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CHEMICAL AND BIOLOGICAL ENGINEERING  
**SEMINAR ANNOUNCEMENT**

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***“Promise and Pitfalls of Liquid Phase Catalysis”***

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# DR. MICHAEL TIMKO

## “Promise and Pitfalls of Liquid Phase Catalysis”

### Abstract

Industrially, the overwhelming majority of chemical processes employ one or more catalytic steps. Historically, most of these catalytic steps have employed homogeneous catalysts in the liquid phase and heterogeneous catalysts in the gas or vapor phase. Use of liquid phase heterogeneous catalysts can benefit many processes, improving process intensity, simplifying separations, improving heat transfer, and increasing overall energy efficiency. The benefits of liquid phase operation are especially important for processing of high-water content feeds, such as many biomass feeds, or for feeds with low volatility, including heavy crude oils. Despite potential opportunities, progress in liquid-phase heterogeneous catalysis remains slow due to scientific and practical challenges associated with catalyst stability, activity, and the nature of active sites when interacting with dense solvents – especially water. In this talk, I will describe recent work by my group and our collaborators on two catalysts deployed in liquid reaction environments: 1) polymer solid acids for cellulose hydrolysis and 2) zeolite catalysts for upgrading heavy oils. Polymer solid acids have shown promise for efficient conversion of cellulose at mild conditions (120 °C); if recognized industrially, the reported performance could drastically reduce the costs of lignocellulosic biofuels. In our studies, we find that one of the most commonly used structural platforms reported for polymer solid acids is not stable under liquid conditions, hydrolyzing to generate the homogeneous acid, HCl. The homogeneous acid and the remaining heterogeneous acid then work cooperatively to effect cellulose hydrolysis. Our work clearly points to a new way of understanding the aqueous phase activity and stability of polymer acid catalysts. Using zeolite catalysts in water-rich environments offers many potential advantages, including coke reductions and utilization of the hydrogen from water as a reductant to reduce consumption of molecular hydrogen. Unfortunately, many zeolites fail to exhibit activity in the presence of high temperature water; those that do exhibit reduced activity compared to that observed in the absence of water. In our work, we examine what factors permit zeolites to remain active in the presence of liquid water phases and suggest diffusion and chemical mechanisms to explain the apparent loss of activity observed when they are used in the water phase. Lastly, we find that zeolites exposed to liquid water have surprising gains in their activity when used for vapor-phase or oil-phase reactions, suggesting that exposure to liquid water may be an efficient zeolite activation strategy.