Abstract
Process Economics Program Report 235
CHEMICALS FROM ETHANOL
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Technologies for producing chemicals from ethanol are well known and have been employed commercially for several decades. Ethylene production by ethanol dehydration, for example, was widely used in the United States and Western Europe during the first half of the 20th century, and in Brazil and India during the 1950s and 1960s. Thereafter, the steam cracking process, which employs petroleum fractions and natural gas liquids as feedstocks, emerged as the dominant method for large-scale ethylene production worldwide. As a consequence of declining oil prices in the 1980s and 1990s and wide availability of olefins from steam cracking, most processes using ethanol as feedstock could no longer compete with their corresponding petrochemical routes, and the ethanol-based chemical industry went into decline.

With the recent boom in the fuel ethanol market, particularly in Brazil and the United States, the production of chemicals from ethanol has attracted renewed interest. Environmental concerns over the use of fossil-based resources and the concept of sustainability have also broadened worldwide interest in renewable sources for both chemical feedstocks and for energy. In the case of bio-derived ethanol, production costs declined significantly over the years as a result of productivity improvements and economies of scale. These, combined with the promise of new technologies from cheap cellulosic biomass, could make ethanol a competitive feedstock for chemicals in the future.

This report presents a technical and economical analysis of the production of chemicals from ethanol, with a special focus on ethylene, acetic acid and ethyl acetate. We have developed conceptual designs and associated cost estimates for the production of each of these three products from ethanol. For ethylene and acetic acid, we use economic models to examine the competitiveness of the ethanol-based process vis-à-vis the existing petrochemical routes. For ethyl acetate, we compare the economics of the conventional process of esterification of acetic acid and ethanol, with those of a recent dehydrogenation process developed by Davy Process Technology. The general conclusions are summarized below:

- The production of ethylene from ethanol can be cost-competitive with steam cracking at small plant capacities. However, based on historical price trends, a dehydration plant that purchases ethanol and sells ethylene at normal market prices would be only marginally profitable. Economics would improve if the ethylene plant could be integrated with the upstream ethanol plant, or if the bio-based ethylene could be sold at a premium over petrochemical ethylene.

- Both capital and production costs of the ethanol-based route to produce acetic acid are currently much higher than those for the methanol carbonylation process.

- Davy’s technology to produce ethyl acetate from ethanol by dehydrogenation is very economically competitive with the conventional esterification process.
CHEMICALS FROM ETHANOL

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