Technology and Costs

Biorenewable Insights: Furandicarboxylic Acid (FDCA)

Furandicarboxylic Acid (FDCA) is one in a series of reports published as part of NexantECA's 2018 Biorenewable Insights program.

Overview

2,5-Furandicarboxylic Acid (FDCA), also known as dehydromucic acid or pyromucic acid, is a furanic compound characterized by its five-membered aromatic ring attached to two carboxylic acid groups. Some of its notable properties include its high melting point, insolubility in many common solvents, and chemical stability.

FDCA is one of the most promising renewable chemical building blocks. It was recognized as such when the United States Department of Energy (U.S. DOE) designated FDCA as one of 12 priority chemicals to establish the "green chemistry" in 2004. The list was revised in 2010 and FDCA was included once again, together with furfural and 5-hydroxymethylfurfural (5-HMF), both of which are furan intermediates that may be produced during FDCA production.

FDCA has potential use in many industrial applications. Most notably, FDCA can be substituted for petrochemical-derived purified terephthalic acid (PTA) in the production of polyethylene furanoate (PEF). PEF is produced from the polymerization of FDCA and monoethylene glycol (MEG), in a similar manner as polyethylene terephthalate (PET) is produced from PTA and MEG. In fact, PEF produced from FDCA demonstrates superior material properties compared to its polyester analogue, PET, with regards to lower gas permeability, higher mechanical strength, and greater thermal stability. While the most exciting opportunity for FDCA is as a replacement for petroleum-derived PTA for the production of renewable PEF, FDCA can potentially be utilized in a range of product types, including polyesters, polyamides, solvents, and plasticizers.

Technologies

FDCA was first synthesized in 1876 by German chemist Wilhelm Rudolf Fittig from hydrobromic acid and sugar-derived mucic acid. However, interest in FDCA technology and commercial production did not develop until 2004, when FDCA was identified as an important green chemical building block with the potential to produce bio-based polyesters, among other end-uses. With growing interest in the potential of FDCA and PEF, many companies began exploring and developing technologies to produce FDCA. Several different routes to FDCA production are currently being explored:

- The most prevalent route being explored and actively developed is the catalysis of sugar to an intermediate furan such as 5-HMF or 5-methoxymethylfurfural (5-MMF), followed by the catalytic oxidation of the intermediate furan to FDCA
- Rather than converting furan intermediates to FDCA through catalytic oxidation routes, some technology players are exploring FDCA production through enzymatic oxidation processes
- Instead of using conventional glucose and fructose feedstocks to produce 5-HMF and then FDCA, a few technology developers are exploring FDCA production using alternative feedstocks, such as furoic acid salts and galactaric acid
- Some are not pursuing FDCA production as a furanic platform, but are instead developing technologies to produce FDME, the methyl ester of FDCA

Process Economics

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

- Catalytic route to FDCA via conventional sugar
- Biological route to FDCA via 5-HMF
- Catalytic route to FDCA via cellulosic sugar
- Catalytic route to FDCA via MMF
- Galactaric acid route to FDCA
- Catalytic route to FDME via glucose

Capacity

NexantECA has catalogued existing and planned FDCA capacity and profiled projects.

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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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