

Chemicals and High Octane Hydrocarbons Produced from Bio-Dimethyl Ether Using a Copper Modified Zeolite

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Abstract

Thermochemical routes to platform chemicals and fuels from biomass typically involve breaking lignocellulose into simple molecules (like synthesis gas and BTX) and then building them back to the desired compounds. While this allows one to convert a significant fraction of the biomass to simple molecules, the catalysts which produce higher value products tend to have marginal selectivity. For instance, the Fischer-Tropsch synthesis produces significant quantities of wax (which requires further processing) and the Methanol to Gasoline (MTG) synthesis produces a mix of aromatics that are difficult to separate for chemical use and exceed maximums for aromatic content in many fuels markets. Further, advanced high efficiency internal combustion engines will require fuels with high octane ratings while maintaining vapor pressures, energy densities, stabilities, corrosivities, and water solubilities that are similar to today's gasoline—a requirement not met with current biomass conversion technologies. In this presentation, we will highlight a catalyst comprised of reducible Lewis-acidic metals (like Cu) and large pore zeolites (like BEA) for the production of C₄-C₈ olefins, high octane paraffins, and hexamethylbenzene (HMB) from dimethyl ether, produced via biomass-derived syngas, with excellent selectivity and yield. Unlike the MTG catalyst and process, this reaction system yields larger amounts of non-aromatic high octane components, can be tuned to produce more olefins, and produces a pure HMB byproduct. Also, unlike most zeolite “hydrocarbon pool” processes, the addition of reducible metals activates hydrogenation and dehydrogenation reactions, increasing the degree of saturation of the final product from DME and decreasing carbon loss due to coke. Alternately, by using reverse reactions, hydrogen can be abstracted from light alkanes like isobutane to produce olefins like isobutene. Reaction mechanisms will be shown with evidence of changes in the reaction chemistry afforded by the metal-zeolite interaction. Finally, it will be shown that olefins produced by the catalyst are readily oligomerized to a distribution of C₁₂-C₂₂ branched paraffins and olefins with properties that align with jet fuel.