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Technology and Costs

TECH 2023-7: Adipic Acid

Adipic Acid is one in a series of reports published as part of NexantECA's 2023 Technoeconomics – Energy & Chemicals (TECH) program.

Overview

Adipic acid is an important chemical intermediate used in the production of polyamide 6,6, thermoplastic polyurethane (TPU), unsaturated polyester resin (UPR) and adipic acid esters. Even though the technology for producing adipic acid is mature, a major downside to the conventional adipic acid production is the release of nitrous oxide (N_2O) as an unwanted byproduct. Therefore, various methods of producing adipic acid are currently being developed that do not produce N_2O, such as direct oxidation with air/oxygen, alternative feedstock, or bio-based routes. Due to the contribution of the process towards global warming, significant focus is placed on the abatement of N_2O.

This TECH report provides an updated overview of the technology, economics, and carbon intensity of adipic acid. The following issues are addressed in this report:

- What are the major technologies for KA oil and subsequent adipic acid production? How do technologies differ? Which technologies are available for license?
- How do the process economics compare across processes and different geographic regions? How does production cost and competitiveness change over time and what are the key drivers?
- What are the available N_2O abatement technologies and how do they differ? What is the current status of the industry with respect to N_2O and what is the impact of N_2O on the carbon intensity of the adipic acid production process?

Commercial Technologies

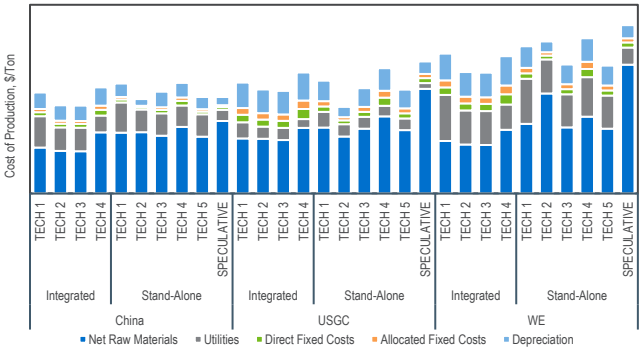
Overall, commercial adipic acid processes depend on the production (or purchase) of KA oil. KA oil is a mixture of cyclohexanone and cyclohexanol; a ketone (K) and an alcohol (A). By far the most common route to the KA oil needed for adipic acid production is the air oxidation of cyclohexane. Various routes involving air oxidation of cyclohexane to KA are reviewed in this report such as the boric acid promoted route, the cobalt catalyst route (the oldest process still in use), and the high peroxide route. Production of KA from phenol is also covered, as well as the Asahi process for cyclohexanol production from benzene via cyclohexene. KA oil is subsequently converted to adipic acid by oxidation using an excess of nitric acid.

Several developing approaches are also covered, these include direct oxidation of cyclohexane / cyclohexene / cyclohexanone / cyclohexanol to adipic acid by air / oxygen / hydrogen peroxide, butadiene carbonylation.

Process Economics

Detailed cost of production estimates for various technologies are presented for USGC, Western Europe, and coastal China locations. Estimates are developed for five commercial routes and one speculative route to adipic acid. The economics of feedstock integrated adipic acid plants are also presented for four commercial routes.

Adipic Acid Cost of Production in USGC, Western Europe, China



In addition, historical cash cost of production analysis for various routes and regions is discussed to illustrate the effect of various macroeconomic events and major global and regional events on adipic acid production.

Commercial Overview

Global adipic acid production capacity was estimated to be approximately 4.9 million tons in 2022, with polyamide 6,6 and TPU being the largest end-uses. Production is concentrated in China, followed by Western Europe, and USGC. A complete global capacity list by producer is provided in this report.

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- Chemistry
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- Process economics – comparative costs of production estimates for different technologies across various geographic regions
- Overview of product applications and markets for new as well as established products
- Regional supply and demand balances for product, including capacity tables of plants in each region
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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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