PEP Review 2011-10

ETHANOL PRODUCTION BY CELANESE ACETYL TECHNOLOGY

By

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ABSTRACT

This Review presents a techno-economic evaluation of an ethanol from acetic acid (AA) production process based upon the technical information and data provided by Celanese in its patents on the subject. The design presented herein may not be an exact construct of the actual commercial process of Celanese, known as TCX™ technology. We firmly believe, however, that our presented process design and economics are a reasonably good simulation of the actual process, and the two should be well within the marginal boundary of errors.

The process essentially consists of hydrogenating vaporized acetic acid in a fixed-bed reactor containing a silica-supported platinum-tin-based catalyst. An alkaline metal-based metasilicate compound (possibly $CaSiO_3$) may also be used as a part of the support as a support modifier. Hydrogenation is carried out at about 482°F (250°C) and 310–320 psia in an excess of H_2. Optimal gas hourly space velocity is equal to 2,500–5,000 hr^{-1}. High H_2 composition in the reactor and elsewhere keeps the process system outside the explosive range. Acetic acid conversion and ethanol selectivity are functions mainly of catalyst composition and process conditions. Generally, maintaining a lower per-pass conversion rate of the acid results in higher ethanol selectivities. Celanese, in its patent application (US 2010/0197485), presents a comprehensive account of the catalysts and process. One typical example (which we selected for our design base) shows an ethanol selectivity of 92% at 24% acid conversion. A major by-product is ethyl acetate (6%). Small amounts of acetaldehyde, CH_4, C_2H_6 and CO_2 are also produced. Excess H_2 and other light gases (CH_4, C_2H_6, CO_2, etc.) are flashed out from the reactor product and recycled to the reactor after recompression. A small amount of the recycle gas is purged prior to recycle to avoid buildup of inerts.

A 92.4 wt% aqueous ethanol product is obtained using a series of distillation towers. Since azeotropic mixtures formation (e.g., a ternary azeotrope of an ethyl acetate-ethanol-water system and a binary azeotrope of an ethanol-water system) is likely in the process, working in the sub-azeotropic distillation zones is beneficial. Despite that, the distillation process is energy-intensive, not to mention the height of a few columns that might contain 65 to 70 plates (per our design). Final ethanol purity of up to 95.0–99.5% is achieved by means of molecular sieves.

Celanese also has a proprietary AA technology commercially known as *Acid Optimization* technology. This low-water technology is based on a rhodium- and iodide-based catalyst system.

Our cost analysis is based on a plant producing 200,000 metric t/yr of ethanol at a 0.9 stream factor (equal to an installed capacity of 222,000 metric t/yr). The required installed capacity of a dedicated AA plant for the above ethanol capacity is about 337,000 metric t/yr (at a 0.9 stream factor). This AA plant has a TFC of $150 million, producing acid at a cost of $0.23/lb including a 25% pre-tax ROI. Methanol used to make the acetic acid is produced from coal-derived syngas. Cost estimates, details thereof and relevant assumptions are provided in this Review.

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CONTENTS

FIGURES

TABLES