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Liquid-Phase Alkylation of Dilute Ethylene to Ethylbenzene by Lummus Process

By Sumod Kalakkunnath

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Abstract

This review presents a technoeconomic evaluation of ethylbenzene production from liquid-phase alkylation of dilute ethylene and benzene based upon the technical information and data available in patents assigned to Lummus Technology Inc. Although a zeolite catalyst-based liquid-phase alkylation of ethylene is an established process, the current configuration developed in a Lummus/CDTECH collaboration has not yet been commercialized. However, we firmly believe that the process design and economics presented herein would be a reasonably accurate representation of the actual process when commercialized.

In this review, 522,000 metric t/yr of ethylbenzene is produced via liquid-phase alkylation of dilute ethylene (from desulfurized FCC off-gas) and benzene. The feedstock FCC gas is first pretreated to remove propane and heavier constituents. The gas with dilute ethylene and benzene is fed to an alkylation reactor wherein ~90% of ethylene conversion takes places at about 220°C (428°F) and 425 psia using a proprietary, zeolite beta catalyst. The innovation lies in the unique “baled” configuration of zeolite catalyst which is arranged as structured packing in the reactor. The reactor, which works on a catalytic distillation principle, gets a liquid benzene reflux from the top and a vapor recycle from the trayed section connected to the bottom. The reactor overheads are condensed and separated into vapor and liquid phases. The vapor phase with a majority of the ethylene is sent to a finishing reactor to complete the ethylene conversion at about 200°C (392°F) and 725 psia. The condensed liquid phase is sent to a transalkylation reactor wherein the polyethylbenzene by-products are converted to ethylbenzene at about 185°C (365°F) and 425 psia. The bottom streams of the three reactors are merged and sent to a product recovery section comprised of three distillation units to separate the ethylbenzene product and recycle the benzene and polyethylbenzenes.

Our cost analysis is based on a plant producing 522,000 metric t/yr of ethylbenzene at a 0.9 stream factor (equal to an installed capacity of 579,000 metric t/yr). Cost estimates, details thereof, and relevant assumptions are provided in this review.
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