

---

# WORLDWIDE REFINERY PROCESSING REVIEW

*Monitoring Technology Development and Competition in One Single Source*

---

## First Quarter 2016

*Aromatics Production*

*Plus*

*Latest Refining Technology Developments & Licensing*



**HYDROCARBON PUBLISHING COMPANY**

*Translating Knowledge into Profitability®*

P.O. Box 815, Paoli, PA 19301-0815 (U.S.A.)

Phone: (610) 408-0117/ Fax: (610) 408-0118

[Review@Hydrocarbonpublishing.com](mailto:Review@Hydrocarbonpublishing.com)



# TABLE OF CONTENTS

## 1Q 2016 Review Aromatics Production

|   |          |
|---|----------|
| <b>1. INTRODUCTION</b> .....  | <b>1</b> |
| <b>2. AROMATICS PRODUCTION</b> .....  | <b>5</b> |
| 2.1 MARKET/TECHNOLOGY TRENDS & OPPORTUNITIES.....                           | 5        |
| 2.1.1 <i>Introduction</i> .....   | 5        |
| 2.1.2 <i>Market Conditions and Outlook</i> .....                            | 6        |
| 2.1.2.1 US Could Be Fertile Ground for On-Purpose Benzene.....              | 7        |
| 2.1.2.2 Shifting Prices in Europe in the Face of Volatile Crude.....        | 9        |
| 2.1.2.3 Mideast PCs Look to Expand, Downstream and Abroad .....             | 9        |
| 2.1.2.4 Asia Remains Active in the PC Industry .....                        | 10       |
| 2.1.2.5 Continued Emergence of Bio-BTX .....                                | 11       |
| 2.1.3 <i>Technology Competition, Directions, and Future Prospects</i> ..... | 13       |
| 2.1.3.1 BTX Production & Recovery Technologies.....                         | 14       |
| 2.1.3.1.1 Catalytic Reforming .....   | 14       |
| 2.1.3.1.2 Toluene Disproportionation/Transalkylation.....                   | 15       |
| 2.1.3.1.3 Xylene Isomerization & Recovery .....                             | 16       |
| 2.1.3.1.3.1 Isomerization .....   | 16       |
| 2.1.3.1.3.2 Separation and Purification of Xylene Isomers .....             | 16       |
| 2.1.3.1.4 Alternative Production Processes.....                             | 17       |
| 2.1.3.1.5 Hydrodealkylation .....   | 18       |
| 2.1.3.1.6 Aromatics Recovery by Extraction or Extractive Distillation ..... | 18       |
| 2.1.3.2 Integrated Refining and Aromatics Production .....                  | 19       |
| 2.1.3.2.1 FCC.....  | 19       |
| 2.1.3.2.2 Hydrocracking.....  | 20       |
| 2.1.3.2.3 Integrated Refinery and PC Complexes .....                        | 20       |
| 2.1.4 <i>Conclusion</i> .....   | 21       |
| 2.2 STATE-OF-THE-ART TECHNOLOGY .....                                       | 23       |
| 2.2.1 <i>Introduction</i> .....   | 23       |
| 2.2.2 <i>Catalytic Reforming</i> .....                                      | 23       |
| 2.2.2.1 Process .....   | 24       |
| 2.2.2.1.1 Axens .....   | 25       |
| 2.2.2.1.2 Chevron Phillips Chemicals.....                                   | 28       |
| 2.2.2.1.3 UOP.....  | 29       |
| 2.2.2.1.3.1 CCR Platforming .....   | 29       |
| 2.2.2.1.3.2 RZ Platforming .....  | 31       |
| 2.2.2.2 Catalyst.....   | 32       |
| 2.2.3 <i>Aromatics from the FCCU</i> .....                                  | 34       |
| 2.2.3.1 Sinopec.....  | 34       |
| 2.2.3.2 Technip Stone & Webster .....                                       | 36       |
| 2.2.3.3 UOP .....   | 37       |
| 2.2.4 <i>Aromatics via Hydrocracking</i> .....                              | 38       |
| 2.2.4.1 UOP .....   | 38       |
| 2.2.5 <i>Alternative Production Processes</i> .....                         | 39       |
| 2.2.5.1 Aromatics from LPG.....   | 39       |
| 2.2.5.2 Aromatics from Olefin-rich Streams.....                             | 40       |
| 2.2.5.2.1 ExxonMobil Chemical .....   | 40       |
| 2.2.5.2.2 Green Chem.....   | 41       |
| 2.2.5.2.3 Technip Stone & Webster.....                                      | 41       |

# TABLE OF CONTENTS

|               |   |    |
|---------------|---|----|
| 2.2.6         | <i>Conversion of Toluene and/or Heavy Aromatics</i> .....                   | 42 |
| 2.2.6.1       | Hydrodealkylation .....   | 42 |
| 2.2.6.1.1     | CB&I.....   | 42 |
| 2.2.6.1.1.1   | DETOL .....   | 42 |
| 2.2.6.1.1.2   | LITOL.....  | 44 |
| 2.2.6.1.1.3   | PYROTOL.....  | 45 |
| 2.2.6.1.2     | UOP .....   | 45 |
| 2.2.6.2       | Disproportionation/Transalkylation.....                                     | 46 |
| 2.2.6.2.1     | ExxonMobil Chemical .....   | 46 |
| 2.2.6.2.1.1   | MTDP-3.....   | 47 |
| 2.2.6.2.1.2   | TransPlus .....   | 48 |
| 2.2.6.2.1.3   | PxMax .....   | 49 |
| 2.2.6.2.2     | GTC Technology.....   | 50 |
| 2.2.6.2.2.1   | GT-STDP.....  | 50 |
| 2.2.6.2.2.2   | GT-TransAlk .....   | 51 |
| 2.2.6.2.2.3   | GT-TolAlk .....   | 52 |
| 2.2.6.2.2.4   | GT-G2A .....  | 52 |
| 2.2.6.2.3     | Sinopec.....  | 52 |
| 2.2.6.2.4     | UOP .....   | 53 |
| 2.2.6.2.4.1   | Tatoray .....   | 53 |
| 2.2.6.2.4.2   | TAC9 .....  | 56 |
| 2.2.6.2.4.3   | PX-Plus.....  | 57 |
| 2.2.6.2.5     | Zeolyst International .....   | 59 |
| 2.2.7         | <i>Xylene Isomerization and Recovery</i> .....                              | 60 |
| 2.2.7.1       | Isomerization .....   | 60 |
| 2.2.7.1.1     | Clariant (Formerly Süd-Chemie).....   | 61 |
| 2.2.7.1.2     | ExxonMobil Chemical .....   | 61 |
| 2.2.7.1.2.1   | Advanced MHAI.....  | 61 |
| 2.2.7.1.2.2   | XyMax.....  | 62 |
| 2.2.7.1.3     | GTC Technology.....   | 63 |
| 2.2.7.1.4     | IFP and Zeolyst .....   | 64 |
| 2.2.7.1.5     | UOP .....   | 66 |
| 2.2.7.2       | Separation and Purification of Xylene Isomers .....                         | 68 |
| 2.2.7.2.1     | Crystallization .....   | 69 |
| 2.2.7.2.1.1   | BEFS Technologies .....   | 69 |
| 2.2.7.2.1.2   | GTC Technology.....   | 70 |
| 2.2.7.2.1.3   | Sulzer Chemtech.....  | 71 |
| 2.2.7.2.1.3.1 | Falling Film Crystallization.....   | 71 |
| 2.2.7.2.1.3.2 | Meta-Xylene Process .....   | 72 |
| 2.2.7.2.1.4   | UOP.....  | 72 |
| 2.2.7.2.2     | Adsorption.....   | 73 |
| 2.2.7.2.2.1   | Axens .....   | 73 |
| 2.2.7.2.2.2   | BASF.....   | 75 |
| 2.2.7.2.2.3   | UOP.....  | 75 |
| 2.2.7.2.2.3.1 | Parex .....   | 75 |
| 2.2.7.2.2.3.2 | MX Sorbex.....  | 77 |
| 2.2.8         | <i>Recovery of Aromatics by Extraction or Extractive Distillation</i> ..... | 78 |
| 2.2.8.1       | Air Liquide .....   | 79 |
| 2.2.8.2       | GTC Technology .....  | 79 |
| 2.2.9         | <i>Sinopec</i> .....  | 83 |
| 2.2.9.1       | Sulzer Chemtech .....   | 84 |
| 2.2.9.2       | ThyssenUdde Krupp Engineering Services .....                                | 85 |
| 2.2.9.2.1     | Morphylane.....   | 86 |
| 2.2.9.2.2     | Octenar.....  | 88 |
| 2.2.9.2.3     | Morphylex .....   | 88 |

# TABLE OF CONTENTS

|               |  |     |
|---------------|--|-----|
| 2.2.9.3       | UOP .....  | 89  |
| 2.2.9.3.1     | Sulfolane .....  | 90  |
| 2.2.9.3.2     | Carom .....  | 91  |
| 2.2.9.3.3     | Udex/Tetra.....  | 92  |
| 2.2.10        | <i>Summary of Commercially Available Aromatics Production Technologies</i> ..... | 93  |
| 2.3           | PLANT OPERATIONS AND PRACTICES.....  | 101 |
| 2.3.1         | <i>Catalytic Reformer Aromatics Production</i> .....                             | 101 |
| 2.3.1.1       | Increasing Aromatics Yield .....   | 101 |
| 2.3.1.1.1     | Naphtha Feed Properties.....   | 101 |
| 2.3.1.1.2     | Catalysts.....   | 102 |
| 2.3.1.2       | Reducing Coke Formation .....  | 103 |
| 2.3.1.3       | Removing Chlorides from Hydrocarbon Streams .....                                | 104 |
| 2.3.2         | <i>Dedicated Aromatics Production Units</i> .....                                | 106 |
| 2.3.2.1       | Removing Olefins from Aromatic Streams .....                                     | 106 |
| 2.3.2.2       | Improving Tray Technology in Aromatic Extraction Units .....                     | 108 |
| 2.3.2.3       | Reducing Corrosion/Foaming in Aromatics Extraction Units.....                    | 109 |
| 2.3.2.4       | Controlling the Feed Composition to a Paraxylene Crystallization Unit.....       | 111 |
| 2.3.2.5       | Improvements to Process Control and Optimization .....                           | 111 |
| 2.3.3         | <i>FCCU Aromatics Production</i> .....   | 112 |
| 2.4           | REFINING R&D ALERT!.....   | 112 |
| 2.4.1         | <i>Introduction</i> .....  | 112 |
| 2.4.2         | <i>Catalytic Reforming</i> .....   | 116 |
| 2.4.2.1       | Patents .....  | 116 |
| 2.4.2.2       | Research .....   | 117 |
| 2.4.3         | <i>Hydrocracking</i> .....   | 119 |
| 2.4.4         | <i>FCC</i> .....   | 121 |
| 2.4.4.1       | Patents .....  | 121 |
| 2.4.4.2       | Research.....  | 122 |
| 2.4.5         | <i>Integration of Refining and BTX Processes</i> .....                           | 123 |
| 2.4.5.1       | Patents .....  | 123 |
| 2.4.5.2       | Research.....  | 127 |
| 2.4.6         | <i>Conversion of Toluene and/or Heavier Aromatics</i> .....                      | 127 |
| 2.4.6.1       | Disproportionation/Transalkylation .....   | 127 |
| 2.4.6.1.1     | Process.....   | 127 |
| 2.4.6.1.1.1   | Patents .....  | 127 |
| 2.4.6.1.1.2   | Research .....   | 131 |
| 2.4.6.1.2     | Catalyst .....   | 131 |
| 2.4.6.1.2.1   | Patents.....   | 131 |
| 2.4.6.1.2.2   | Research .....   | 133 |
| 2.4.6.2       | Toluene Alkylation.....  | 134 |
| 2.4.7         | <i>Xylene Isomerization and Recovery</i> .....                                   | 135 |
| 2.4.7.1       | Isomerization.....   | 135 |
| 2.4.7.1.1     | Process.....   | 135 |
| 2.4.7.1.1.1   | Preparation of Feedstock Prior to Isomerization .....                            | 135 |
| 2.4.7.1.1.2   | Dual-phase Processes .....   | 136 |
| 2.4.7.1.1.3   | Heat Integration between Isomerization and Recovery Sections .....               | 137 |
| 2.4.7.1.1.4   | Miscellaneous .....  | 138 |
| 2.4.7.1.2     | Catalyst .....   | 139 |
| 2.4.7.1.2.1   | Patents.....   | 139 |
| 2.4.7.1.2.2   | Research .....   | 140 |
| 2.4.7.2       | Separation and Purification of Xylene Isomers.....                               | 141 |
| 2.4.7.2.1     | Adsorption .....   | 141 |
| 2.4.7.2.1.1   | Patents.....   | 141 |
| 2.4.7.2.1.1.1 | Zeolitic Adsorbents.....   | 141 |
| 2.4.7.2.1.1.2 | Integration with Fractionation .....   | 141 |

## TABLE OF CONTENTS

|               |  |     |
|---------------|--|-----|
| 2.4.7.2.1.1.3 | Miscellaneous .....  | 143 |
| 2.4.7.2.1.2   | Research .....   | 144 |
| 2.4.7.2.2     | Crystallization .....  | 147 |
| 2.4.7.2.3     | Combined Adsorption and Crystallization .....  | 149 |
| 2.4.8         | <i>Alternative Production Technologies</i> .....   | 150 |
| 2.4.8.1       | Patents .....  | 150 |
| 2.4.8.2       | Research.....  | 151 |
| 2.4.9         | <i>Recovery of Aromatics by Extraction, Extractive Distillation, or Distillation</i> ..... | 151 |
| 2.4.9.1       | Patents .....  | 151 |
| 2.4.9.2       | Research.....  | 153 |
| 2.5           | WORLDWIDE INSTALLED CAPACITY .....   | 154 |
| 2.6           | CONSTRUCTION .....   | 156 |
| 2.6.1         | <i>Recent Construction Activity</i> .....  | 156 |
| 2.6.2         | <i>Completed Construction Projects</i> .....   | 158 |
| 2.7           | REFERENCES .....   | 170 |