravalles R., Perea, L.A. Catalysis Reviews, Vol. 60 (2018) 278-335.
2. Finiels, A., Fajula, F., Hulea V. Catal Sci. Technol., 4 (2014) 2412-2426
3. Lwin, S., Wachs, I.E., ACS Catal., 4 (2014) 2505-2520

Speaker Bio

Eli Ream is a 4th year PhD student in the Department of Chemical and Biomolecular Engineering at Lehigh University. Eli is a member of the Operando Molecular Spectroscopy & Catalysis Research Lab and advised by Prof. Israel E. Wachs. Her research involves the characterization of heterogeneous supported metal oxide catalysts for applications including ethylene dimerization and olefin metathesis. Before her time at Lehigh University, Eli graduated Summa Cum Laude with a Bachelor of Science in Chemical Engineering from the University of Pittsburgh in 2018.

