Gas Phase Conversion of Sugars to C3 Chemicals

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ABSTRACT

The limited fossil oil reserve, fast-rising crude oil price and increasing environmental concerns make scientists and researchers give a serious look at biomass as feed stocks to produce chemicals and fuels. Five chapters in this dissertation focused on various methodologies to convert biomass into value-added chemicals.

The vapor pressure estimation and evaporation of sugars and sugar alcohols was first discussed. The purpose of this study is to overcome the drawbacks of liquid phase hydrogenolysis (low selectivities to desired products and high cost of catalyst recovery) and identify potential conditions for gas phase hydrogenolysis. A thermogravimetric analysis (TGA) method was used to estimate a boiling point of 362 ℃ for sorbitol with sorbitol's vapor pressure following a Clausius-Clapeyron model behavior. In addition, evaporation studies demonstrated sobitol evaporation and condensation on a practical level. The evaporation of sorbitol was experimentally validated with no decomposition at 0.1 bar and 294 ℃ and

2.5 % (mass fraction) in water. The evaporation of high-concentration sorbitol feed can be achieved by mixing with a high-temperature gas. Glucose evaporated with partial decomposition at temperatures as low as 220 ℃.

Gas phase catalytic hydrogenolysis was secondly demonstrated to be a means to produce valuable chemicals from sugars and sugar alcohols. Copper-chromite, palladium, and nickel beads catalysts were investigated for gas phase hydrogenolysis of sorbitol. Complete conversion was attained at reaction pressures of 0.3 to 1 bars. The highest selectivities favored acetol. The advantages over liquid phase hydrogeonolysis are mild reaction conditions (low temperatures and pressures), high selectivity to acetol and continuous operation in packed bed reactor.

In addition, gas phase dehydration of glycerol was studied in the presence of solid acid catalyst. The reaction mechanism of producing acroelin from glycerol was proposed and validated. At mild condition of 260℃ and 0.85 bar, up to 84% selectivity to acrolein can be achieved. Compared with other processes, this technology showed more advantages, e.g. higher selectivity, milder reaction conditions and long catalyst life. This process was considered as an alternative process for industry-scale production of acrolein.