Abstract for AIChE Annual Meeting 2014

Renewable Chemicals from Fatty Acids via Hydrothermal Catalytic Treatment with Zeolite

Fatty acids are very attractive renewable feedstocks, because they can be major components of both terrestrial and aquatic biomass, such as algae. There are several proposed chemical processes that generate aqueous streams rich in fatty acids [1-3], including hydrothermal liquefaction of algal biomass [4]. However, there has been no research on conversion of aqueous streams rich in fatty acids to value added hydrocarbon chemicals.

We explored the hydrothermal cracking of palmitic acid by HZSM-5 zeolite in a batch reactor, at temperatures near the critical point of water. Zeolite catalysis is applied because these catalysts promote aromatization reactions, and aromatics are our versatile chemical products. At 400 °C, 180 min reaction, the major liquid products were aromatic hydrocarbons (e.g., xylenes, toluene) and alkanes (e.g., 2-methyl-pentane, heptane). As shown in Figure 2, the yields of toluene and xylenes increase steadily with time and reach 22% and 49%, respectively, at 180 min. The conversion of palmitic acid increased with time and reached 95% at 180 min. The major gaseous products were CO and CO_2, but appreciable yields of propane and butane were also obtained. The effects of several reaction variables, such as batch holding time, temperature, hydrogen pressure, water density, and reactant-to-catalyst ratio on product yields were studied. Total yields of gas and liquid products exceeding 90 wt % are available at reaction conditions of 400 ° C, 180 min, and either with no added H_2 and a water density of 0.1 g/mL or less or with added H_2 and a water density of 0.15 g/mL. The activation energy for palmitic acid disappearance is 31 ± 1 kJ/mol. The zeolite catalyst undergoes some modest structural changes under the hydrothermal reaction conditions employed, but the catalyst can be regenerated by controlled oxidation to remove coke and calcination, thus restoring the structure.

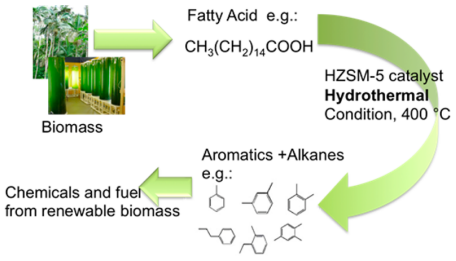


Figure 1. Illustration of the Process [5]

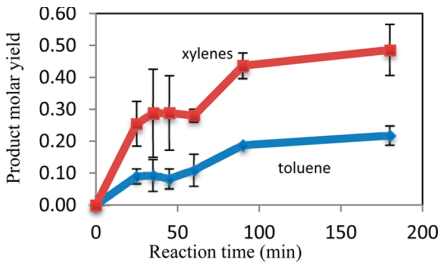


Figure 2. Temporal variation of toluene and xylenes molar yields at 400 °C.

These results demonstrate the technical feasibility of using HZSM-5 under hydrothermal conditions to produce chemicals from renewable fatty acid feedstocks.

References:

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