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Technology and Costs

Biorenewable Insights: Bio-Polyols for Polymers

Bio-Polyols for Polymers is one in a series of reports published as part of NexantECA's 2023 Biorenewable Insights program.

Overview

The main use of polyols within the chemical industry is to produce polyurethanes. Polyether polyols are typically used in flexible foam while polyester polyols are used in rigid foams. Both can be used in CASE applications depending on the required properties.

Bio-based polyols are well-accepted by the industry and are taking increasing market share as sustainability, renewability, and bio-based content have become more important.

Polyols can be produced from a range of starting ingredients such as a starter, oxides, glycols, and dicarboxylic acids/anhydrides, and therefore developing a new 100 percent bio-based bio-polyol could require finding alternatives to multiple ingredients. However, one type of bio-based polyol is already used industrially: natural oil polyols (NOPs). For example, Ford Motor Corporation has used soy oil-derived polyols in the polyurethane flexible foams employed in its seats since 2008.

Technologies

Polyols produced from renewable sources are most commonly produced from vegetable oils such as soybean oil, rapeseed oil, and castor oil.

Castor oil is the only commercially available natural oil polyol (NOP) that is produced directly from a plant source; all other NOPs require chemical modification of the oils directly available from plants to introduce hydroxy groups. Castor oil is somewhat expensive, and not produced in all regions of the world. Therefore, other chemistries continue to be explored to make suitable NOPs from renewable sources. Chemistries being investigated include:

- Ozonolysis
- Autoxidation (of the double bond found in natural oils)
- Acid catalyzed ring opening of epoxidized soybean oil
- Treatment with carbon monoxide and hydrogen in the presence of a metal catalyst (i.e., hydroformylation)

An alternative approach is to substitute petrochemical building blocks with renewable "drop-in" alternatives.

Process Economics

Cost of production models for the USGC, China, Brazil, and Western are shown for:

- Alkoxylation of glycerin starter with propylene oxide
- Alkoxylation of glycerin starter with propylene oxide and ethylene oxide (95:5)
- Alkoxylation of glycerin starter with propylene oxide and ethylene oxide (80:20)
- Alkoxylation of sorbitol starter with propylene oxide
- Alkoxylation of sucrose starter with propylene oxide
- Alkoxylation of soybean oil with propylene oxide
- Ring opening of epoxidized soybean oil with hydrogen peroxide and acetic acid
- Polycondensation of succinic acid with diethylene glycol (DEG)
- Melt-condensation esterification of adipic acid with 1,4-butanediol

A comparison of the cost of production for petrochemical and bio-derived ethylene/propylene oxide/glycol are included.

Commercial Impact

Increased substitution of conventional with biopolyols (where the properties allow) is expected and seen in consumer segments with significant market pull, such as the automotive sector. As bio-based and renewable content become more important from the consumer's side, more bio-based polyols are being used, and polyurethane manufacturers are increasingly marketing products.

Favorable government policies for manufacturing bio-based products are also expected to positively impact bio-based polyol market growth.

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Technology and Costs comprises the Technoeconomics – Energy & Chemicals (TECH) program, the Biorenewable Insights program (BI), and the new Cost Curve Analysis. These programs provide comparative economics of different process routes and technologies in various geographic regions.

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