

Oleochemicals

Table of Contents

A Report by Nexant's CHEMSYSTEMS
Process Evaluation/Research Planning (PERP) Program
PERP 2011S6 - Published May 2012

www.chemsystems.com

Section	Page
1 Executive Summary	1
1.1 FEEDSTOCKS FOR OLEOCHEMICALS	1
1.2 OLEOCHEMICALS PRODUCTION PROCESSES	2
1.2.1 Production of Fatty Acids and Glycerine	2
1.2.2 Production of Methyl Esters	4
1.2.3 Fatty Alcohols	5
1.3 PROCESS ECONOMICS	9
1.3.1 Fatty Acids	9
1.3.2 Methyl Ester	10
1.3.3 Fatty Alcohols	11
1.3.4 Sensitivity Analysis	12
1.4 FATTY ACID MARKET ANALYSIS	13
1.4.1 Global Supply, Demand, and Trade	13
1.5 GLYCERINE MARKET ANALYSIS	14
1.5.1 Global Demand	14
1.5.2 Global Supply	14
1.5.3 Global Trade	15
1.6 FATTY ALCOHOLS MARKET ANALYSIS	16
1.6.1 C ₁₂ -C ₁₄ Alcohols	16
1.6.2 C ₁₆ -C ₁₈ Alcohols	16
1.6.3 C ₈ -C ₁₀ Alcohols	16
1.6.4 Global Supply, Demand, and Trade	17
2 Introduction	18
2.1 OVERVIEW OF BASIC OLEOCHEMICALS	18

3	Feedstocks for Oleochemicals	20
3.1	FEEDSTOCK COMPOSITION	20
3.2	PALM OIL.....	22
3.3	PALM KERNEL OIL (PKO)	24
3.4	COCONUT OIL.....	24
3.5	SOYBEAN OIL	25
3.6	TALLOW.....	25
3.7	RAPESEED OIL.....	26
3.8	OLEOCHEMICALS PRODUCTION OVERVIEW	27
4	Production of Fatty Acids and Glycerine	28
4.1	CHEMISTRY	28
4.2	FEEDSTOCK SPECIFICATION	29
4.3	PROCESS DESCRIPTION	31
4.3.1	Splitting Process.....	31
4.3.2	Fatty Acids Fractionation and Distillation.....	34
4.3.3	Fatty Acid Hydrogenation.....	36
4.3.4	Glycerine Purification.....	38
4.3.5	Glycerine Pretreatment and Evaporation	38
4.3.6	Glycerine Distillation and Bleaching.....	38
4.3.7	Glycerine Purification via Ion Exchange.....	42
4.4	PRODUCT QUALITY AND CONFIGURATION.....	44
4.4.1	Fatty Acids	44
4.4.2	Glycerine.....	46
4.5	APPLICATION	47
4.5.1	Fatty Acids	47
4.5.2	Glycerine.....	48
4.6	TECHNOLOGY PROVIDERS	49
5	Production of Methyl Esters	50
5.1	CHEMISTRY	50
5.2	FEEDSTOCK	51
5.3	PROCESS DESCRIPTION	51
5.3.1	Oil Pretreatment	52
5.3.2	Transesterification.....	53
5.3.3	Product Recovery and Purification	58

5.3.4	Methyl Ester Fractionation/Distillation	58
5.3.5	Methanol Recovery	59
5.4	PRODUCT QUALITY AND CONFIGURATION.....	60
	Properties	63
5.5	APPLICATION	63
5.6	TECHNOLOGY PROVIDERS	64
6	Fatty Alcohols	65
6.1	CHEMISTRY	65
6.2	FEEDSTOCK	65
6.3	PROCESS DESCRIPTION	65
6.3.1	Production of Fatty Alcohol via Esterification of Fatty Acids	66
6.3.2	Production of Fatty Alcohols via Fatty Acid Slurry	72
6.3.3	Production of Fatty Alcohol via Methyl Esters using a Fixed Bed Process	76
6.4	PRODUCT QUALITY AND CONFIGURATION.....	83
6.5	APPLICATION	85
6.5.1	C ₁₂ -C ₁₄ Alcohols	85
6.5.2	C ₁₆ -C ₁₈ Alcohols	85
6.5.3	C ₈ -C ₁₀ Alcohols	85
6.6	TECHNOLOGY PROVIDERS	86
7	Process Economics	88
7.1	COSTING BASIS	88
7.1.1	Investment Basis	88
7.1.2	Pricing Basis	89
7.1.3	Cost of Production Basis.....	90
7.2	PRODUCTION COST ESTIMATES (CHINA, MALAYSIA, NORTH AMERICA, WESTERN EUROPE).....	91
7.2.1	Fatty Acids	91
7.2.2	Methyl Ester.....	98
7.2.3	Fatty Alcohols	104
7.3	SENSITIVITY ANALYSIS	111
7.3.1	Sensitivity to Feedstock Prices	111
7.3.2	Sensitivity to Byproducts Prices	112
7.3.3	Sensitivity to Total Project Investment.....	113

7.3.4	Sensitivity to Production Plant Capacity	114
8	Fatty Acid Regional Market Analysis	115
8.1	GLOBAL SUMMARY	115
8.1.1	Applications	115
8.1.2	Demand	116
8.1.3	Supply	117
8.1.4	Supply, Demand, and Trade.....	118
8.1.5	Global Trade	119
8.2	NORTH AMERICA	119
8.2.1	Demand	119
8.2.2	Supply	120
8.2.3	Supply, Demand, and Trade.....	121
8.3	EUROPE	122
8.3.1	Demand	122
8.3.2	Supply	122
8.3.3	Supply, Demand, and Trade.....	123
8.4	SOUTH-EAST ASIA.....	125
8.4.1	Demand	125
8.4.2	Supply	126
8.4.3	Supply, Demand, and Trade.....	128
8.5	REST OF WORLD	129
8.5.1	Demand	129
8.5.2	Supply	129
8.5.3	Supply, Demand, and Trade.....	131
9	Glycerine Regional Market Analysis	132
9.1	GLOBAL SUMMARY	132
9.1.1	Applications	132
9.1.2	Demand	133
9.1.3	Supply	134
9.1.4	Trade	136

10	Fatty Alcohols Regional Market Analysis	138
10.1	GLOBAL SUMMARY	138
10.1.1	Applications	138
10.1.2	Demand	141
10.1.3	Supply	142
10.1.4	Supply, Demand, and Trade.....	143
10.1.5	Global Trade	145
10.2	NORTH AMERICA	145
10.2.1	Demand	145
10.2.2	Supply	146
10.2.3	Supply, Demand, and Trade.....	146
10.3	EUROPE.....	147
10.3.1	Demand	147
10.3.2	Supply	147
10.3.3	Supply, Demand, and Trade.....	148
10.4	SOUTH-EAST ASIA.....	150
10.4.1	Demand	150
10.4.2	Supply	150
10.4.3	Supply, Demand, and Trade.....	151
10.5	REST OF WORLD	153
10.5.1	Demand	153
10.5.2	Supply	153
10.5.3	Supply, Demand, and Trade.....	154
11	Glossary	156
12	References.....	158
	Appendix	Page
A	Definition of Capital Cost Terms Used in Process Economics	A-1
B	Definitions of Operating Cost Terms Used in Process Economics.....	B-1
C	PERP Program Title Index (2001/2002- 2011).....	C-1

Figure	Page
1.1 Global Breakdown of Vegetable Oil Types.....	2
1.2 Production of Fatty Acids and Glycerine from Hydrolysis	3
1.3 Processing Steps for Production of Methyl Esters.....	5
1.4 Simplified Blow Flow Diagram of Fatty Alcohol Production via Fatty Acid Esterification	6
1.5 Blow Flow Diagram of Fatty Alcohol Production from Direct Hydration of Fatty Acid.....	7
1.6 Simple Block Flow of Production of Fatty Alcohol via Transesterification of Oils and Fats	8
2.1 Overview of Basic Oleochemicals.....	19
3.1 Global Vegetable Oils Production 2010/2011	20
3.2 Fatty Acid Composition in Oleochemicals	21
3.3 Chemical Structure of Oil and Fat Molecules.....	27
4.1 Hydrolysis of Oils and Fats.....	28
4.2 Fatty Acid and Glycerine Production Flow Scheme.....	31
4.3 Splitting Process.....	33
4.4 Fatty Acid Fractionation and Distillation	35
4.5 Fatty Acid Hydrogenation.....	37
4.6 Glycerine Water Pretreatment.....	39
4.7 Glycerine Water Evaporation	40
4.8 Glycerine Distillation and Bleaching.....	41
4.9 Glycerine Purification via Ion Exchange.....	43
5.1 Transesterification of Oils and Fats into Methyl Esters Reaction Chemistry.....	51
5.2 Methyl Ester Production Block Flow Scheme.....	52
5.3 Free Fatty Acids with Sodium Methoxide Catalyst Reaction Chemistry	52
5.4 DBO's Methyl Ester Process	54
5.5 Transesterification of Oils and Fats to Methyl Esters (Lurgi Process).....	56
5.6 Transesterification to Methyl Esters (Henkel Process).....	57
6.1 Fatty Alcohol Production via Fatty Acid Esterification Block Flow Diagram.....	66
6.2 Esterification of Fatty Acid to Methyl Ester Reaction Chemistry	67
6.3 Fixed Bed Hydrogenation of Methyl Esters Reaction Chemistry	68
6.4 Ester Removal via Wax Ester Formation Reaction Chemistry.....	68
6.5 Ester Recovery from Wax Ester Reaction Chemistry.....	69
6.6 Co-Production of Fatty Alcohol Composites Block Flow Scheme	71
6.7 Direct Hydrogenation of Fatty Acid to Fatty Alcohol Reaction Chemistry	72
6.8 Direct Hydrogenation of Fatty Acids to Fatty Alcohol Block Flow Diagram.....	73
6.9 Direct Fatty Acid Hydrogenation to Fatty Alcohol Process Flow Scheme	75
6.10 Transesterification of Oil and Fat to Fatty Alcohol Block Flow Diagram	76
6.11 Fixed Bed High Pressure Hydrogenation of Methyl Esters Process Flow Diagram.....	78
6.12 Fixed Bed Fatty Alcohol Production from Fatty Acid via Wax Ester Block Flow Diagram	79
6.13 Wax Ester Formation from Fatty Acids and Alcohol Reaction Chemistry	79

6.14	Hydrogenation of Wax Ester to Fatty Alcohol Reaction Chemistry	80
6.15	Wax Ester Route for Fatty Alcohol Production	82
7.1	Sensitivity of Oleochemicals production Costs to Feedstock Prices	111
7.2	Sensitivity of Oleochemicals Production Costs to Byproduct Prices	112
7.3	Sensitivity of Oleochemicals Cost of Production plus 10 Percent Return on Capital Employed to Variation in the Total Project Investment.....	113
7.4	Sensitivity of Oleochemicals Cost of Production plus 10 percent ROCE to Production Plant Capacity Scale	114
8.1	Fatty Acid Demand by Derivative	116
8.2	Global Fatty Acid Capacity by Region	117
8.3	Global Fatty Acid Supply, Demand, and Trade.....	118
8.4	Global Fatty Acid Trade	119
8.5	North America Fatty Acid Supply, Demand, and Trade	121
8.6	European Fatty Acid Supply, Demand, and Trade	124
8.7	South-East Asian Fatty Acid Supply, Demand, and Trade.....	128
8.8	Rest of the World Fatty Acid Supply, Demand, and Trade	131
9.1	Global Glycerine Demand by Derivative	133
9.2	Global Glycerine Supply by Source	135
9.3	Global Glycerine Supply by Region	136
9.4	Regional Glycerine Trade	137
10.1	C ₁₂ -C ₁₄ Alcohol Demand by Derivative	139
10.2	C ₁₆ -C ₁₈ Alcohol Demand by Derivative	140
10.3	C ₈ -C ₁₀ Alcohol Demand by Derivative.....	141
10.4	Global Fatty Alcohol Capacity by Region.....	143
10.5	Global Fatty Alcohol Supply, Demand, and Trade.....	144
10.6	Global Fatty Acid Trade	145
10.7	North America Fatty Alcohol Supply, Demand, and Trade	146
10.8	European Fatty Alcohol Supply, Demand, and Trade	149
10.9	South-East Asian Fatty Alcohol Supply, Demand, and Trade.....	152
10.10	Rest of the World Fatty Alcohol Supply, Demand, and Trade.....	155

Table	Page
1.1 Production Costs for Fatty Acids.....	9
1.2 Various Production Costs for Methyl Esters	10
1.3 Cost of Production Comparison of C ₁₂ -C ₁₄ fatty Alcohols in various Regions.....	12
1.4 Global Fatty Acid Supply, Demand, and Trade.....	13
1.5 Global Glycerine Demand	14
1.3 Global Fatty Alcohol Supply, Demand, and Trade.....	17
3.1 Fatty Acid Composition, %.....	23
3.2 Top Palm Oil Producing Countries, 2010/2011.....	23
3.3 Top Coconut Oil Producing Countries, 2011 Estimates.....	24
3.4 Top Soybean Producing Countries, 2010/2011	25
3.5 Top Rapeseed Oil Producing, Countries 2011.....	26
4.1 Feedstock Specifications.....	30
4.2 Fatty Acid Quality Samples	45
4.3 Typical Glycerine Quality.....	47
5.1 Samples of Methyl Ester Quality Specification.....	61
5.2 EN 14214 Fatty Acid Methyl Ester Standard	63
6.1 Sample of Fatty Alcohol Quality Specifications	84
6.2 Davy Process Technology's Fatty Alcohol References.....	86
6.3 Lurgi's Fatty Alcohol References	87
7.1 Raw Materials, Utilities and Manpower Price Basis	89
7.2 Cost of Production Estimate for Fatty Acids and Glycerine Plant (China) Process: Fat Splitting of Palm Stearine (PST)	93
7.3 Cost of Production Estimate for Fatty Acids and Glycerine Plant (Malaysia) Process: Fat Splitting of Palm Stearine (PST)	94
7.4 Cost of Production Estimate for Fatty Acids and Glycerine Plant (North America) Process: Fat Splitting of Bleachable Fancy Tallow (BFT).....	95
7.5 Cost of Production Estimate for Fatty Acids and Glycerine Plant (Western Europe) Process: Fat Splitting of Bleachable Fancy Tallow	96
7.6 Fatty Acid Production Cost Summary	97
7.7 Cost of Production Estimate for Methyl Ester and Glycerine Plant (China) Process: Transesterification of Refined Palm Oil (RPO)	99
7.8 Cost of Production Estimate for Methyl Ester and Glycerine Plant (Malaysia) Process: Transesterification of Crude Palm Oil (CPO)	100
7.9 Cost of Production Estimate for Methyl Ester and Glycerine Plant (North America) Process: Transesterification of Soybean Oil Palm Oil (SBO).....	101
7.10 Cost of Production Estimate for Methyl Ester and Glycerine Plant (Western Europe) Process: Transesterification of Rapeseed Oil (RO)	102
7.11 Methyl Ester Production Cost Summary	103
7.12 Cost of Production Estimate for C ₁₂ -C ₁₄ Fatty Alcohols (China) Process: Fatty Acids.....	105

7.13 Cost of Production Estimate for C ₁₂ -C ₁₄ Fatty Alcohols (Malaysia) Process: Fatty Acids.....	106
7.14 Cost of Production Estimate for C ₁₂ -C ₁₄ Fatty Alcohols (North America) Process: Fatty Acids.....	107
7.15 Cost of Production Estimate for C ₁₂ -C ₁₄ Fatty Alcohols (Western Europe) Process: Fatty Acids.....	108
7.16 Cost of Production Estimate for C ₁₂ -C ₁₄ Fatty Alcohols (Malaysia) Process: Methyl Ester.....	109
7.17 C ₁₂₋₁₄ Fatty Alcohols Production Cost Summary	110
8.1 Global Fatty Acid Demand	116
8.2 Global Fatty Acid Supply, Demand, and Trade.....	118
8.3 Capacities of Fatty Acid in North America	120
8.4 Capacities of Fatty Acid in North America	121
8.5 Capacities of Fatty Acid in Europe.....	123
8.6 European Fatty Acid Supply, Demand, and Trade	124
8.7 Capacities of Fatty Acid in South-East Asia.....	127
8.8 South-East Asian Fatty Acid Supply, Demand, and Trade.....	128
8.9 Capacities of Fatty Acid in Rest of the World.....	130
8.10 Rest of the World Fatty Acid Supply, Demand, and Trade	131
9.1 Global Glycerine Demand	134
10.1 Global Fatty Alcohol Demand	142
10.2 Global Fatty Alcohol Supply, Demand, and Trade.....	144
10.3 Capacities of Fatty Alcohol in North America	146
10.4 North America Fatty Alcohol Supply, Demand, and Trade	147
10.5 Capacities of Fatty Alcohol in Europe.....	148
10.6 European Fatty Alcohol Supply, Demand, and Trade	149
10.7 Capacities of Fatty Alcohol in South-East Asia	151
10.8 South-East Asian Fatty Alcohol Supply, Demand, and Trade.....	152
10.9 Capacities of Fatty Alcohol in Rest of the World.....	154
10.10 Rest of the World Fatty Alcohol Supply, Demand, and Trade	155

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 single report basis.

Contact Details:

London: Dr. Alexander Coker, Manager, PERP Program
Phone: + 44-(20)-7950-1570, e-mail: acoker@nexant.com

New York: Heidi Junker Coleman, Global Multi-Client Programs Support Manager
Phone: + 1-914-609-0381, e-mail: hcoleman@nexant.com

Shanghai: Dr. Y. Larry Song, General Manager, Nexant China
Phone: +86 21 6182 6791, e-mail: ylsong@nexant.com

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.

Copyright © by Nexant Inc. 2012. All Rights Reserved.