Technology and Costs

Biorenewable Insights: Lactic Acid and PLA

Lactic Acid and PLA is one in a series of reports published as part of NexantECA's 2019 Biorenewable Insights program.

Overview

PLA started to garner interest back in late 1990s and early 2000s due it's renewable nature. Some of its chemical and mechanical properties are superior to the traditional plastics such as PET, polypropylene, and polystyrene in fiber and packaging applications.

The market drivers for PLA can vary depending on the region. In North America, Western Europe, and Japan, the 'green image' of PLA is one of the major drivers, as consumers are more aware and conscious of what they buy and its impact on the environment. Polystyrene foam bans are also driving the use of PLA. In Europe, legislative measures and composability are important drivers increasing demand. Cost of production of competitive downstream fabricated products is the motivation behind PLA market developments in China and Asia Pacific.

In contrast to biofuels, there are currently no strong, comprehensive policy frameworks in place to support biobased materials (such as mandatory targets, tax incentives) except in European countries. Another major challenge for PLA penetration in the market is the high price of PLA (compared to conventional plastics).

The PLA market has strong growth potential. It is made from biorenewable raw materials, it's industrially compostable, and is the first renewable polymer able to compete with existing polymers, having attractive functional properties like transparency, gloss and stiffness. There is considerable potential for market growth in Europe, driven by regulations for end-of-life management, and in North America, driven by consumers and brand-owners actively pushing for improved sustainability of plastics and packaging. PLA is already a leading alternative for many single-use plastics applications and will continue to gain market share because of its environmental attributes, however there are limitations to the marketability of PLA's end-of-life benefits due to a lack of infrastructure for industrial composting, and the fact that it is not marine biodegradable.

Technologies

The current generation of lactic acid technology involves fermentation of a carbohydrate (usually sugar) obtained from sugarcane or saccharification of starchy biomass (e.g., corn).

Three main routes are possible for polymerization of lactic acid to PLA. The major route in commercial use is via preparation of a low molecular weight pre-polymer from lactic acid followed by a cyclizing depolymerization reaction that results in formation of lactide. The depolymerization stage is catalyzed, typically using tin (II) oxide (SnO). Lactide next undergoes a ring opening polymerization to form polylactide over a catalyst (typically a tin based material such as tin-2-ethylhexanoate: $Sn(Oct)_2$). This catalyst is suitable due to its solubility in molten lactide, high reactivity, low rate of racemization of the polymer and low toxicity.

Two other routes are possible – one is a direct condensation route and the other is a route via azeotropic dehydration. Neither of these routes is commonly practiced.

Process Economics

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

- Lactic Acid
  - NatureWorks
  - Total-Corbion
  - Generic Dextrose Fermentation
  - TK-Uhde
  - Acetalydehde Nitriliation
- PLA
  - NatureWorks
  - Total-Corbion
  - Uhde Inventa

Capacity

NexantECA has catalogued existing and planned lactic acid and PLA capacity and provides project profiles.

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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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