Abstract
Process Economics Program Report No. 209
AROMATICS INDUSTRY OUTLOOK
(June 1992)

The aromatics industry today is experiencing considerable uncertainty resulting from the move toward reformulated gasoline in the United States and changes in crude oil prices. This report assesses the impact of changes occurring in the fuel markets, and is intended to help petrochemical producers and refiners identify future opportunities in the BTX aromatics market.

In this report, we examine the likely process changes and modifications that refiners will have to make in order to produce reformulated gasoline. The BTX market is closely linked to the refining industry, because the primary use of aromatics is in the gasoline pool. Petrochemical demand for aromatics is a small percentage of the total demand, and BTX consumption and production are likely to be affected by the changes in refining. We estimate the future availability of BTX aromatics from U.S. refineries based on a variety of gasoline reformulation scenarios and regional capabilities. To reduce aromatics levels in gasoline, less BTX will be produced by catalytic reforming. Nonetheless, we expect an increased volume of benzene to be extracted from the gasoline pool, which will in turn reduce the amount of toluene used to make benzene via hydrodealkylation (HDA).

We present worldwide and regional BTX supply and demand balances for the recent past and SRI’s projections for 1995 and 2000. A buildup in new BTX capacity since the late 1980s, combined with an economic recession, have caused a downcycle in the BTX industry. While BTX demand is forecast to increase worldwide following economic recovery, overcapacity will continue for the next several years.

A forecast of future BTX prices, including a crude oil price scenario, is also presented.
CONTENTS

1 INTRODUCTION 1-1

2 SUMMARY 2-1
   SOURCES OF BTX AROMATICS 2-1
   IMPACT OF REFORMULATED GASOLINE ON BTX AROMATICS SUPPLY 2-2
   BENZENE SUPPLY/DEMAND 2-3
   TOLUENE SUPPLY/DEMAND 2-7
   XYLENES SUPPLY/DEMAND 2-10
   BTX PRICING TRENDS 2-10

3 SOURCES OF BTX AROMATICS 3-1
   REFINERY BTX AROMATICS 3-3
   ETHYLENE PLANT BTX AROMATICS 3-3
   AROMATICS PLANT PROCESSING SCHEME 3-5

4 IMPACT OF REFORMULATED GASOLINE ON BTX AROMATICS SUPPLY 4-1
   NEW U.S. GASOLINE REQUIREMENTS 4-1
      Oxygenated Gasoline 4-1
      Reformulated Gasoline 4-3
      EPA Rules 4-4
   REFORMULATED GASOLINE MARKET 4-5
   REFINERS’ OPTIONS 4-8
      Oxygenate Supply 4-8
      Aromatics Reduction 4-12
      Benzene Reduction 4-13
      Volatility (RVP) Reduction 4-16
      Olefin Reduction 4-16
      Sulfur Reduction/Hydrotreating 4-17
   REFORMULATION SCENARIOS 4-17
      Aromatics and Benzene Specifications 4-18
      Refinery Imbalances 4-19
4 IMPACT OF REFORMULATED GASOLINE ON BTX AROMATICS SUPPLY (Concluded)

IMPACT OF REFORMULATION ON WORLDWIDE BTX SUPPLY 4-25
United States 4-25
Western Europe 4-26
East Asia 4-27

5 BENZENE INDUSTRY 5-1
HISTORICAL INDUSTRY PERSPECTIVE 5-3
WORLD BENZENE OUTLOOK 5-4
U.S. BENZENE OUTLOOK 5-9
WESTERN EUROPE’S BENZENE OUTLOOK 5-13
JAPAN’S BENZENE OUTLOOK 5-14
ASIA’S (EXCLUDING JAPAN) BENZENE OUTLOOK 5-14
ROW BENZENE OUTLOOK 5-15

6 TOLUENE INDUSTRY 6-1
HISTORICAL INDUSTRY PERSPECTIVE 6-4
WORLD TOLUENE OUTLOOK 6-5
U.S. TOLUENE OUTLOOK 6-10
WESTERN EUROPE’S TOLUENE OUTLOOK 6-15
JAPAN’S TOLUENE OUTLOOK 6-15
ASIA’S (EXCLUDING JAPAN) TOLUENE OUTLOOK 6-16
ROW TOLUENE OUTLOOK 6-16

7 XYLENES INDUSTRY 7-1
HISTORICAL INDUSTRY PERSPECTIVE 7-1
Para-xylene 7-2
Ortho-xylene 7-3
WORLD XYLENES OUTLOOK 7-4
Para-xylene 7-8
Ortho-xylene 7-13
CONTENTS (Concluded)

7 XYLENES INDUSTRY (Concluded)
U.S. XYLENES OUTLOOK 7-18
Para-xylene 7-18
Ortho-xylene 7-20
WESTERN EUROPE’S XYLENES OUTLOOK 7-20
Para-xylene 7-20
Ortho-xylene 7-20
JAPAN’S XYLENES OUTLOOK 7-21
Para-xylene 7-21
Ortho-xylene 7-21
ASIA’S (EXCLUDING JAPAN) XYLENES OUTLOOK 7-21
Para-xylene 7-21
Ortho-xylene 7-22
ROW XYLENES OUTLOOK 7-22
Para-xylene 7-22
Ortho-xylene 7-23

8 TRENDS IN BTX AROMATICS PRICING 8-1
CRUDE OIL OUTLOOK 8-1
BTX OUTLOOK 8-3
Benzene 8-7
Toluene and Mixed Xylenes 8-9
Para-xylene 8-9
Ortho-xylene 8-9

APPENDIX A: CITED REFERENCES A-1
ILLUSTRATIONS

3.1 INTEGRATED AROMATICS PLANTS
SCHEMATIC BLOCK FLOW DIAGRAM 3-7

4.1 U.S. CLEAN AIR ACT NONATTAINMENT AREAS 4-7

4.2 REGIONAL U.S. BENZENE LEVELS IN GASOLINE IN 1990 4-14

5.1 U.S. BENZENE DEMAND: 1955-1990 5-3

5.2 WORLD BENZENE CAPACITY BY REGION: 1985-2000 5-6

5.3 BENZENE CAPACITY AND PRODUCTION BY REGION 5-8

5.4 REGIONAL BENZENE TRADE BALANCES (EXPORTS - IMPORTS) 5-9

6.1 U.S. TOLUENE PRODUCTION: 1955-1990 6-4

6.2 WORLD TOLUENE CAPACITY BY REGION: 1985-2000 6-8

6.3 TOLUENE CAPACITY AND PRODUCTION BY REGION 6-9

6.4 REGIONAL TOLUENE TRADE BALANCES (EXPORT - IMPORTS) 6-10


7.2 U.S. PARA-XYLENE USE FOR DMT AND TPA: 1960-2000 7-3

7.3 U.S. ORTHO-XYLENE CONSUMPTION: 1960-1990 7-4

7.4 WORLD PARA-XYLENE CAPACITY BY REGION: 1985-2000 7-10

7.5 PARA-XYLENE CAPACITY AND PRODUCTION BY REGION 7-11

7.6 REGIONAL PARA-XYLENE TRADE BALANCES (EXPORTS - IMPORTS) 7-12

7.7 WORLD ORTH-OXYLENE CAPACITY BY REGION: 1985-2000 7-14

7.8 ORTHO-XYLENE CAPACITY AND PRODUCTION BY REGION 7-15

7.9 REGIONAL ORTHO-XYLENE TRADE BALANCES (EXPORTS - IMPORTS) 7-16

8.1 U.S. BTX PRICES AND VALUES 8-6
TABLES

2.1 WORLD BENZENE DEMAND 2-5
2.2 WORLD BENZENE SUPPLY 2-6
2.3 WORLD TOLUENE DEMAND 2-8
2.4 WORLD TOLUENE SUPPLY 2-9
2.5 WORLD PARA-XYLENE DEMAND 2-12
2.6 WORLD PARA-XYLENE SUPPLY 2-13
2.7 WORLD ORTHO-XYLENE DEMAND 2-14
2.8 WORLD ORTHO-XYLENE SUPPLY 2-15
3.1 WORLD BTX (PETROCHEMICAL) PRODUCTION BY SOURCE 3-2
4.1 CARBON MONOXIDE NONATTAINMENT AREAS REQUIRING OXYGENATED GASOLINE BY 1992 4-2
4.2 OZONE NONATTAINMENT AREAS REQUIRING REFORMULATED GASOLINE BY 1995 4-3
4.3 OZONE NONATTAINMENT AREAS LIKELY TO “OPT-INTO” REFORMULATED GASOLINE PROGRAM 4-6
4.4 ADDITIVE BLENDING PROPERTIES ETHERS 4-9
4.5 ADDITIVE BLENDING PROPERTIES ALCOHOLS 4-10
4.6 U.S. GASOLINE POOL REFORMULATION SCENARIOS GASOLINE REQUIREMENTS AND REFINERY PROCESS CHANGES 4-20
4.7 U.S. GASOLINE POOL COMPOSITION: 1990-2000 REFORMULATION SCENARIO “A” 4-21
4.8 U.S. GASOLINE POOL COMPOSITION: 1990-2000 REFORMULATION SCENARIO “B” 4-22
4.9 U.S. GASOLINE POOL COMPOSITION: 1990-2000 REFORMULATION SCENARIO “C” 4-23
### TABLES (Concluded)

<table>
<thead>
<tr>
<th>Table Number</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
</table>
| 4.11         | U.S. REFORMULATION SCENARIOS  
INCREMENTAL BENZENE EXTRACTED FROM REFORMATE | 4-26 |
| 5.1          | WORLD BENZENE (PETROCHEMICAL) SUPPLY AND DEMAND | 5-2 |
| 5.2          | WORLD BENZENE (PETROCHEMICAL) CAPACITY | 5-7 |
| 5.3          | U.S. BENZENE AVAILABILITY AND USES -  
1995 REFORMULATION SCENARIOS | 5-11 |
| 5.4          | U.S. BENZENE AVAILABILITY AND USES -  
2000 REFORMULATION SCENARIOS | 5-12 |
| 6.1          | WORLD TOLUENE (CHEMICAL) SUPPLY AND DEMAND | 6-3 |
| 6.2          | WORLD TOLUENE (CHEMICAL CAPACITY | 6-7 |
| 6.3          | U.S. TOLUENE AVAILABILITY AND USES -  
1995 REFORMULATION SCENARIOS | 6-13 |
| 6.4          | U.S. TOLUENE AVAILABILITY AND USES -  
2000 REFORMULATION SCENARIOS | 6-14 |
| 7.1          | WORLD PARA-XYLENE SUPPLY AND DEMAND | 7-6 |
| 7.2          | WORLD ORTHO-XYLENE SUPPLY AND DEMAND | 7-7 |
| 7.3          | WORLD PARA-XYLENE CAPACITY | 7-9 |
| 7.4          | WORLD ORTHO-XYLENE CAPACITY | 7-17 |
| 7.5          | U.S. GASOLINE POOL REFORMULATION SCENARIOS  
GASOLINE REQUIREMENTS AND REFINERY PROCESS CHANGES | 7-19 |
| 8.1          | PRICES AND VALUES OF AROMATICS IN HOUSTON: 1985-2000 | 8-4 |
| 8.2          | PRICES AND VALUES OF AROMATICS IN SINGAPORE: 1985-2000 | 8-5 |
| 8.3          | TOLUENE DEALKYLATION PROCESS ECONOMICS | 8-8 |