

PERP Program

April 1996

Chem Systems' Process Evaluation/Research Planning program has published a new report: ***Styrene/Ethylbenzene (94/95-8)***.

Until 1980 nearly all ethylbenzene was produced from polymer grade ethylene and nitration grade benzene in a liquid phase alkylation with aluminum chloride as the catalyst. Variations of this method still account for about 40 percent of global ethylbenzene capacity. The most dramatic change in ethylbenzene technology occurred in 1980 when the commercialization of the Mobil/Badger process took place. Based on Mobil's proprietary ZSM-5 zeolite catalyst, and using polymer grade ethylene, the new technology offered vapor phase operation with a truly heterogeneous catalyst that did not present the waste disposal and metallurgical problems of processes using homogeneous Lewis acid catalysts. Lummus, in conjunction with its partner UOP, has developed a competing liquid phase zeolite alkylation process, which operates at lower reaction temperatures but higher reaction pressures, compared to the vapor phase process.

Variations in ethylbenzene production include the use of energy efficient technology offered by CDTECH, which combines catalytic reaction with distillation to simultaneously separate components of the reaction mixture, and the use of dilute ethylene sources.

There is less distinction between the competing processes for the vapor phase dehydrogenation of ethylbenzene to styrene. Lummus and UOP offer the SMART™ process, which uses a novel oxidative reheating step to provide reaction heat by controlled oxidation of hydrogen in the gas stream. Otherwise, differences between the Lummus/UOP CLASSIC dehydrogenation process and the Fina/Badger dehydrogenation process, which both utilize conventional reheat technology, are subtle, and involve design philosophy, mechanical integrity, heat integration, etc.

Styrene/Ethylbenzene presents the production economics for nine competing technologies including:

- Liquid phase aluminum chloride-catalyzed alkylation and conventional dehydrogenation
- Mobil/Badger vapor phase alkylation and Fina/Badger dehydrogenation
- Mobil/Badger EBMSM alkylation and Fina/Badger dehydrogenation

- CDTECH alkylation via catalytic distillation and Lummus/UOP CLASSIC dehydrogenation
- Lummus/UOP liquid phase alkylation and Lummus/UOP SMART™ dehydrogenation with oxidative reheat
- Mobil/Badger vapor phase alkylation using dilute ethylene with absorption pretreatment and Fina/Badger dehydrogenation
- ARCO propylene oxide/styrene monomer process, utilizing hydroperoxidation followed by epoxidation, with costs allocated between the coproducts
- Dow process for styrene production by butadiene dimerization followed by oxidative dehydrogenation of the intermediate 4-vinylcyclohexene
- Speculative process based on methanol alkylation of toluene

Our analysis indicates that all of the zeolite-based processes are very closely competitive. Aluminum chloride catalyzed alkylation shows higher costs, on a new plant basis, due to lower raw material efficiency, higher catalyst cost, and smaller scales. The propylene oxide co-product process economics can vary considerably depending on the credit allowed for propylene oxide. The butadiene-based process developed by Dow is penalized by a plant size limited by the availability of butadiene from a single world-scale ethylene cracker. Further, this process is somewhat more investment intensive than conventional styrene processes. We believe the key to commercialization of the Dow process is siting of the plant where butadiene has a low value. This condition prevails in some parts of East Asia and Europe.