

CHEMSYSTEMS PERP PROGRAM

# Developments in *para*-Xylene Technology

Cost savings of BP's crystallization technology and several new UOP processing schemes are assessed. Current commercial technology is reviewed. Supply/demand forecasts are also provided.

PERP 08/09S11

Report Abstract December 2009

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## **Report Abstract**

### Developments in *para*-Xylene Technology PERP 08/09S11

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#### INTRODUCTION

The configuration of an aromatics complex depends upon the available feedstock, the desired product slate, and the amount of investment capital. A fully-integrated modern complex designed to produce benzene, *para*-xylene, and *ortho*-xylene from naphtha typically contains the following process technologies:

- Naphtha Hydrotreating Process
- Reforming Process
- Extractive Distillation
- TDP process
- THDA process
- Separation technology
- Isomerization technology
- Fractionation

The choice between the THDA and TDP processes depends upon whether the principal product is benzene or *para*-xylene and their relative values.

This report discusses recent improvements to the separation techniques for the production of *para*-xylene - specifically those made by BP to the crystallization separation process and developments by UOP. Current commercial technologies are reviewed. Process economics estimates and commercial market analysis are included.

#### DEVELOPING TECHNOLOGIES

Historically, crystallization technology was perceived to suffer from disadvantages of requiring low temperature refrigerants for the freezing process and requiring more rotating mechanical equipment. BP Corporation North America, Inc. (formerly Amoco Chemical Company) has continually improved their *para*-xylene crystallization process since commissioning their first commercial *para*-xylene unit in 1967, such that they now claim that their new crystallization technique has lower energy use and unit capital cost than other *para*-xylene production methods.

*para*-Xylene separation from mixed xylene feedstocks requires first stage crystallization temperatures as low as -90 °F (-68 °C). The conventional crystallization processes use cascaded ethylene/propane or ethylene/propylene ( $C_2/C_3$ ) vapor compression refrigeration systems. The  $C_3$  compressor is an expensive piece of equipment, and a large user of electricity. This report describes a new energy efficient technique that uses waste heat powered ammonia absorption refrigeration (AAR) instead of conventional  $C_3$  refrigeration.



UOP (a Honeywell Company) has made a number of developments directed at simplification/optimization of the UOP flow scheme. These improvements are geared toward a notable reduction in capital investment for the aromatics complex. In addition, work on a relatively recent development in the production of *para*-xylene from mixed butanes or isobutylene is provided, as well as a novel bio *para*-xylene approach.

#### COMMERCIAL TECHNOLOGIES

The recovered aromatics stream from extraction of reformate consists of benzene, toluene, mixed xylenes, and  $C_{9+}$  materials. Each of these can be separated by conventional distillation, although it is difficult to separate the individual xylenes isomers due to the closeness of their boiling points. It is feasible to separate ethylbenzene and *ortho*-xylene from the mixed xylenes feed by conventional distillation.

This report reviews traditional *para*-Xylene Separation/Isomerization:

- Adsorption and crystallization process technologies and licensor variations
- Isomerization process technology & licensor variations

#### ECONOMIC ANALYSIS

In this section, the costs of production for producing *para*-xylene have been estimated for production with the following feedstocks and at world scale capacities:

• Overall aromatics complex employing naphtha feed

UOP has made a number of improvements in the aromatics complex directly involved in reducing the investment as referenced in the developments cited in this report. An analysis of the sensitivity of the cost of production of *para*-xylene to capital investment and utility consumption has been carried out.

The costs of production for the *para*-xylene produced on the U.S. Gulf Coast are compared with those of Western Europe, Japan, South Korea, South East Asia, and the Middle East.

- Separation/isomerization employing mixed xylene feed three cases:
  - BP's crystallization/isomerization process employing ammonia absorption refrigeration (AAR) unit
  - Conventional adsorption/isomerization process (e.g., UOP's Parex<sup>TM</sup> and Isomar<sup>TM</sup> technology)
  - Conventional crystallization/isomerization process

Various sensitivities have been explored to illustrate the effects of variations in certain parameters on the base case economics presented. These results can also be used to make approximate comparisons between cases for which detailed economics that have not been provided by adjusting for capacity differences, alternative feedstock valuation, etc. The sensitivity of the cost of production of *para*-xylene via adsorption/isomerization and crystallization/isomerization is examined for feed and by-product pricing, economy of scale, and capital investment in this section. In addition, the sensitivity of the utility consumption for the BP process is examined.

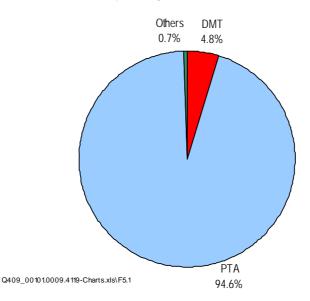
• A conceptual design based on the UOP developments dealing with *para*-xylene produced from C<sub>4</sub>s has been developed starting with an isobutylene feed and employing the dimerization, aromatization and crystallization unit operations

The sensitivity of the cost of production to the isobutylene feed price has been carried out

#### **COMMERCIAL ANALYSIS**

*para*-Xylene is the isomer most in demand for chemical end uses, although it accounts for only 16-20 percent in the mixed xylenes stream. As a result, a large portion is made by isomerizing the other isomers.

Virtually all *para*-xylene consumed as a chemical feedstock is used to produce either terephthalic acid (PTA) or dimethyl terephthalate (DMT) as illustrated by the figure below. Small volumes are also consumed in the production of di-*para*-xylene (used in coatings of electrical substrates) and low volume products such as vitamins, pharmaceutics, and insecticides.



#### Global *para*-Xylene End-Use Pattern

- Regional supply, demand and trade data is given and discussed in the report for the U.S.
  Western Europe and Asia Pacific; a global overview is also given
- Tables giving individual plant production capacity according to plant location, plant owner, and process technology used for the regions listed above are also included in the report





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