

# Polyether Polyols

## Table of Contents

A Report by **NexantThinking™**

Process Evaluation/Research Planning (PERP) Program

PERP Report 2015S11 – Published December 2015

[www.nexantthinking.com](http://www.nexantthinking.com)

Section	Page
1 Executive Summary .....	1
1.1 TECHNOLOGY OVERVIEW.....	3
1.1.1 Technology Based on Conventional Routes .....	3
1.1.2 Reaction Chemistry.....	3
1.1.3 Process Overview .....	5
1.2 TECHNOLOGY BASED ON RENEWABLE SOURCES.....	5
1.3 BUSINESS STRATEGY OVERVIEW .....	7
1.4 PROCESS ECONOMICS OVERVIEW .....	8
1.4.1 Product Analysis.....	9
1.4.2 Regional Analysis.....	11
1.4.3 Sensitivity Analysis.....	12
1.5 MARKET OVERVIEW .....	15
1.5.1 Demand.....	15
1.5.2 Supply .....	15
1.5.3 Supply, Demand, and Trade .....	16
1.5.4 Global Trade.....	17
2 Introduction.....	18
2.1 POLYOL OVERVIEW .....	18
2.2 POLYURETHANE OVERVIEW .....	20
2.3 BIO OVERVIEW .....	22
2.4 BUSINESS OVERVIEW .....	23
2.5 PHYSICAL PROPERTIES .....	23
2.5.1 Viscosity .....	23
2.5.2 Density .....	24
2.5.3 Solubility .....	24

2.5.4	Handling .....	24
3	Technologies Based on Conventional Routes .....	25
3.1	DIFUNCTIONAL POLYOLS – POLYPROPYLENE GLYCOLS .....	25
3.1.1	Process Chemistry .....	25
3.1.2	Process Description .....	27
3.2	HIGHER-FUNCTIONAL POLYOLS .....	30
3.2.1	Trifunctional Polyols .....	31
3.2.2	Polyols with Functionality Greater than Three .....	34
3.2.3	Polyols Containing Nitrogen or Phosphorous .....	36
3.3	COMMERCIAL PROCESSES .....	38
3.3.1	Buss ChemTech Process.....	38
3.3.2	Covestro (Bayer MaterialScience) IMPACT™ Process .....	41
4	Technologies Based on Renewable Sources .....	43
4.1	COVESTRO (LEVERKUSEN, GERMANY) .....	43
4.2	NOVOMER .....	44
4.3	BIOBASED TECHNOLOGIES® (BBT) .....	44
4.4	EMERY OLEOCHEMICALS .....	46
4.5	DOW CHEMICAL .....	46
4.6	CARGILL (WAYZATA, MN).....	47
4.7	DUPONT (WILMINGTON, DE) .....	47
4.8	HUNTSMAN CORPORATION .....	47
4.9	IFS CHEMICALS (NORFOLK, UK).....	47
4.10	VERTELLUS PERFORMANCE MATERIALS (INDIANAPOLIS, IN) .....	47
5	Process Economics .....	48
5.1	COSTING BASIS .....	48
5.1.1	Investment Basis .....	48
5.1.2	Pricing Basis.....	48
5.1.3	Cost of Production Basis .....	49
5.2	PRODUCTION COST ESTIMATES.....	50
5.2.1	Product Analysis.....	50
5.2.2	Regional Analysis .....	63
5.2.3	Sensitivity Analysis .....	78
6	Regional Market Analysis.....	81
6.1	GLOBAL .....	81
6.1.1	Applications .....	81

6.1.2	Demand.....	82
6.1.3	Supply .....	82
6.1.4	Supply, Demand, and Trade .....	83
6.1.5	Global Trade.....	84
6.2	NORTH AMERICA .....	85
6.2.1	Demand.....	85
6.2.2	Supply .....	85
6.2.3	Supply, Demand, and Trade .....	86
6.3	WESTERN EUROPE .....	87
6.3.1	Demand.....	87
6.3.2	Supply .....	87
6.3.3	Supply, Demand, and Trade .....	88
6.4	ASIA PACIFIC .....	89
6.4.1	Demand.....	89
6.4.2	Supply .....	89
6.4.3	Supply, Demand, and Trade .....	91
6.5	REST OF THE WORLD .....	92
6.5.1	Demand.....	92
6.5.2	Supply .....	92
6.5.3	Supply, Demand, and Trade .....	93
7	Glossary .....	94
8	References .....	95

Appendix	Page
A Definition of Capital Cost Terms Used in Process Economics .....	A-1
B Definition of Operating Cost Terms Used in Process Economics.....	B-1
C Cost of Production Estimates for Key Transfer Prices Used (USGC).....	C-1
D PERP Program Title Index (2006 - 2015) .....	D-1

Figure	Page
1.1 Polyurethane Value Chain.....	2
1.2 Global Polyether Polyol Demand by Application.....	3
1.3 Summary of Economics for Production of Different Polyols .....	10
1.4 Summary of Economics for Production of Glycerin-Based Polyols in Different Regions.....	11
1.5 Summary of Economics for Production of Higher Functional Polyols in Different Regions ...	12
1.6 Sensitivity of Polyether Polyol Production Costs to Feedstock Prices in China .....	13
1.7 Sensitivity of Polyether Polyol Production Costs to Feedstock Prices in USGC .....	13
1.8 Sensitivity of Polyether Polyol Production Costs to Economy of Scale in China .....	14
1.9 Sensitivity of Polyether Polyol Production Costs to Economy of Scale in USGC .....	14
1.10 Global Polyether Polyol Capacity by Region.....	16
1.11 Global Polyether Polyols Supply, Demand, and Trade .....	16
1.12 Global Polyether Polyols Trade.....	17
2.1 Polyurethane Value Chain.....	20
3.1 Polyol Production via Batch Processing.....	28
3.2 Schematic of Buss ChemTech Alkoxylation Reactor .....	39
3.3 Simplified Process Flow Diagram of Buss ChemTech Alkoxylation Process .....	40
3.4 Simplified Process Flow Diagram of Covestro IMPACT™ Continuous Process for Polyol Production .....	42
5.1 Summary of Economics for Production of Different Polyols .....	62
5.2 Summary of Economics for Production of Glycerin-Based Polyols in Different Regions.....	78
5.3 Summary of Economics for Production of Higher Functional Polyols in Different Regions ...	78
5.4 Sensitivity of Polyether Polyol Production Costs to Feedstock Prices in China .....	79
5.5 Sensitivity of Polyether Polyol Production Costs to Feedstock Prices in USGC .....	79
5.6 Sensitivity of Polyether Polyol Production Costs to Economy of Scale in China .....	80
5.7 Sensitivity of Polyether Polyol Production Costs to Economy of Scale in USGC .....	80
6.1 Global Polyether Polyol Demand by Application.....	81
6.2 Global Polyether Polyol Capacity by Region.....	83
6.3 Global Polyether Polyols Supply, Demand, and Trade .....	83
6.4 Global Polyether Polyols Trade.....	84
6.5 North America Polyether Polyol Supply, Demand, and Trade .....	86
6.6 West European Polyether Polyol Supply, Demand, and Trade .....	88
6.7 Asian Polyether Polyol Supply, Demand, and Trade .....	91
6.8 Rest of the World Polyether Polyol Supply, Demand, and Trade .....	93

<b>Table</b>	<b>Page</b>
1.1 Properties and Uses of Polyether Polyols .....	1
1.2 Summary of Key Market Considerations.....	8
1.3 Key Prices Used in Cost of Production Tables (First Quarter of 2015 Basis).....	9
1.4 Global Polyether Polyol Demand by Region .....	15
1.5 Global Polyether Polyols Supply, Demand, and Trade .....	17
2.1 Properties and Uses of Polyether Polyols.....	18
2.2 Typical Input Requirements for Selected Polyurethanes .....	19
2.3 Summary of Key Market Considerations.....	23
3.1 Typical Specifications for a 2 000 MW Poly(oxypropylene) Glycol .....	29
3.2 Properties of Common Starters for Polyurethane Polyols .....	31
3.3 Typical Properties of Glycerin-PO adduct with MW of 2 900 to 3 300 .....	33
3.4 Typical Properties of 3 000 MW TMP-PO Adduct.....	34
5.1 Key Prices Used in Cost of Production Tables (First Quarter of 2015 Basis).....	49
5.2 Cost of Production Estimate for: Glycerin-Based 3 000 MW Polyol Process: Alkoxylation of Glycerin Starter with 100 Percent PO .....	52
5.3 Cost of Production Estimate for: Glycerin-Based 5 000 MW Polyol Process: Alkoxylation of Glycerin Starter with 95 Percent PO and 5 Percent EO .....	53
5.4 Cost of Production Estimate for: Glycerin-Based 5 000 MW Polyol Process: Alkoxylation of Glycerin Starter with 80 Percent PO and 20 Percent EO .....	54
5.5 Cost of Production Estimate for: Trinethylolpropane-Based 3 000 MW Polyol Process: Alkoxylation of Trimethylolpropane Starter with 100 Percent PO .....	55
5.6 Cost of Production Estimate for: Phosphoric Acid-Based Polyol (672 MW) Process: Alkoxylation of Phosphoric Acid Starter with 100 Percent PO .....	56
5.7 Cost of Production Estimate for: Sorbitol-Based PO Polyol (732 MW) Process: Alkoxylation of Sorbitol Starter with 100 Percent PO .....	57
5.8 Cost of Production Estimate for: Sucrose-Based Polyol (976 MW) Process: Alkoxylation of Sucrose Starter with 100 Percent PO .....	58
5.9 Cost of Production Estimate for: Toluenediamine-Based Polyol Process: Alkoxylation of Toluenediamine Starter with 100 Percent PO .....	59
5.10 Cost of Production Estimate for: Soybean Oil-Based Polyol Process: Alkoxylation of Soybean Oil with 100 Percent PO .....	60
5.11 Cost of Production Estimate for: Soybean Oil-Based Polyol Process: Ring Opening of Epoxidized Soybean Oil with Hydrogen Peroxide and Acetic Acid.....	61
5.12 Summary of Economics for Production of Different Polyols .....	62
5.13 Cost of Production Estimate for: Glycerin-Based 3 000 MW Polyol in China Process: Alkoxylation of Glycerin Starter with 100 Percent PO .....	65

5.14	Cost of Production Estimate for: Glycerin-Based 3 000 MW Polyol in Western Europe Process: Alkoxylation of Glycerin Starter with 100 Percent PO .....	66
5.15	Cost of Production Estimate for: Glycerin-Based 5 000 MW Polyol in China Process: Alkoxylation of Glycerin Starter with 95 Percent PO and 5 Percent EO .....	67
5.16	Cost of Production Estimate for: Glycerin-Based 5 000 MW Polyol in Western Europe Process: Alkoxylation of Glycerin Starter with 95 Percent PO and 5 Percent EO .....	68
5.17	Cost of Production Estimate for: Glycerin-Based 5 000 MW Polyol in China Process: Alkoxylation of Glycerin Starter with 80 Percent PO and 20 Percent EO .....	69
5.18	Cost of Production Estimate for: Glycerin-Based 5 000 MW Polyol in Western Europe Process: Alkoxylation of Glycerin Starter with 80 Percent PO and 20 Percent EO .....	70
5.19	Cost of Production Estimate for: Sorbitol-Based Polyol in China Process: Alkoxylation of Sorbitol Starter with 100 Percent PO .....	71
5.20	Cost of Production Estimate for: Sorbitol-Based Polyol in Western Europe Process: Alkoxylation of Sorbitol Starter with 100 Percent PO .....	72
5.21	Cost of Production Estimate for: Sucrose-Based Polyol in China Process: Alkoxylation of Sucrose Starter with 100 Percent PO .....	73
5.22	Cost of Production Estimate for: Sucrose-Based Polyol in Western Europe Process: Alkoxylation of Sucrose Starter with 100 Percent PO .....	74
5.23	Cost of Production Estimate for: Soybean-Based Polyol in China Process: Ring Opening of Epoxidized Soybean Oil with Hydrogen Peroxide and Acetic Acid.....	75
5.24	Cost of Production Estimate for: Soybean-Based Polyol in China Process: Ring Opening of Epoxidized Soybean Oil with Hydrogen Peroxide and Acetic Acid.....	76
5.25	Summary of Economics for Production of Glycerin-Based Polyols in Different Regions.....	77
5.26	Summary of Economics for Production of Higher Functional Polyols in Different Regions ...	77
6.1	Global Polyether Polyol Demand by Region .....	82
6.2	Global Polyether Polyols Supply, Demand, and Trade .....	84
6.3	Polyether Polyol Capacity in North America in 2014 .....	85
6.4	North America Polyether Polyol Supply, Demand, and Trade .....	86
6.5	Polyether Polyol Capacities in Western Europe in 2014.....	87
6.6	West European Polyether Polyol Supply, Demand, and Trade .....	88
6.7	Polyether Polyol Capacities in Asia Pacific in 2014 .....	90
6.8	Asian Polyether Polyol Supply, Demand, and Trade .....	92
6.9	Key Polyether Polyol Capacities in Rest of the World in 2014.....	92
6.10	Rest of the World Polyether Polyol Supply, Demand, and Trade .....	93

# Nexant Thinking™

## Process Evaluation/Research Planning



The NexantThinking™ 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 single report basis.

### Contact Details:

**New York:** Marcos Nogueira Cesar, Vice President, Global Products, E&CA: Nexant Thinking™  
Phone: + 1-914-609-0324, e-mail: [mcesar@nexant.com](mailto:mcesar@nexant.com)

**New York:** Heidi Junker Coleman, Global Programs Support Manager  
Phone: + 1-914-609-0381, e-mail: [hcoleman@nexant.com](mailto:hcoleman@nexant.com)

Nexant, Inc. ([www.nexant.com](http://www.nexant.com)) is a leading management consultancy to the global energy, chemical, and related industries. For over 38 years, Nexant 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 Nexant Inc. 2015. All Rights Reserved.