

TECHNOLOGY & COSTS**Technoeconomics - Energy & Chemicals (TECH)****TECH 2020-3 Acrylonitrile**

Table of Contents

A Report by **NexantECA, Inc.**

Published Date: October 2020

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

1	Executive Summary	1
1.1	Introduction.....	1
1.1.1	Background	1
1.2	Commercial Technology.....	1
1.2.1	Licensors	1
1.3	Developing Technology.....	3
1.4	Process Economics.....	3
1.5	Applications	5
1.6	Regional Market Analysis.....	6
1.6.1	Global	6
2	Introduction.....	10
2.1	Background	10
2.2	Value Chain.....	11
2.3	Historical Process Routes	11
2.4	Development of Conventional Propylene Ammoxidation Technology	12
2.5	Development of Alternative Propane Ammoxidation Technology.....	13
2.6	Developing Technology.....	14
2.7	Licensors	14
2.7.1	INEOS	15
2.7.2	Sinopec	15
2.7.3	Asahi Kasei	15
2.8	Key Physical and Thermodynamic Properties	16
2.9	Regulatory Requirements.....	17
2.9.1	Storage and Transportation	17
2.9.2	Health Hazards.....	17
3	Commercial Technologies.....	18
3.1	Introduction.....	18
3.2	Propylene Ammoxidation	18
3.2.1	INEOS	18
3.2.2	Sinopec	27

3.3	Propane Ammoxidation	31
3.3.1	PTT Asahi Chemicals Joint Venture (PTTAC)	31
3.4	Inactive Licensors and Technology Players	36
3.4.1	Ascend Performance Materials LLC	36
3.4.2	DuPont and KBR	37
4	Developing Technology	38
4.1	Introduction	38
4.2	Glycerol Route	38
4.2.1	Two-Step from Glycerol via Acrolein	38
4.2.2	One-Step from Glycerol	42
4.2.3	Three-Step from Glycerol via Acrolein	42
4.3	Glutamic Acid Route	42
4.4	Biomass Route	44
4.4.1	Southern Research and the United States Department of Energy	44
4.4.2	National Renewable Energy Laboratory	48
4.5	Bio-based Propylene Route	52
4.5.1	AnQore Econitrile	54
5	Production Economics	55
5.1	Costing Basis	55
5.1.1	Investment Basis	55
5.1.2	Pricing Basis	55
5.1.3	Cost of Production Basis	57
5.2	Cost of Production Evaluation Basis	58
5.2.1	Capacity	58
5.2.2	Key Feedstocks and Other Assumptions	58
5.3	Process Cost Competitiveness	59
5.3.1	United States	59
5.3.2	Middle East	60
5.3.3	China	61
5.3.4	Southeast Asia	62
5.3.5	Western Europe	63
5.3.6	Cost of Production Summaries	64
5.4	Regional Cost Competitiveness	74
5.5	Historical Feedstock Price Sensitivity	75
6	Commercial Applications	77
6.1	Overview	77
6.2	Styrene Acrylonitrile (SAN)/Acrylonitrile Butadiene Styrene (ABS)	77
6.3	Fibers	77
6.4	Acrylamide	78
6.5	Hexamethylene Diamine or 1,6-Diaminohexane (HMDA)	78
6.6	Others	78
7	Regional Market Analysis	79
7.1	Global	79

7.1.1	Consumption	79
7.2	North America	84
7.2.1	Consumption	84
7.5.3	Supply, Demand, and Trade	99
B.1	Variable Cost	106

Appendices

A	Definitions of Capital Cost Terms Used in Process Economics	101
B	Definitions of Operating Cost Terms Used in Process Economics	106
C	TECH Program Title Index (2010-2020)	109
D	References	112

Figures

Figure 1	Acrylonitrile Chemical Structure	1
Figure 2	Regional Propylene Ammoxidation and Propane Ammoxidation Cost Competitiveness	4
Figure 3	Acrylonitrile Commercial Applications	5
Figure 4	Global Acrylonitrile Demand, 2019-e	6
Figure 5	Global Acrylonitrile Consumption by Region	7
Figure 6	Global Acrylonitrile Capacity Share by Marketer, 2019-e	8
Figure 7	Global Acrylonitrile Supply, Demand, and Trade	9
Figure 8	Acrylonitrile Chemical Structure	10
Figure 9	Acrylonitrile Commercial Applications	11
Figure 10	Propylene Ammoxidation Mechanism	21
Figure 11	Acrylonitrile via Propylene	25
Figure 12	Integrated Acrylonitrile Wastewater Treatment System	27
Figure 13	Sinopec S-ANT Process	29
Figure 14	Asahi Kasei's Propane Ammoxidation Process	35
Figure 15	Acrylonitrile from Glycerol Process	41
Figure 16	Reaction 1: Hydrocracking of Sugar	45
Figure 17	Reaction 2: Glycerol Dehydration	46
Figure 18	Reaction 3: Ammoxidation of Acrolein	46
Figure 19	SR's B2ACN Process	47
Figure 20	Nitrilation Process	49
Figure 21	Nitrilation Process Reaction Mechanism	50
Figure 22	Total-Conversion Experiment Process Flow	51
Figure 23	Conceptual Process to Produce Bio-Acrylonitrile from Biomass-Derived Sugars	52
Figure 24	Routes to Bio-Propylene	53
Figure 25	Typical Cost of Production Overview	57
Figure 26	Summary Acrylonitrile Cost of Production – United States	59
Figure 27	Summary Acrylonitrile Cost of Production – Middle East	60
Figure 28	Summary Acrylonitrile Cost of Production - China	61

Figure 29	Summary Acrylonitrile Cost of Production – Southeast Asia	62
Figure 30	Summary Acrylonitrile Cost of Production – Western Europe	63
Figure 31	Regional Propylene Ammoxidation and Propane Ammoxidation Cost Competitiveness	75
Figure 32	Historical Sensitivity to Propylene and Propane Prices	76
Figure 33	Acrylonitrile Commercial Applications	77
Figure 34	Global Acrylonitrile Demand, 2019-e	80
Figure 35	Global Acrylonitrile Consumption by Region	81
Figure 36	Global Acrylonitrile Capacity Share by Marketer, 2019-e	82
Figure 37	Global Acrylonitrile Supply, Demand, and Trade	83
Figure 38	North America Acrylonitrile Consumption, 2019-e	85
Figure 39	North America Acrylonitrile Supply, Demand, and Trade	86
Figure 40	Western Europe Acrylonitrile Consumption by Derivative, 2019-e	89
Figure 41	Western Europe Acrylonitrile Supply, Demand, and Trade	90
Figure 42	Middle East Acrylonitrile Consumption by Derivative, 2019-e	92
Figure 43	Middle East Acrylonitrile Supply, Demand, and Trade	94
Figure 44	Asia Pacific Consumption by Derivative, 2019-e	97
Figure 45	Asia Pacific Acrylonitrile Supply, Demand, and Trade	99

Tables

Table 1	Acrylonitrile Technology Licensors	2
Table 2	Global Acrylonitrile Consumption by End Use	7
Table 3	Global Acrylonitrile Supply, Demand, and Trade	9
Table 4	Commercial Specifications for Acrylonitrile	10
Table 5	Acrylonitrile Technology Licensors	15
Table 6	Key Physical and Thermodynamic Properties of Acrylonitrile	16
Table 7	SANC-08 Catalyst Specifications	28
Table 8	Performance of SANC-08 and SANC-11 Catalysts	28
Table 9	S-ANT Process Parameters	30
Table 10	Asahi Kasei Best Documented Acrylonitrile Yields from Patent Publications	33
Table 11	Asahi Kasei's Propane Ammoxidation Experimental Results	33
Table 12	Southern Research's Biomass to Acrylonitrile (B2ACN) Process Costs and GHG Reductions	44
Table 13	Prices of Raw Materials, Utilities, and Labor	56
Table 14	Process Economics Capacity Basis by Licensor	58
Table 15	Summary Acrylonitrile Cost of Production – United States	59
Table 16	Summary Acrylonitrile Cost of Production – Middle East	60
Table 17	Summary Acrylonitrile Cost of Production - China	61
Table 18	Summary Acrylonitrile Cost of Production – Southeast Asia	62
Table 19	Summary Acrylonitrile Cost of Production – Western Europe	63
Table 20	Cost of Production Estimate for: Acrylonitrile Process: Propylene Ammoxidation; USGC	64

Table 21	Cost of Production Estimate for: Acrylonitrile Process: Propane Ammoxidation; USGC.....	65
Table 22	Cost of Production Estimate for: Acrylonitrile Process: Propylene Ammoxidation; Middle East.....	66
Table 23	Cost of Production Estimate for: Acrylonitrile Process: Propane Ammoxidation; Middle East	67
Table 24	Cost of Production Estimate for: Acrylonitrile Process: Propylene Ammoxidation; China	68
Table 25	Cost of Production Estimate for: Acrylonitrile Process: Propane Ammoxidation; China.....	69
Table 26	Cost of Production Estimate for: Acrylonitrile Process: Propylene Ammoxidation; Southeast Asia	70
Table 27	Cost of Production Estimate for: Acrylonitrile Process: Propane Ammoxidation; Southeast Asia	71
Table 28	Cost of Production Estimate for: Acrylonitrile Process: Propylene Ammoxidation; Western Europe	72
Table 29	Cost of Production Estimate for: Acrylonitrile Process: Propane Ammoxidation; Western Europe	73
Table 30	Global Acrylonitrile Consumption by End Use.....	80
Table 31	Global Acrylonitrile Supply, Demand, and Trade	83
Table 32	North America Acrylonitrile Consumption by End Use	85
Table 33	Acrylonitrile Capacity in North America	85
Table 34	North America Acrylonitrile Supply, Demand, and Trade.....	87
Table 35	Western Europe Acrylonitrile Consumption by End Use	89
Table 36	Acrylonitrile Capacity in Western Europe	89
Table 37	Western Europe Acrylonitrile Supply, Demand, and Trade.....	90
Table 38	Middle East Acrylonitrile Consumption by End Use	93
Table 39	Acrylonitrile Capacity in the Middle East	93
Table 40	Middle East Acrylonitrile Supply, Demand, and Trade	94
Table 41	Asia Pacific Acrylonitrile Consumption by End Use	97
Table 42	Acrylonitrile Capacity in Asia Pacific and China	98
Table 43	Asia Pacific Acrylonitrile Supply, Demand, and Trade	99



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. Nexant has its main offices in San Francisco (California), White Plains (New York), and London (UK), and satellite offices worldwide.

Copyright © by NexantECA 2021. All Rights Reserved.