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On-Purpose Acetic Acid

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Abstract

This report consolidates and updates the IHS Chemical Process Economics Program (PEP)'s technical and economic analyses of acetic acid manufacturing technologies from 1994 to the present. Acetic acid is a moderate-volume commodity chemical used mainly in the production of vinyl acetate, terephthalic acid, acetic anhydride, ethyl acetate, and butyl acetate. The current global production of nearly 20 million metric tons per year (MMtpa) is forecast to increase by 12% over the next four to five years. Celanese and BP (formerly British Petroleum) are the main producers of acetic acid in the Americas and Europe, respectively. In Asia, Celanese technology is used in China and Singapore, and BP's process is used in Korea, Malaysia, and Taiwan.

Commercial carbonylation of methanol followed a path of homogeneous catalyst development over the years, from the BASF "high-pressure" process based on an iodide-promoted cobalt catalyst, followed by Monsanto's dramatically improved "low-pressure" process using a methyl iodide-promoted rhodium catalyst, and then the improved "low-water" processes of Celanese and BP that decreased the cost of downstream separations. Chiyoda subsequently introduced a comparable process using a heterogeneous, supported form of the rhodium system that further simplified separations and catalyst operations. Most recently, BP sidestepped the need to purchase methanol by developing a novel carbonylation process using synthesis gas as feedstock.

Processes based on partial oxidation of C_2 or C_4 hydrocarbons were quickly replaced in new plant construction by the Monsanto process in the 1970s, and perhaps just one low-capacity plant using C_2 feedstock still operates today. Yet hydrocarbons still have the potential to compete with C_1 feedstocks for acetic acid production in some locations, and thus SABIC developed a streamlined process for production of acetic acid from ethane. A simplified ethylene-based process was also developed, by Showa Denko.

Technical descriptions and economic analysis are provided herein for the following six technologies:

- The Monsanto process for production of acetic acid by carbonylation of methanol at low-pressure conditions, using a homogeneous, aqueous rhodium–based catalyst;
- The Celanese AO Plus™ process for production of acetic acid by carbonylation of methanol at low pressure and low-water conditions, using a homogeneous rhodium-based catalyst;
- The BP Cativa™ process for production of acetic acid by carbonylation of methanol at low pressure and low-water conditions, using a homogeneous iridium-based catalyst;
- The BP SaaBre™ process for production of acetic acid via carbonylation of dimethyl ether at low pressure and low-water conditions, using a series of heterogeneous zeolite-based catalysts;
- The SABIC process for production of acetic acid by one-step, direct oxidation of ethane using a heterogeneous mixed metal oxide catalyst based on molybdenum and vanadium; and
- The Showa Denko process for production of acetic acid by one-step, direct oxidation of ethylene using a heterogeneous supported palladium-based catalyst.

Production of acetic acid is reviewed, with characterization of full patent portfolios for these technologies and selected characterization for other, noncommercial processes. The industry status is updated, and a summary of the processes is provided in terms of comparative economics and the key process indicators (KPI) of capital intensity, energy intensity, carbon efficiency, and carbon intensity. Lastly an interactive module is included, the iPEP Navigator Acetic Acid tool, that provides a snapshot of economics for each process and allows the user to select the process, units, and region of interest.

While the processes presented herein represent PEP's independent interpretation of the literature and may not reflect in whole or in part the actual plant configurations, we do believe the conceptual designs sufficiently representative of plant configurations to enable Class III economic evaluations.

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