

Terephthalic Acid

PERP 09/10-6

May 2011

Aline Bastidon

CHEMSYSTEMS **PERP PROGRAM**



www.chemsystems.com

The ChemSystems Process Evaluation/Research Planning (PERP) program is recognized globally as the industry standard source for information relevant to the chemical process and refining industries. PERP reports are available as a subscription program or on a report by report basis.

Nexant, Inc. (www.nexant.com) is a leading management consultancy to the global energy, chemical, and related industries. For over 38 years, ChemSystems has helped clients increase business value through assistance in all aspects of business strategy, including business intelligence, project feasibility and implementation, operational improvement, portfolio planning, and growth through M&A activities. Nexant has its main offices in San Francisco (California), White Plains (New York), and London (UK), and satellite offices worldwide.

For further information about these reports, please contact the following:

London, Dr. Alexander Coker, Manager PERP Program, phone: + 44-(20)-70950-1570, e-mail: acoker@nexant.com.

New York, Dr. Jeffrey S. Plotkin, Vice President, phone: + 1-914-609-0315, e-mail: jplotkin@nexant.com; or Heidi Junke Colema, Multi-client Programs Administrator, phone: + 1-914-609-0381, e-mail: hcoleman@nexant.com. Website: www.chemsystems.com

Copyright © by Nexant Inc. 2011. All Rights Reserved.

Contents

Section	Page
1 Executive Summary	1
1.1 TECHNOLOGY	2
1.1.1 Purified Terephthalic Acid.....	2
1.1.2 Medium Quality Terephthalic Acid	5
1.1.3 Technology Developments	5
1.2 ECONOMICS	9
1.2.1 Process Comparison.....	9
1.2.3 Regional Comparison.....	12
1.2.4 Conclusion	15
1.3 COMMERCIAL	16
1.3.1 Applications	16
1.3.2 Markets	17
2 Introduction.....	21
2.1 GENERAL.....	21
2.2 OVERVIEW OF TEREPHTHALIC ACID TECHNOLOGY LICENSING	21
3 Purified Terephthalic Acid (PTA) Technology	23
3.1 CHEMISTRY	23
3.2 CONVENTIONAL PROCESS.....	24
3.2.1 CTA Production Process.....	29
3.2.2 PTA Production Process	32
3.3 DAVY PROCESS TECHNOLOGY/DOW (DPT/DOW).....	35
3.3.1 Chemistry	36
3.3.2 Process Description.....	36
3.3.3 Process Features.....	43
3.4 INVISTA.....	44
3.4.1 CTA Production Process.....	44
3.4.2 PTA Production Process	47
3.4.3 Process Features.....	51

3.5	BP (AMOCO)	51
3.5.1	Process Description.....	52
3.5.2	Process Features.....	56
3.6	GTC TECHNOLOGY	57
3.6.1	Process Description.....	57
3.6.2	Process Performances	63
3.6.3	Process Features.....	65
4	Medium Quality Terephthalic Acid (MTA)	66
4.1	INTRODUCTION	66
4.2	EASTMAN/LURGI EPTA PROCESS	67
4.2.1	Process Description.....	67
4.2.2	Claimed Advantages	76
4.3	MITSUBISHI CHEMICAL QTA PROCESS	77
4.3.1	Overview.....	77
4.3.2	Process Description.....	78
4.3.3	Specification	79
4.3.4	Experience.....	79
4.4	COMPARISON OF MTA AND PTA	80
4.4.1	Quality and Potential Color Formation.....	80
4.4.2	Application Comments	82
4.5	CONCLUSIONS.....	84
4.5.1	Usage and Cost Issues.....	84
4.5.2	Market Issues	84
5	Patent Review	86
5.1	DOW	86
5.1.1	Oxidation Reactor Design Improvement	86
5.1.2	Oxidation Catalyst Recovery	88
5.2	BP.....	90
5.2.1	Catalyst Innovations.....	90
5.2.2	Common Solvent for Oxidation and Hydrogenation	91
5.3	MITSUBISHI GAS CHEMICAL.....	92

5.4	MITSUBISHI CHEMICAL CORPORATION	93
5.4.1	Oxidation Intermediates Recovery	93
5.4.2	Solid/Liquid Separation System	95
5.4.3	Improved Solvent Recovery with Membrane	95
5.5	MECHEMA CHEMICALS INTERNATIONAL.....	96
5.6	SAUDI BASIC INDUSTRIES CORPORATION.....	98
5.7	HRONEC ET AL.....	99
5.8	EASTMAN CHEMICAL	99
5.8.1	Improved Oxidation Bubble Reactor	99
5.8.2	Improved Energy and Solvent Recovery	100
5.9	SAM NAM PETROCHEMICALS	102
5.10	WHAT IS THE NEXT STEP FOR PTA?	105
5.10.1	Process Intensification	105
5.10.2	Supercritical Route to PTA	108
5.10.3	Alternative Feedstock - Green Route to PTA	109
6	Economics	113
6.1	BASIS	113
6.1.1	Pricing Basis	113
6.1.2	Investment Basis	113
6.1.3	Cost of Production Basis.....	114
6.2	PROCESS COMPETITIVENESS	115
6.2.1	Conventional PTA Production.....	116
6.2.2	COMPRESS TM PTA Production.....	118
6.2.3	INVISTA PTA Production	120
6.2.4	BP PTA Production.....	124
6.2.5	GTC Technology PTA Production	126
6.2.6	Eastman/Lurgi MTA Production	128
6.2.7	Conclusion	133
6.3	REGIONAL COMPETITIVENESS	133
6.4	CONCLUSION	143

	Page
7 Commercial Applications	145
7.1 FIBER	145
7.1.1 Textile Fibers	145
7.1.2 Fiberfill	146
7.1.3 Non-woven Fabrics	146
7.1.4 Carpet Facing	146
7.1.5 Industrial Fibers	146
7.2 CONTAINER	146
8 Regional Market Review	148
8.1 GLOBAL OVERVIEW	148
8.1.1 Consumption	148
8.1.2 Supply	150
8.2 NORTH AMERICA	152
8.2.1 Overview	152
8.2.2 Consumption	152
8.2.3 Supply	154
8.2.4 Supply, Demand, and Trade	155
8.3 WESTERN EUROPE	156
8.3.1 Consumption	156
8.3.2 Supply	157
8.3.3 Supply, Demand, and Trade	159
8.4 ASIA PACIFIC	159
8.4.1 Overview	159
8.4.2 Consumption	160
8.4.3 Supply	162
8.4.4 Supply, Demand, and Trade	167
9 Glossary	168
10 References	170
Appendix	Page
A Nexant's ChemSystems Capital Cost Estimates.....	A-1
B PERP Program Title Index (2000/2001 - 2009/2010).....	B-1

Figure	Page
1.1 Terephthalic Acid Process Comparison, USGC – 2010 Q2	12
1.2 Forthcoming Plants Competitiveness, 2010-2015	14
1.3 Global PTA Consumption.....	18
1.4 Global PTA Capacity Additions	19
1.5 Global PTA Capacity	20
3.1 Crude Terephthalic Acid Process (Block Flow Diagram)	25
3.2 Purified Terephthalic Acid Process (Block Flow Diagram)	26
3.3 Crude Terephthalic Acid Process Flow Diagram	30
3.4 Purified Terephthalic Acid Process Flow Diagram	34
3.5 COMPRESS™ PTA - CTA Flow Diagram.....	38
3.6 COMPRESS™ PTA - Purification Process Flow Diagram	41
3.7 INVISTA CTA Process Flow Diagram	46
3.8 INVISTA Pure Terephthalic Acid Process Flow Diagram.....	49
3.9 BP Amoco Terephthalic Acid Process Flow Diagram	53
3.10 GTC Technology Basic Process Diagram	58
3.11 GTC Technology Flow Diagram	59
3.12 Solubility Curve in NMP	63
3.13 Solubility Curve in Methanol.....	63
3.14 Water Ratio Influence on Conversion.....	64
3.15 Hydrogen Peroxide Ratio Influence on Conversion	64
4.1 Eastman/Lurgi EPTA Block Flow Diagram	68
4.2 EPTA Technology Process Flow Diagram	69
5.1 Dow's Liquid Gas Phase Improved Reactor System	87
5.2 Close View of Condensate Distributor	87
5.3 Recovery of Oxidation Catalyst with Resins	89
5.4 Mitsubishi Gas Chemicals Catalyst Recovery System	94
5.5 Screen-Type Centrifugal Separator with an Inside Screw Conveyor	97
5.6 SABIC Oxidation Promoter against Conventional Initiator Performance.....	98
5.7 Eastman Improved Terephthalic Acid Process	101
5.8 Conventional Oxidizer and Sam Nam Petrochemicals Reactor Comparison	103

5.9	Cross-sectional View of Reactant SNP Feed System	104
5.10	PTA Process from PET	110
5.11	Effect of Water on PET Ethanolysis	111
6.1	Terephthalic Acid Process Comparison, Percentage Basis.....	132
6.2	Terephthalic Acid Process Comparison.....	132
6.3	Forthcoming Plants Competitiveness, 2010-2015	141
6.4	Forthcoming Plants Competitiveness, 2010-2015	141
8.1	Global PTA Consumption.....	149
8.2	Global PTA Capacity Additions	151
8.3	Global PTA Capacity	151
8.4	North America PTA Consumption, 2009	153
8.5	West European PTA Consumption, 2009	157
8.6	Asia Pacific Consumption, 2009.....	162

Table	Page
1.1 Comparison of Processes	10
1.2 Global PTA Consumption by End-Use.....	18
3.1 Molar Efficiency of Terephthalic Acid Technology.....	28
3.2 Characteristics of PTA.....	33
3.3 Required Raw Material Characteristics	35
3.4 COMPRESS™ PTA Product Specifications (Source: DPT).....	42
3.5 Typical PTA Specification.....	50
3.6 Typical Raw Material Specifications.....	50
3.7 Typical Purification by Solvent Crystallization Efficiency	65
4.1 Mitsubishi PTA History	78
4.2 PTA/QTA Impurity Levels	78
4.3 MCC QTA Specification	79
4.4 Mitsubishi Chemical Group PTA/QTA Capacity.....	79
4.5 Comparison of PTA and MTA Specifications.....	80
5.1 DET and Ethylene Glycol Recovered Using Various PET Flakes	109
5.2 DET/ <i>para</i> -xylene Oxidation Results	111
5.3 FDCA Conversion to TA	112
6.1 Pricing Basis for Terephthalic Acid.....	113
6.2 Direct and General Overheads, Maintenance, Tax, and Insurance	115
6.3 Cost of Production Estimate for Purified Terephthalic Acid.....	117
6.4 Cost of Production Estimate for: Purified Terephthalic Acid Process: Oxidation/Hydrogenation (COMPRESS™).....	119
6.5 Cost of Production Estimate for: Purified Terephthalic Acid Process: Oxidation/Hydrogenation (INVISTA 1.12 million tons per year Capacity)	121
6.6 Cost of Production Estimate for: Purified Terephthalic Acid Process: Oxidation/Hydrogenation (INVISTA 700 000 tons per year Capacity).....	123
6.7 Cost of Production Estimate for: Purified Terephthalic Acid Process: Oxidation/Hydrogenation (BP).....	125
6.8 Cost of Production Estimate for: Purified Terephthalic Acid Process: Oxidation/Crystallization (GTC Technology).....	127
6.9 Cosof Production Estimate for: Medium Terephthalic Acid Process: EPTA (Eastman/Lurgi).....	129

6.10 Comparison of Processes	130
6.11 Plants Considered.....	135
6.12 Cost of Production Estimated for North-East Asia (China) Process: Oxidation/Hydrogenation	136
6.13 Cost of Production Estimated for South Asia (India) Process: Oxidation/Hydrogenation	137
6.14 Cost of Production Estimated for Central Europe (Poland) Process: Oxidation/Hydrogenation	138
6.15 Cost of Production Estimated for Middle East (Oman) Process: Oxidation/Hydrogenation	139
6.16 Cost of Production Estimated for South America (Brazil) Process: Oxidation/Hydrogenation	140
6.17 Regional Competitiveness Cost Summary.....	142
8.1 Global PTA Consumption.....	149
8.2 North American PTA Consumption by Region.....	153
8.3 North American PTA Consumption by End-Use	154
8.4 North America PTA Capacity, 2009	155
8.5 North American PTA Supply, Demand, and Trade	156
8.6 West European PTA Consumption by End-Use	157
8.7 West European PTA Capacity, 2009	158
8.8 West European PTA Supply, Demand, and Trade	159
8.9 Asia Pacific PTA Consumption by Region	161
8.10 Asia Pacific PTA Consumption by End-Use	161
8.11 Asia Pacific PTA Capacity, 2009	164
8.12 Asia Pacific PTA Supply, Demand, and Trade.....	167