

Acid-Catalyzed Aqueous-Phase Conversion of Biomass to Fuel Precursors

With a Teledyne ISCO Syringe Pump Equipped w/ Slurry Mixer

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Introduction

Lignocellulosic biomass has the potential to replace crude oil as the primary source of liquid fuels worldwide. At present, the lack of efficient technologies serves as the limiting step to realize this undertaking. Our research thus far in the field of aqueous phase biomass conversion has led us to significant findings pertaining to the chemistry and design of solid acid catalyst for the dehydration of carbohydrates.

Experimental Procedures

First, we developed a kinetic model for the dehydration of xylose (5-carbon sugar) to furfural in a biphasic batch reactor with microwave heating. We then used our model to describe the optimal reaction conditions for furfural production, which consist of a biphasic regime, relatively high temperature and short reaction times.[1]

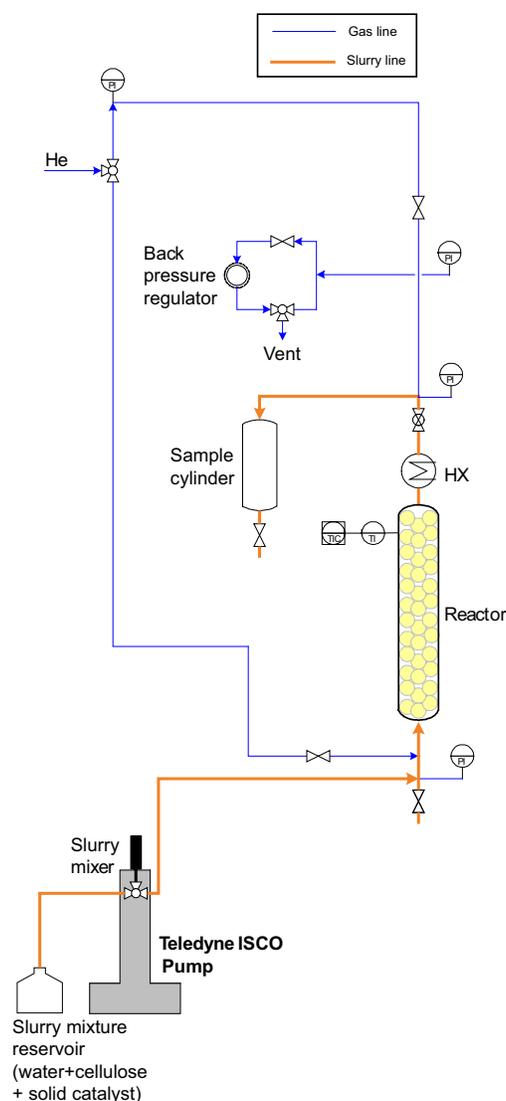
We also prepared a series of well characterized acid catalysts and tested them for aqueous phase dehydration of xylose. We characterized the concentration of both Brønsted and Lewis acid sites in these catalysts and compared the catalytic activity and selectivity with that of homogeneous catalysts for the dehydration of aqueous solutions of xylose. We found the catalyst selectivity to be a direct function of the Brønsted to Lewis acid site ratio for both the heterogeneous and homogeneous reactions.[2]

Finally, we also developed a kinetic model for aqueous-phase HMF (5-hydroxymethyl furfural) and levulinic acid production from glucose with a homogeneous acid catalyst. Accordingly, we then predicted the optimal reactor design and operating conditions for HMF and levulinic acid production in a continuous reactor system. High temperature and short reaction times were essential to maximize the HMF content. In contrast, relatively low temperature and long residence times are essential for maximum levulinic acid yield.[3]

The next research phase consists of a continuous reactor system to produce versatile renewable biochemicals such as furfural, HMF and levulinic acid from biomass feedstocks. The feed is a slurry mixture consisting of the cellulosic biomass, water and a solid acid catalyst. Helium gas flows continuously into the system to induce mixing as the slurry flows through the reaction system. Constant pressure in the system is maintained by way of a back pressure regulator, which vents out the excess gas. The final liquid product, along with the solid acid catalyst, is collected in a sample cylinder. Conclusions from the previous studies mentioned

above will be used to obtain the optimal reaction conditions and catalyst.

The slurry feed is pumped into the system by way of a Teledyne ISCO syringe pump. The pump ensures a smooth and constant flow of the feed at the desired system pressure. Flow accuracy is also imperative to sustain the desired residence times in the reactor; and a relatively large syringe capacity (i.e. 500 mL) makes for a convenient operation. In addition, a Teledyne ISCO slurry mixer will be used to continuously mix the slurry while in the syringe pump cylinder. This is essential to maintain a homogeneous mixture as the slurry enters the reaction system.



References

1. R. Weingarten, J. Cho, W. C. Conner, G. W. Huber, *Green Chemistry* 2010, 12, 1423.
2. R. Weingarten, G. A. Tompsett, W. C. Conner, G. W. Huber, *Journal of Catalysis* 2011, 279, 174.
3. R. Weingarten, J. Cho, R. Xing, W. C. Conner, G. W. Huber, *ChemSusChem* 2011, submitted.

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