

PERP Report

Xylenes

05/06-8

August 2006



44 South Broadway, White Plains, New York 10601, USA

Tel: +1 914 609 0300 Fax: +1 914 609 0399

Copyright© by Nexant, Inc. 2006

This report was prepared by Nexant, Inc ("Nexant") and is part of the Process Evaluation Research Planning (PERP). Except where specifically stated otherwise in this Report, the information contained herein is prepared on the basis of information that is publicly available, and contains no confidential third party technical information to the best knowledge of Nexant. Aforesaid information has not been independently verified or otherwise examined to determine its accuracy, completeness or financial feasibility.

Neither NEXANT, Subscriber nor any person acting on behalf of either assumes any liabilities with respect to the use of or for damages resulting from the use of any information contained in this Report. Nexant does not represent or warrant that any assumed conditions will come to pass.

The report is submitted on the understanding that the Subscriber will maintain the contents confidential except for the Subscriber's internal use. The Report should not be reproduced, distributed or used without first obtaining prior written consent by Nexant. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Contents

Section	Page
1 Executive Summary	1
1.1 INTRODUCTION	1
1.2 CONFIGURATON OPTIONS	2
1.3 XYLENES PRODUCTION.....	7
1.3.1 Catalytic Reforming.....	7
1.3.2 Toluene Disproportionation, Transalkylation and Dealkylation	8
1.3.3 Other Sources.....	11
1.4 XYLENES RECOVERY.....	12
1.4.1 Introduction.....	12
1.4.2 para-Xylene.....	15
1.4.3 ortho-Xylene	18
1.4.4 meta-Xylene.....	18
1.4.5 Ethylbenzene.....	20
1.5 PROCESS ECONOMICS.....	20
1.5.1 Investment.....	20
1.5.2 Cost of Production	21
1.6 COMMERCIAL ANALYSIS.....	23
1.6.1 Applications	23
1.6.2 Global Outlook.....	23
2 Current Commercial Technology	29
2.1 INTRODUCTION	29
2.2 CONFIGURATON OPTIONS	30
2.3 XYLENES PRODUCTION.....	35
2.3.1 Catalytic Reforming.....	35
2.3.2 Toluene Disproportionation, Transalkylation and Dealkylation	39
2.3.3 Other Sources.....	49
2.4 XYLENES RECOVERY.....	50
2.4.1 Introduction.....	50
2.4.2 para-Xylene.....	53

2.4.3	ortho-Xylene	66
2.4.4	meta-Xylene.....	68
2.4.5	Ethylbenzene.....	75
2.5	PROCESS ECONOMICS.....	77
2.5.1	Basis.....	77
2.5.2	Investment.....	79
2.5.3	Cost of Production	79
2.5.4	Sensitivities	91
3	Developing Technologies	105
3.1	INTRODUCTION	105
3.2	EXXONMOBIL.....	106
3.3	UOP.....	107
3.4	AXENS (IFP).....	110
3.5	OTHERS	112
4	Commercial Analysis	114
4.1	APPLICATIONS	114
4.1.1	Background.....	114
4.1.2	Mixed Xylenes.....	114
4.1.3	para-Xylene.....	115
4.1.4	ortho-Xylene	116
4.1.5	meta-Xylene.....	118
4.2	GLOBAL OUTLOOK.....	119
4.2.1	Mixed Xylenes.....	119
4.2.2	para-Xylene.....	119
4.3	NORTH AMERICA	124
4.3.1	Mixed Xylenes.....	124
4.3.2	para-Xylene.....	125
4.4	WESTERN EUROPE	129
4.4.1	Mixed Xylenes.....	129
4.4.2	para-Xylene.....	129
4.5	ASIA PACIFIC.....	133

4.5.1	Mixed Xylenes	133
4.5.2	para-Xylene.....	133
5	References	139

Appendix		Page
A	Nexant's Chemsystems Capital Cost Estimates	A-1
B	PERP Program Title Index	B-1

Figure		Page
1.1	Simplified Block Flow Diagram for a Simple Aromatics Plant	3
1.2	Simplified Block Flow Diagram for Recovery of ortho-Xylene	4
1.3	Simplified Block Flow Diagram for an Aromatics Complex with TDP	5
1.4	Simplified Block Flow Diagram for an Aromatics Complex with C ₉ Transalkylation	6
1.5	Xylenes Recovery Processes.....	13
1.6	Equilibrium Concentrations for C ₈ -Aromatic Compounds.....	14
1.7	Typical Aromatics Plant Capital Breakdown	21
1.8	para-Xylene Cash Cost Of Production.....	22
1.9	para-Xylene Cost of Production + Return	23
1.10	Regional para-Xylene Capacity	26
1.11	Global para-Xylene Supply and Demand	27
1.12	Global para-Xylene Net Trade.....	28
2.1	Simplified Block Flow Diagram for a Simple Aromatics Plant	31
2.2	Simplified Block Flow Diagram for Recovery of ortho-Xylene	32
2.3	Simplified Block Flow Diagram for an Aromatics Complex with TDP	33
2.4	Simplified Block Flow Diagram for an Aromatics Complex with C ₉ Transalkylation	34
2.5	Semi Regenerative Reformer Process Flow Diagram	37
2.6	Continuous Catalytic Reforming Process Flow Diagram.....	38
2.7	Toluene Disproportionation/Transalkylation Typical Flowsheet	43
2.8	para-Xylene Production PxMax Process Flow Diagram	46

2.9 PX-Plus Process Flow Diagram.....	48
2.10 Xylenes Recovery Processes.....	51
2.11 Equilibrium Concentrations for C ₈ -Aromatic Compounds.....	52
2.12 para-Xylene Production via UOP Parex/Isomar Process.....	55
2.13 Eluxyl Process Flow Diagram	58
2.14 para-Xylene Production via Crystallization/Isomerization.....	60
2.15 Xylenes Isomerization: UOP Isomar Process	65
2.16 ortho-Xylene from Mixed Xylenes by Fractionation.....	67
2.17 meta-Xylene Production via UOP MX Sorbex Process	69
2.18 meta-Xylene via MGC'S HF/BF ₃ Extraction Process	73
2.19 Sulzer's meta-Xylene Process.....	74
2.20 Ethylbenzene Extraction by Superfractionation	76
2.21 Typical Aromatics Plant Capital Breakdown	79
2.22 para-Xylene Cash Cost of Production.....	80
2.23 BTX Price History	94
2.24 Effect of Benzene Pricing on Xylenes Adsorption/Isomerization Economics	95
2.25 Effect of Benzene Pricing on TDP and Transalkylation Economics	96
2.26 Effect of Toluene Pricing on TDP Economics	97
2.27 Effect of Mixed Xylenes Pricing on TDP Economics	98
2.28 Effect of C ₉ Aromatics Pricing on TDP Economics	99
2.29 Effect of ortho-Xylene Pricing on Xylenes Isomerization Economics.....	100
2.30 Effect of LPG Pricing on Cyclar Economics	101
2.31 Economics of Scale With Respect to Adsorption/Isomerization Economics	102
2.32 Effect of Investment on para-Xylene Economics - Adsorption/Isomerization.....	102
2.33 Effect of Operating Rate on para-Xylene Economics.....	103
2.34 para-Xylene Cost of Production + Return	104
3.1 U.S. Patents – para-Xylene Awarded 2002-2005	105
3.2 UOP's Patented Aromatics Complex Flow Scheme.....	108
3.3 UOP Dual Transalkylation Process Flow Scheme.....	109
3.4 Historical Pricing (USGC).....	111
4.1 Global para-Xylene Demand, 2005	120

4.2 Global para-Xylene Firm Capacity Additions	121
4.3 Regional para-Xylene Capacity	122
4.4 Global para-Xylene Supply and Demand	123
4.5 Global para-Xylene Net Trade.....	124
4.6 North American para-Xylene Consumption, 2005	126
4.7 North American para-Xylene Supply/Demand and Trade.....	128
4.8 West European para-Xylene Consumption, 2005.....	130
4.9 West European para-Xylene Supply/Demand and Trade	132
4.10 Asia Pacific para-Xylene Consumption, 2005.....	134
4.11 Asia Pacific para-Xylene Supply/Demand and Trade	138

Table	Page
1.1 Licensors of Aromatics Technology	1
1.2 Regional para-Xylene Consumption.....	25
2.1 Licensors of Aromatics Technology.....	29
2.2 Reactor Operating Conditions of MSTDP and PxMax.....	47
2.3 Composition of Mixed Xylenes Lean in ortho-Xylene.....	66
2.4 C8 Aromatic Distribution in MX Sorbex Feed.....	70
2.5 Merchant meta-Xylene Specifications.....	70
2.6 Composition of Mixed Xylenes Lean in Ethylbenzene	75
2.7 Price Basis.....	77
2.8 Utilities Basis	77
2.9 Cost of Production Estimate for: para-Xylene Process: Adsorption/Isomerization (EB Isomerization)	81
2.10 Cost of Production Estimate for: para-Xylene Process: Adsorption/Isomerization (EB Dealkylation).....	82
2.11 Cost of Production Estimate for: para-Xylene Process: Crystallization/Isomerization (EB Dealkylation)	83
2.12 Cost of Production Estimate for: para-Xylene Process: Adsorption/Isomerization (EB Isomerization) w/ortho-Xylene By-Product	85
2.13 Cost of Production Estimate for: para-Xylene Process: Selective Toluene Disproportionation Followed by One-Stage Crystallization.....	86

2.14 Cost of Production Estimate for: para-Xylene Process: PxMax Followed by Melt Static Crystallization.....	87
2.15 Cost of Production Estimate for: para-Xylene Process: Conventional TDP – Toluene Feed Followed by Adsorption/Isomerization.....	88
2.16 Cost of Production Estimate for: para-Xylene Process: TDP – Toluene/C9 Aromatics Feeds Followed by Adsorption/Isomerization.....	89
2.17 Cost of Production Estimate for: para-Xylene Process: C9 Transalkylation Followed by Adsorption/Isomerization	90
2.18 Cost of Production Estimate for: para-Xylene Process: Cyclar/Adsorption/Isomerization.....	92
2.19 Cost of Production Estimate for: para-Xylene Process: UOP MX Sorbex.....	93
3.1 Comparison of Transalkylation Schemes from U.S. Patent 6,958,425	110
3.2 APU Yields and Products	111
4.1 Global para-Xylene Consumption	120
4.2 Regional para-Xylene Consumption.....	120
4.3 Global para-Xylene Supply and Demand	123
4.4 North American para-Xylene Consumption by End Use	125
4.5 North American para-Xylene Consumption by Country	125
4.6 Capacities of para-Xylene in North America.....	127
4.7 North American para-Xylene Supply/Demand and Trade.....	128
4.8 West European para-Xylene Consumption.....	129
4.9 West European para-Xylene Capacity	131
4.10 West European para-Xylene Supply/Demand and Trade	132
4.11 Asia Pacific para-Xylene Consumption.....	133
4.12 Asia Pacific para-Xylene Consumption by Country.....	135
4.13 Capacities for para-Xylene in Asia Pacific.....	136
4.14 Asia Pacific para-Xylene Supply/Demand and Trade	138