

PERP Report

Specialty LDPE Copolymers

03/04S9

December 2004



44 South Broadway, White Plains, New York 10601, USA
Tel: +1 914 609 0300 Fax: +1 914 609 0399

Copyright© by Nexant, Inc. 2004

This Report was prepared by Nexant, Inc. ("Nexant") and is part of ChemSystems Process Evaluation/Research Planning (PERP) Program. Except where specifically stated otherwise in this Report, the information contained herein is prepared on the basis of information that is publicly available, and contains no confidential third party technical information to the best knowledge of Nexant. The aforesaid information has not been independently verified or otherwise examined to determine its accuracy, completeness, or feasibility.

Neither Nexant, Subscriber, nor any person acting on behalf of either assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information contained in this Report. Nexant does not represent or warrant that any assumed conditions will come to pass.

The Report is submitted on the understanding that the Subscriber will maintain the contents confidential except for the Subscriber's internal use. The Report shall not be reproduced, distributed, or used outside Subscriber's organization without first obtaining prior written consent by Nexant. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Contents

Section	Page
1 Summary	1
1.1 INTRODUCTION	1
1.2 ETHYLENE VINYL ACETATE (EVA)	2
1.3 ETHYLENE METHYLACRYLATE (EMA)	10
1.4 ETHYLENE ETHYL ACRYLATE (EEA).....	11
1.5 ETHYLENE N-BUTYL ACRYLATE (EBA)	12
1.6 ETHYLENE ACRYLIC ACID (EAA)	13
1.7 ETHYLENE METHACRYLIC ACID (EMAA).....	13
1.8 IONOMERS.....	14
1.9 LDPE COPOLYMER PRODUCTION	17
1.10 ECONOMICS	19
1.11 REGIONAL ANALYSIS	24
1.11.1 North America	24
1.11.2 Western Europe.....	25
1.11.3 Japan	26
2 Introduction	28
2.1 ETHYLENE VINYL ACETATE (EVA)	29
2.2 ETHYLENE METHYLACRYLATE (EMA)	39
2.3 ETHYLENE ETHYL ACRYLATE (EEA).....	40
2.4 ETHYLENE N-BUTYL ACRYLATE (EBA)	41
2.5 ETHYLENE ACRYLIC ACID (EAA)	42
2.6 ETHYLENE METHACRYLIC ACID (EMAA).....	43
2.7 IONOMERS.....	43
3 Conventional Technology	49
3.1 CHEMISTRY	49
3.2 LDPE TECHNOLOGY	52
3.2.1 Overview.....	52
3.2.2 LDPE Tubular Process.....	53
3.2.3 LDPE Autoclave Processes.....	56

3.3	LDPE COPOLYMER PRODUCTION	58
3.3.1	Overview	58
3.3.2	Ethylene Ester Copolymers.....	60
3.3.3	Ethylene Acid Copolymers	60
3.3.4	Ionomers	61
3.4	TECHNOLOGY TRENDS.....	64
4	Economics	65
4.1	BASIS	65
4.2	INVESTMENT	66
4.3	ECONOMICS	68
4.4	RAW MATERIAL SENSITIVITY	88
4.5	SENSITIVITY TO SCALE	89
5	Commercial	93
5.1	END-USE ANALYSIS.....	93
5.1.1	ETHYLENE VINYL ACETATE COPOLYMERS (EVA)	93
5.1.2	Acrylate Copolymers	102
5.1.3	Acid Copolymers (EAA and EMAA).....	104
5.1.4	Ionomers	104
5.1.5	Other Specialty LDPE Copolymers	105
5.2	REGIONAL ANALYSIS	106
5.2.1	North America	106
5.2.2	Western Europe.....	114
5.2.3	Japan	122
Appendix		Page
A	Elements of Nexant/ChemSystems' Capital Cost Estimates Process Evaluation/Research Planning, 2004	A-1
B	PERP Program Title Index	B-1

Figure	Page
1.1 Physical Property Comparison.....	2
1.2 Crystallinity of EVA as a Function of Vinyl Acetate Content	3
1.3 Stiffness of EVA at 20°C as a Function of Vinyl Acetate Content	4
1.4 Variation of EVA Resin Property with Melt Index and Vinyl Acetate Level	6
1.5 EVA Application Range	7
1.6 Comparison of Reactivity of Comonomers	18
1.7 Homopolymer LDPE and EVA Copolymer Production Costs.....	21
1.8 Homopolymer LDPE and other Specialty Copolymer Production Costs.....	23
2.1 Physical Property Comparison.....	29
2.2 Crystallinity of EVA as a Function of Vinyl Acetate Content	30
2.3 Stiffness of EVA at 20°C as a Function of Vinyl Acetate Content	31
2.4 Variation of EVA Resin Property with Melt Index and Vinyl Acetate Level	33
2.5 EVA Application Range	34
2.6 Hot Melt adhesive Uses of EVA.....	37
2.7 Schematic Structure of Ionomer	44
2.8 Melt Viscosity of Ionomer Compared to LDPE	47
3.1 Low Density Polyethylene Tubular Process	54
3.2 Low Density Polyethylene Autoclave Process	57
3.3 Comparison of Reactivity of Comonomers	59
3.4 Twin-Screw Geometry of a Co-Rotating System	62
3.5 Plant for Producing Ionomer Resins	63
4.1 Homopolymer LDPE and EVA Copolymer Production Costs.....	70
4.2 Homopolymer LDPE and other Specialty Copolymer Production Costs.....	72
4.3 Effects of Ethylene Price on 18% EVA Copolymer Economics(1)	88
4.4 Scale Comparison of 18% EVA Production.....	90
5.1 Use of EVAs in Flexible Packaging	94
5.2 Notched IZOD Impact Test Results (@RT) for Selected Thermoplastic Resins	103
5.3 North American EVA Copolymer Demand by End Use, 2004.....	107
5.4 North American EVA Exports by Destination, 2003	110

5.5	North American Acrylate Copolymer Demand by End Use, 2004	111
5.6	North American EAA Demand by End Use, 2004	112
5.7	North American Ionomer Demand by End Use, 2004.....	114
5.8	West European EVA Copolymer Demand by End Use, 2004.....	116
5.9	West European Acrylate Copolymer Demand by End Use, 2004	119
5.10	West European Acid Copolymer Demand by End Use, 2004	120
5.11	West European Ionomer Demand by End Use, 2004	121
5.12	Japanese EVA Copolymer Demand By End Use, 2004	124
5.13	Japanese EVA Export By Destination, 2003	126
5.14	Japanese EEA Demand By Application, 2004	127
5.15	Japanese Ionomer Demand By Application, 2004.....	129

Table	Page	
1.1	Typical EVA Properties.....	8
1.2	Selection of EVA Type for Film Applications	9
1.3	EMA Copolymer Film Properties.....	10
1.4	Properties of Crosslinked EEA	11
1.5	EEA Copolymer Properties.....	12
1.6	EBA Copolymer Properties	12
1.7	EAA Acid Copolymer Film Properties.....	13
1.8	EMAA Copolymer Properties.....	13
1.9	Effect of Cation on Ionomer Property	14
1.10	Selected Properties of Ionomers	15
1.11	Ionomer Property Grid.....	16
1.1	Reactivity Ratios in High Pressure Ethylene/Copolymerization	17
1.13	Homopolymer LDPE and EVA Copolymer Production Costs(1)	20
1.14	Homopolymer LDPE and Other Specialty Copolymer Production Costs(1)	22
1.15	North American Ethylene Copolymer Demand.....	24
1.16	North American Ethylene Copolymer Producers, 2004	25
1.17	West European Ethylene Copolymer Demand	25

1.18 West European EVA Producers, 2004.....	26
1.19 Japanese Ethylene Copolymer Demand.....	27
1.20 Japanese EVA Producers, 2004(1)	27
2.1 Typical EVA Properties.....	35
2.2 Selection of EVA Type for Film Applications	36
2.3 EVA Competitive Material Properties and Applications.....	38
2.4 Property Comparison of EVA, SBS, SIS and SB Polymers	39
2.5 EMA Copolymer Film Properties.....	40
2.6 Properties of Crosslinked EEA	41
2.7 EEA Copolymer Properties.....	41
2.8 EBA Copolymer Properties	42
2.9 EAA Acid Copolymer Film Properties.....	42
2.10 EMAA Copolymer Properties.....	43
2.11 Effect of Cation on Ionomer Property	45
2.12 Selected Properties of Ionomers	45
2.13 Ionomer Property Grid.....	46
2.14 Comparison of Ionomer Properties to EVA and EEA.....	48
3.1 LDPE Autoclave Versus Tubular Reactors	55
3.2 Reactivity Ratios in High Pressure Ethylene/Copolymerization.....	58
3.3 Reactivity Ratios for Acid Comonomers.....	61
4.1 USGC Specialty LDPE Copolymer Capital Cost Estimates.....	67
4.2 Homopolymer LDPE and EVA Copolymer Production Costs(1).....	69
4.3 Homopolymer LDPE and Other Specialty Copolymer Production Costs(1)	71
4.4 Cost of Production Estimate for: Homopolymer LDPE Process: Tubular.....	73
4.5 Cost of Production Estimate for: EVA – 10% VA Process: Tubular.....	74
4.6 Cost of Production Estimate for: EVA – 18% VA Process: Tubular.....	75
4.7 Cost of Production Estimate for: EVA – 28% VA Process: Tubular.....	76
4.8 Cost of Production Estimate for: Homopolymer LDPE Process: Autoclave.....	77

4.9	Cost of Production Estimate for EVA – 10% VA Process: Autoclave.....	78
4.10	Cost of Production Estimate for: EVA – 18% VA Process: Autoclave.....	79
4.11	Cost of Production Estimate for: EVA –28% VA Process: Autoclave.....	80
4.12	Cost of Production Estimate for: EVA – 40% VA Process: Autoclave.....	81
4.13	Cost of Production Estimate for: EEA – 18% EA Process: Tubular.....	82
4.14	Cost of Production Estimate for: EAA – 10% AA Process: Autoclave.....	83
4.15	Cost of Production Estimate for: EMA – 7% MA Process: Autoclave.....	84
4.16	Cost of Production Estimate for: EMAA – 7% MAA Process: Autoclave.....	85
4.17	Cost of Production Estimate for: Ionomer – Direct Coupled to Reactor Process: Autoclave.....	86
4.18	Cost of Production Estimate for; Ionomer – Separate Compounding Step Process: Compounding – 92 mm twin screw.....	87
4.19	Scale Sensitivity of 18% EVA Copolymer Production (1,2).....	89
4.20	Cost of Production Estimate for: EVA – 18% VA Process: Tubular.....	91
4.21	Cost of Production Estimate for: EVA – 18% VA Process: Autoclave.....	92
5.1	Use of Specialty LDPE’s as Polymer Modifiers.....	100
5.2	North American Ethylene Copolymer Demand.....	106
5.3	North American EVA(1) Copolymer Consumption by End-Use Segment.....	107
5.4	North American Ethylene Copolymer Producers, 2004.....	109
5.5	North American EVA Copolymer Supply, Demand and Trade.....	109
5.6	North American Acrylate Copolymer Supply, Demand and Trade.....	112
5.7	North American Acid Copolymer Supply, Demand and Trade.....	113
5.8	North American Ionomer Supply, Demand and Trade.....	114
5.9	West European Ethylene Copolymer Demand.....	115
5.10	West European EVA Copolymer Demand by Application.....	116

5.11 West European EVA Demand by Vinyl Acetate Level, 2004.....	117
5.12 West European EVA Copolymer Demand by Country, 2004	117
5.13 West European EVA Producers, 2004.....	118
5.14 West European EVA(1) Copolymer Supply, Demand and Trade	119
5.15 West European Acrylate Copolymer Supply, Demand and Trade	120
5.16 West European Acid Copolymer supply, Demand and Trade	121
5.17 West European Ionomer Supply, Demand and Trade	122
5.18 Japanese Ethylene Copolymer Demand.....	123
5.19 Japanese EVA(1) Copolymer Consumption.....	123
5.20 Japanese EVA Demand Breakdown By VA Content, 2004	125
5.21 Japanese EVA Producers, 2004(1)	125
5.22 Japanese EVA(1) Copolymer Supply, Demand and Trade	126
5.23 Japanese Acrylate Copolymer Supply, Demand and Trade.....	128
5.24 Japanese Acid Copolymer Supply, Demand and Trade.....	128
5.25 Japanese Ionomer Supply, Demand and Trade.....	129
5.26 Japanese Other Ethylene Copolymer Demand	130