NexantECA

Technology and Costs

Biorenewable Insights: Polyurethanes

Polyurethanes is one in a series of reports published as part of NexantECA's 2018 Biorenewable Insights program.

Overview

The polyurethane (PU) industry is coming closer to being able to provide 100 percent bio-based, renewable PU, as several commercial and competitive options exist for polyurethanes with significant amounts of bio-based content. PUs have received significant market pull for renewable feedstock, particularly from the automotive sector. Bio-based polyols have emerged as a partial solution, allowing for polyurethanes to be as much as 30 to 70 percent renewable; however, increasing this amount has been a goal of the industry. Bio-based polyols have been well-accepted by the industry, and have been taking increasing market share as sustainability, renewability, and bio-based content has become more important from a marketing perspective and as consumers increasingly demand these qualities.

To create a 100 percent renewable polyurethane, two options have emerged: bio-based diisocyanates or a novel non-isocyanate route to polyurethanes. Bio-based diisocyanates, while the easier of the two to commercialize due to similar chemistry with the conventional route, still have several obstacles, including in any case requiring toxic phosgene (which is unlikely to be produced renewably, thus leaving the PU only partially renewable — though with a considerably higher percentage of renewable carbon), and toxicity concerns. Still, this route has been commercialized and is being pursued by major polyurethane players. Non-isocyanate bio-based routes to PU in contrast are currently in their infancy and have their own obstacles.

Technologies

Two main classes of polyols are used in the production of polyurethanes: polyether polyols and polyester polyols. These are conventionally cross-linked by MDI or TDI to form a thermoset PUR. Although both polyether polyols and polyester polyols are used in coating, adhesive, sealant and elastomer applications (collectively referred to as CASE), polyether polyols are more often used in flexible foam, while polyester polyols are more commonly used in rigid foams. However, depending on the application, the polyols requirements can shift, or even involve a mix of both types. Polyester polyols typically provide superior mechanical properties, such as tensile strength, abrasion, and wear resistance, as well as solvent and oil resistance, to the polyurethanes in which they are used. Polyether polyols provide unusually high hydrolytic stability and good low-temperature flexibility. The only bio-based diisocyanate commercially available for polyurethane manufacture is pentamethylene diisocyanate (PDI), produced by Covestro. Significant research efforts in recent years by both industry and academia have aimed at producing a polyurethane formulation derived from a non-isocyanate precursor. The most advanced of these developing routes appears to be the reaction of diamines with cyclic carbonates.

Process Economics

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

- Polyols
  - Via Alkoxylation
    - Glycerin with propylene oxide
    - Glycerin with propylene oxide and ethylene oxide (95:5)
    - Glycerin with propylene oxide and ethylene oxide (80:20)
    - Sorbitol with propylene oxide
    - Sucrose with propylene oxide
    - Soybean oil with propylene oxide
    - Ring opening of epoxidized soybean oil with hydrogen peroxide and acetic acid
    - Polycondensation of succinic acid with diethylene glycol
    - Melt-condensation esterification of adipic acid with 1,4-butanediol
- Isocyanate - PDI

Capacity

NexantECA has catalogued existing and planned bio-PU and monomer capacity.

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