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Synthesis of Sorbitol Fatty Acid Ester through Esterification of Sorbitol and Azelaic Acid Catalysed by Germanium (IV) Oxide

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EXTENDED ABSTRACT

Conventionally, polyurethane (PU) is produced using polyol polyester derived from non-renewable petroleum feedstock. In addition to the restricted resources of petroleum feedstock, inefficient disposal of the non-biodegradable petroleum-based PU waste through landfill and incineration has caused environmental problem. [1]. As an alternative for the current resource, bio-based polyol polyester such as sorbitol fatty acid ester is introduced. Commonly, homogeneous acid catalyst such as sulfuric acid is used in esterification process for the synthesis of polyol polyester [2, 3]. In this study, sorbitol (SL) and azelaic acid (AA) derived from renewable resources were used in the esterification reaction to produce bio-based polyol polyester. Germanium (IV) oxide, a heterogeneous acid catalyst was chosen to eliminate the use of homogeneous acid catalyst that renders corrosiveness, difficulty in the downstream separation and catalyst reuse [4, 5]. The effects of important operating parameters include reaction temperature (160˚C to 220˚C), molar ratio of SL/AA (1:1 to 4:1) and catalyst loading (1 to 4 vol%) were investigated. The reaction was carried out in a batch reactor and the products were analyzed for its acid value through titration and concentration sorbitol and its anhydrides through gas chromatography (GC).

The conversion of AA increased as the temperature rised from 160 – 200˚C. A further increase of temperature did not significantly affect the conversion. Similarly, the conversion of AA increased with the increase of catalyst loading up to 3 vol%. The excessive amount of catalyst did not enhance the AA conversion [6]. The conversion of AA was significantly affected by the molar ratio of SL/AA as the excess of SL promoted forward reaction and led to a higher conversion of AA fatty acid and excess in alcohol [7]. Isosorbide is a sorbitol anhydride [8] and it was found in the product synthesized at a reaction temperature of 200˚C and above. The isosorbide concentration increased with the molar ratio of SL/AA and catalyst loading.

The best operating condition yielding the highest AA conversion of 80.61% corresponding to acid value of 24.30 mg KOH/g sample, was identified at reaction temperature of 200˚C, molar ratio of 4:1 (SL/AA) and catalyst loading of 3 vol%. Figure 1 shows the acid value and conversion of AA at the best operating condition for the reaction between sorbitol and azelaic acid. The presence of isosorbide confirmed the production of sorbitol based branched polyester with improved polyester properties in temperature flexibility, tensile strength, tear strength, elongation, abrasion resistance and solvent resistance [9].

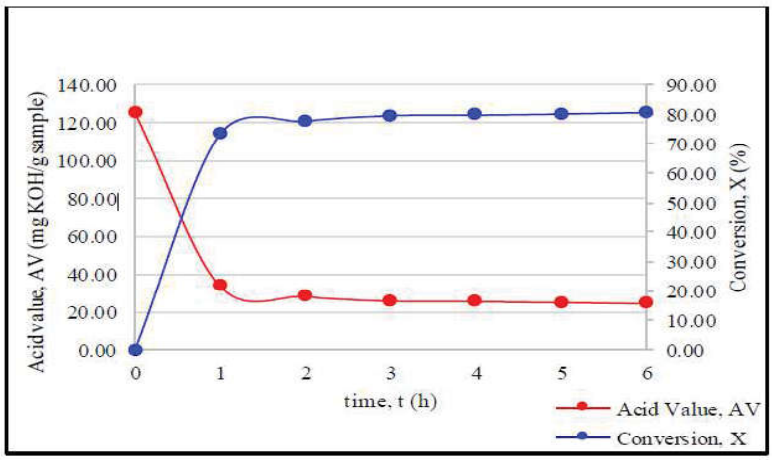

Figure 1: Acid value and conversion profile for the reaction carried out at 200˚C, 4:1 (SL/AA) and 3 vol% germanium (IV) oxide.

Keywords: Polyurethane; Polyol polyester; Biodegradable; Sorbitol fatty acid ester; Heterogeneous acid catalyst

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