Department of Chemical Engineering Seminar Series

Distributed Ammonia Manufacturing

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Abstract

Those in the chemical enterprise now agree that the future of the chemical industry depends on becoming more sustainable. Such goal includes developing energy sources that are not based on fossil fuels, that do not entirely depend on tankers and pipelines, and that do not release large quantities of climate-changing gases.

At the University of Minnesota, I have been working on designing a sustainable small scale Haber-Bosch process, powered by wind-generated electricity. The electricity generated by the stranded wind is used to split water to produce hydrogen, and to separate nitrogen from the air by pressure swing adsorption. Once produced, hydrogen and nitrogen are fed to a Haber-Bosch reactor to synthesize carbon-neutral ammonia. Our analysis of this small process shows that its performance is governed by three characteristic times: those for chemical reaction, for ammonia removal by condensation, and for unreacted gas recycle. As the process is currently operated, the reaction time is the largest of the three, thus the small process is currently controlled by the chemical kinetics. However, we have not focused to improve the reaction chemistry because a century of intensive effort to improve the catalyst has only resulted in minor improvements in the reaction kinetics. We have focused instead on designing a novel reactive-separation process that reduces the constraints of the reversible reaction.

In this talk, I will explain how my analysis of the catalytic reaction suggests that if we remove ammonia efficiently, the suppression of the equilibrium limitation is sufficient to achieve greater production rates at much lower operating pressure. Additionally, I will discuss how in the reactive-separation process, conversion is increased, from 20% in conventional process to over 90% in the reactive-separation process.

SEMINAR
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