MATERIALS SCIENCE AND ENGINEERING (MS&E) SEMINAR SERIES

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"Conversion of Stranded Energy Resources to Transportable Chemicals"

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Abstract: Methane must be activated to a high-energy transition state before it can further react to produce stable products. The high reaction temperatures (>700oC) required to activate methane's strong C-H bonds usually results in rapid and extensive coke formation that blocks catalyst micropores, deactivating the catalyst. The gaps in scientific understanding of the direct, non-oxidative methane conversion process preclude the design of highly selective catalysts and reactors to make desired higher value products. Technical hurdles include catalyst stability and thermodynamic limitations that constrain the desired product yields. In this study, methane conversion reaction is enhanced with microwave irradiation to demonstrate microwave reaction chemistry at catalyst-reactant interface for selective C-H bond activation

Stranded electricity can be converted to liquid ammonia under ambient pressure and 320oC using water and air as feedstock. Conventional ammonia synthesis process, i.e. Haber-Bosch process, cannot be scaled down economically due to the high temperature and high pressure operation and the intermittent nature of renewable electricity that requires frequent startup and shutdown. Catalytic ammonia synthesis was conducted under two microwave irradiation scenarios: microwave and microwave plasma. Other than selective activation of dinitrogen to metastable radicals, the most obvious advantage that microwave irradiation affords in driving a heterogeneously catalyzed reaction is the ability to locally heat the catalytic sites. Many industrial processes utilizing heterogeneous catalysts are high-temperature processes wherein both components of the reaction (i.e., catalyst and medium) are heated to the temperature required for the reaction to occur. Specifically discussed in this presentation are the effects of electromagnetic properties of catalysts, microwave frequency and microwave energy absorbed on the conversion of nitrogen and ammonia yield.

The potential for a dramatic transformation in the chemical process industries is emerging from the rapid development of process intensification. This can potentially yield substantial economic and environmental benefits in combination with advanced manufacturing by significantly reducing the size of chemical process plants. Our research aims to revolutionize the chemical process industries by enabling the development of intensified and, where appropriate, modular process plants.

Dr. John Hu is a Statler Chair Professor and the Director of Shale Gas Center at West Virginia University. He leads an interdisciplinary faculty team carrying out cutting edge research in natural gas conversion as well as renewable energy utilization. Currently he undertakes a number of DOE, NSF and WV HEPC funded projects in energy research. Before joining WVU, Dr. Hu worked as a Director of Innovation at Koch Industries. He was a research leader at Pacific Northwest National Laboratory and BP Oil. He has been granted 35 U.S. patents and published more than 76 peer-reviewed journal articles and over 150 conference presentations.

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