

TECHNOLOGY & COSTS**Technoeconomics - Energy & Chemicals (TECH)****TECH 2020S2 Alkoxylation Technologies**

Table of Contents

A Report by **NexantECA, Inc.**

Published Date: November 2020

www.nexanteca.com/subscriptions-and-reports**Contents**

1	Executive Summary	1
1.1	Business Structure	2
1.2	Market Overview	2
1.3	Cost Competitiveness	3
1.4	Technology Comparison	3
2	Business Overview	4
2.1	Surfactants Overview	5
2.2	Historical Development	7
2.2.1	Market Development	7
2.3	Business Structure	11
2.4	Alkoxylated Surfactant Products	14
2.4.1	Alkylphenol Ethoxylates (APE).....	16
2.4.2	Alcohol Ethoxylates (AE).....	16
2.4.3	Propoxylated Alcohols.....	18
2.4.4	Fatty Acid Ethoxylates.....	18
2.4.5	Others.....	18
2.5	Feedstocks	22
2.5.1	Lipophiles - Alcohols	22
2.5.2	Lipophiles - Alkyl Phenol	23
2.5.3	Lipophiles - Fatty Acids	23
2.5.4	Alkyl Oxides - Ethylene Oxide	25
2.5.5	Alkyl Oxides – Propylene Oxide	26
2.5.6	Alkyl Oxides - Butylene Oxide	26
2.6	Market Entry Considerations	27
2.7	Properties	28
2.7.1	Measuring Properties	29
2.7.2	Controlling Performance	30
2.8	Handling and Storage.....	33
2.9	Safety and Environmental Considerations	34

2.9.1	1,4-Dioxane	34
2.10	Regulatory Developments and Sustainability.....	35
2.10.1	Detergents Regulation.....	35
2.10.2	Certification (e.g., EU Ecolabel and RSPO).....	35
2.10.3	Other Regulations	36
3	Process Technology	37
3.1	Process Background	37
3.2	Reactor Types	38
3.2.1	Traditional Stirred Reactors	39
3.2.2	Loop Reactors	39
3.3	Licensor	42
3.3.1	Desmet Ballestra	42
3.3.2	Buss ChemTech.....	42
3.3.3	HH Technology	42
3.3.4	Thyssenkrupp.....	42
3.4	Process Safety	43
3.4.1	Key Safety Principles	43
3.4.2	Control System.....	43
3.4.3	Safety Philosophies.....	45
3.5	Process Development	45
3.6	Stirred Reactor Technology.....	46
3.6.1	Process Description	46
3.6.2	Features and Limitations	48
3.7	Spray Loop Technology	50
3.7.1	Original Pressindustria Process	50
3.7.2	Desmet Ballestra Process	51
3.7.3	Developments in Desmet Ballestra Process	53
3.8	Jet Loop Technology	55
3.8.1	Overview	55
3.8.2	Pre-treatment	55
3.8.3	Reaction	56
3.8.4	Post-treatment.....	58
3.8.5	Filtration Section.....	58
3.8.6	Growth Ratio	61
3.8.7	Production of MPEGs.....	62
3.8.8	Developments in Buss Process	63
3.9	Other Technologies and Developments.....	64
3.9.1	Other Technologies	64
4	Process Economics	66
4.1	Overview.....	66
4.2	Costing Basis	66
4.2.1	Investment Basis	66

4.2.2	Pricing Basis.....	67
4.2.3	Cost of Production Basis	67
4.3	Production Cost Estimates	68
4.3.1	Product Analysis.....	68
4.3.2	Reactor Type	72
4.3.3	Regional Analysis.....	73
4.3.4	Sensitivity Analysis.....	76
5	Market Dynamics.....	78
5.1.1	Demand by Derivative	78
5.1.2	End-Use Sectors	79
5.2	Global	80
5.2.1	Demand.....	80
5.2.2	Supply	81
5.2.3	Supply, Demand, and Trade	82
5.2.4	Global Trade.....	83
5.3	North America	84
5.3.1	Demand.....	84
5.3.2	Supply	84
5.3.3	Supply, Demand, and Trade	86
5.4	Western Europe	87
5.4.1	Demand.....	87
5.4.2	Supply	87
5.4.3	Supply, Demand, and Trade	89
5.5	Asia Pacific.....	90
5.5.1	Demand.....	90
5.5.2	Supply	90
5.5.3	Supply, Demand, and Trade	93
5.6	Rest of the World.....	94
5.6.1	Demand.....	94
5.6.2	Supply	94
5.6.3	Supply, Demand, and Trade	95
5.7	SWOT Analysis	96

Appendices

A	Pricing.....	98
B	Cost of Production.....	99
C	Definitions of Capital Cost Terms Used in Process Economics.....	125
D	Definitions of Operating Cost Terms Used in Process Economics	130
E	TECH Program Title Index (2010-2020)	133
F	References	136

Figures

Figure 1	Ethoxylation and Propoxylation Reactions	1
Figure 2	Example of an Ethoxylate: C ₁₂ Fatty Alcohol Ethoxylate (5 EO)	1
Figure 3	Alkoxylation Value Chain and Key Players	2
Figure 4	Summary of Economics for Production of Ethoxylates in Different Cost Scenarios	3
Figure 5	Representation of a Model Surfactant Molecule	4
Figure 6	Ethoxylation and Propoxylation Reactions	4
Figure 7	Surfactant Grease Removal Mechanism.....	5
Figure 8	Various Detergent Products	6
Figure 9	Saponification Reaction Using Sodium Hydroxide	8
Figure 10	Excerpt from Early Detergent Advert.....	8
Figure 11	Alkoxylation Value Chain and Key Players	11
Figure 12	Relative Weight and Value of Surfactants in Typical Detergents	13
Figure 13	Example of an Ethoxylate: C ₁₂ Fatty Alcohol Ethoxylate (5 EO)	15
Figure 14	Alkoxylation Value Chain.....	15
Figure 15	Nonylphenol Ethoxylate	16
Figure 16	Various Alcohol Ethoxylate Structures	17
Figure 17	Etymology of Detergent Alcohol Names.....	17
Figure 18	Fatty Acid Ethoxylates	18
Figure 19	Methyl Ester Ethoxylates	19
Figure 20	Alkyl Amine Ethoxylates	19
Figure 21	Ethylene Diamine-based EO/PO Product	19
Figure 22	EO/PO Copolymer (Central PEG Block)	20
Figure 23	Sodium Diethoxylated Alkyl Phosphate.....	20
Figure 24	Example of a Glycerol Ester.....	20
Figure 25	Polyoxyethylene Sorbitan Stearate	21
Figure 26	Example of Fat Splitting Reaction	23
Figure 27	Natural Oil Component by Carbon Number	24
Figure 28	Ethylene Oxide Derivatives Value Chain.....	25
Figure 29	Critical Micelle Concentration (CMC)	30
Figure 30	Impact of Alkyl Chain Length on Surfactant Properties.....	31
Figure 31	Impact of the Degree of Branching on Surfactant Properties.....	32
Figure 32	Formation of 1,4-dioxane through Ethoxylation.....	34
Figure 33	Development of Reactor Types	38
Figure 34	Stirred Reactor Types.....	39
Figure 35	Loop Reactor Types	39
Figure 36	Spray Loop Reactor.....	40
Figure 37	<i>Classical</i> Buss Loop Reactor (BLR) and the <i>Advanced</i> Buss Loop Reactor (ABLR)	41
Figure 38	Dual Loop Reactor.....	41
Figure 39	Safety Requirements on EO/N ₂ Partial Pressure	44
Figure 40	Schematic of Conventional Stirred Tank Reactor	46
Figure 41	Simplified Process Flow Diagram of Conventional Ethoxylation Process	47

Figure 42	Schematic of First Generation Pressindustria Reactor System	50
Figure 43	Schematic of DBI Ethoxylation Reactor	52
Figure 44	Simplified Process Flow Diagram of Desmet Ballestra Ethoxylation Process	54
Figure 45	Jet Mixer	57
Figure 46	Thyssenkrupp Alkoxylation Process.....	59
Figure 47	Simplified Process Flow Diagram of Buss ChemTech Ethoxylation Process	60
Figure 48	Schematic of Dual Loop Ethoxylation Reactor	61
Figure 49	Classical Buss Loop Reactor (BLR) and Advanced Buss Loop Reactor (ABLR)	63
Figure 50	Schematic of a New Ethoxylation Reactor System by Xiamen Ju Sheng.....	65
Figure 51	Summary of Economics for Production of Different Degrees of Ethoxylation	70
Figure 52	Summary of Economics for Production of Ethoxylates with Different Lipophiles, USGC	71
Figure 53	Net Raw Materials Breakdown for different Lipophiles, USGC	71
Figure 54	Summary of Economics for Production of Ethoxylates in Different Reactors	72
Figure 55	Summary of Economics for Production of Ethoxylates in Different Regions, 9EO	74
Figure 56	Summary of Economics for Production of Ethoxylates in Different Regions, 9EO	74
Figure 57	Summary of Economics for Production of Ethoxylates in Different Regions, 3EO	75
Figure 58	Summary of Economics for Production of Ethoxylates in Different Cost Scenarios	76
Figure 59	Global Ethoxylates Demand by Derivative	78
Figure 60	Ethoxylates Global Demand by End-Use Sector.....	79
Figure 61	Global Ethoxylation Capacity by Region	81
Figure 62	Global Demand of Ethoxylate by Derivatives	82
Figure 63	Global Ethoxylate Supply, Demand, and Trade	82
Figure 64	Global Ethoxylate Trade	83
Figure 65	North America Ethoxylate Supply, Demand, and Trade.....	86
Figure 66	Asian Ethoxylate Supply, Demand, and Trade.....	93
Figure 67	Rest of the World Ethoxylate Supply, Demand, and Trade	95
Figure 68	SWOT Analysis for Ethoxylates.....	96

Tables

Table 1	Detergent Industry Inventions.....	10
Table 2	Major Players in Alkoxylation Business and Level of Integration	14
Table 3	Summary of Key Market Considerations	27
Table 4	Typical Hydrophilic-Lipophilic Balance (HLB) Range and Application	29
Table 5	Examples of Cloud Point of Ethoxylates	30
Table 6	Storage and Handling Properties of Various Detergent Alcohols and Cuts	33
Table 7	Reactors and Licensors	38
Table 8	Prices Used in Cost of Production Tables (Second Quarter of 2020 Basis)	67
Table 9	Summary of Economics for Production of Different Degrees of Ethoxylation	69
Table 10	Summary of Economics for Production of Ethoxylates with Different Lipophiles, USGC	70
Table 11	Summary of Economics for Production of Ethoxylates in Different Reactors	72
Table 12	Summary of Economics for Production of Ethoxylates in Different Regions, 9EO	73
Table 13	Summary of Economics for Production of Ethoxylates in Different Regions, 3EO	75
Table 14	Summary of Economics for Production of Ethoxylates in Different Cost Scenarios	76
Table 15	Global Ethoxylate Demand by Region	80
Table 16	Global Ethoxylate Supply, Demand, and Trade	83
Table 17	Ethoxylation Capacity in North America in 2020	85
Table 18	North America Ethoxylate Supply, Demand, and Trade.....	86
Table 19	Ethoxylation Capacities in Western Europe in 2020	88
Table 20	Western Europe Ethoxylate Supply, Demand, and Trade.....	89
Table 21	Western Europe Ethoxylate Supply, Demand, and Trade.....	89
Table 22	Ethoxylation Capacities in the Asia Pacific in 2020.....	91
Table 23	Asian Ethoxylate Supply, Demand, and Trade.....	93
Table 24	Ethoxylation Capacities in Rest of the World in 2020.....	94
Table 25	Rest of the World Ethoxylate Supply, Demand, and Trade.....	95
Table 26	Full List of Prices Used in Cost of Production	98
Table 27	Cost of Production Estimate for: Purified Ethylene Oxide Process: Ethylene Oxidation; USGC	99
Table 28	Cost of Production Estimate for: Purified Ethylene Oxide Process: Ethylene Oxidation; Western Europe	100
Table 29	Cost of Production Estimate for: Purified Ethylene Oxide Process: Ethylene Oxidation; China	101
Table 30	Cost of Production Estimate for: C ₁₁ -C ₁₉ Synthetic Alcohol Process: Modified-Oxo Process; U.S. Gulf Coast	102
Table 31	Cost of Production Estimate for: C ₁₂ -C ₁₄ Detergent Alcohols Process: Lurgi Wax Ester LP3; Western Europe	103
Table 32	Cost of Production Estimate for: C ₁₂ -C ₁₄ Detergent Alcohols Process: Lurgi Wax Ester LP3; China Coast.....	104
Table 33	Cost of Production Estimate for: C ₁₁ -C ₁₈ LIOs/LAO Process: SHOP Process; U.S. Gulf Coast	105
Table 34	Cost of Production Estimate for: Synthesis Gas (2:1) Process: Autothermal Reforming (ATR); U.S. Gulf Coast.....	106

Table 35	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Conventional Reactor System; U.S. Gulf Coast.....	107
Table 36	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Conventional Reactor System; West Europe	108
Table 37	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Conventional Reactor System; China	109
Table 38	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Spray Loop Reactor System; U.S. Gulf Coast	110
Table 39	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Spray Loop Reactor System; West Europe.....	111
Table 40	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Spray Loop Reactor System; China Coast.....	112
Table 41	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 7EO Process: Spray Loop Reactor System; U.S. Gulf Coast	113
Table 42	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 3EO Process: Spray Loop Reactor System; U.S. Gulf Coast	114
Table 43	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 3EO Process: Spray Loop Reactor System; West Europe.....	115
Table 44	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 3EO Process: Spray Loop Reactor System; China Coast.....	116
Table 45	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Jet Loop Reactor System; U.S. Gulf Coast	117
Table 46	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Jet Loop Reactor System; West Europe	118
Table 47	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 9EO Process: Jet Loop Reactor System; China Coast	119
Table 48	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 7EO Process: Jet Loop Reactor System; U.S. Gulf Coast	120
Table 49	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 3EO Process: Jet Loop Reactor System; U.S. Gulf Coast	121
Table 50	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol + 3EO Process: Jet Loop Reactor System; West Europe	122
Table 51	Cost of Production Estimate for: C ₁₂ -C ₁₄ Fatty Alcohol +3EO Process: Jet Loop Reactor System; China Coast	123
Table 52	Cost of Production Estimate for: Nonylphenol + 9EO Process: Conventional Reactor System; U.S. Gulf Coast.....	124



TECHNOLOGY & COSTS

Technoeconomics - Energy & Chemicals (TECH)

The NexantECA Subscriptions' Technoeconomics - Energy & Chemicals (TECH) program is recognized globally as the industry standard source for information relevant to the chemical process and refining industries. Technoeconomics - Energy & Chemicals (TECH) reports are available as a subscription program or on a single report basis.

Contact Details:

Americas:

Marcos Nogueira Cesar, Vice President, Global Products, E&CA: NexantECA Subscriptions
Phone: + 1-914-609-0324, e-mail: mcesar@nexantECA.com

Erica Hill, Client Services Coordinator, E&CA-Products
Phone: + 1-914-609-0386, e-mail: ehill@nexantECA.com

EMEA:

Anna Ibbotson, Director, NexantECA Subscriptions
Phone: +44-207-950-1528, aibbotson@nexantECA.com

Asia:

Chommanad Thammanayakatip, Managing Consultant, Energy & Chemicals Advisory
Phone: +66-2793-4606, email: chommanadt@nexantECA.com

NexantECA (www.nexantECA.com) is a leading management consultancy to the global energy, chemical, and related industries. For over 38 years, NexantECA 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. NexantECA has its main offices in White Plains (New York), and London (UK), and satellite offices worldwide.

Copyright © by NexantECA 2020. All Rights Reserved.