

Report No. 20

ABS RESINS

by ROBERT G. MULLER

contributions by Shigeyoshi Takaoka

December, 1966

A private report by the

PROCESS ECONOMICS PROGRAM

STANFORD RESEARCH INSTITUTE



MENLO PARK, CALIFORNIA

CONTENTS

I	INTRODUCTION	1
II	SUMMARY	3
III	INDUSTRY STATUS	11
IV	CHEMISTRY	23
	Introduction	23
	SAN Copolymer	24
	Reactivity Ratio of Styrene and Acrylonitrile	27
	Azeotropic Composition of SAN Copolymer	29
	Criteria for Producing Copolymer of Uniform Composition	31
	Heat of Copolymerization	33
	Variables Affecting Physical Properties of SAN	33
	Relation Between Molecular Weight and Viscosity	37
	Copolymers of Alpha-Methylstyrene and Acrylonitrile	37
	Mass Polymerization of SAN	38
	Solution Polymerization of SAN	40
	Suspension Polymerization of SAN	42
	Emulsion Polymerization of SAN	44
	ABS Polyblends	50
	Mechanism of Reinforcement	51
	Composition	54
	ABS Graft Resins	56
	Grafting Mechanism	57
	Reinforcement Mechanism	60
	Composition	62
V	PROPERTIES OF ABS RESINS	65
	Introduction	65
	General Properties	66
	Factors Influencing ABS Properties	70
VI	MANUFACTURING PROCESSES FOR SAN COPOLYMER	75
	Introduction	75
	SAN by Mass Polymerization	76
	Summary of Processes	76
	Process Description	86
	Materials of Construction	93
	Process Discussion	93

CONTENTS

VI	(continued)		
	SAN by Solution Polymerization: Summary of Processes	96	
	SAN by Emulsion Polymerization	97	
	Summary of Processes	97	
	Process Description	107	
	Materials of Construction	118	
	Process Discussion	118	
	SAN by Suspension Polymerization	122	
	Summary of Processes	122	
	Process Discussion	133	
VII	MANUFACTURING PROCESSES FOR ABS RESINS	135	
	Polyblends: Summary of Processes	135	
	ABS Graft Resins by Emulsion Polymerization	149	
	Summary of Processes	149	
	Process Description	166	
	Materials of Construction	179	
	Process Discussion	179	
	ABS Graft Resins by Mass-Suspension Polymerization	185	
	Summary of Processes	186	
	Process Description	188	
	Materials of Construction	196	
	Process Discussion	196	
	ABS Resins by Other Processes	199	
	ABS Graft Resins by Mass Polymerization	199	
	ABS Graft Resin by Suspension Polymerization	201	
	Miscellaneous Processes for ABS Resins	201	
VIII	COST ESTIMATES	203	
	ABS Graft Resin--SAN Copolymer by Emulsion Polymerization,		
	ABS Graft by Emulsion Polymerization	203	
	Capital Costs	203	
	Production Costs	208	
	ABS Graft Resin--SAN Copolymer by Mass Polymerization,		
	ABS Graft by Emulsion Polymerization	214	
	Capital Costs	214	
	Production Costs	214	
	ABS Graft Resin by Mass-Suspension Polymerization	221	
	Capital Costs	221	
	Production Costs	226	

CONTENTS

APPENDIX A	DESIGN AND COST BASIS	235
APPENDIX B	PHYSICAL DATA	241
APPENDIX C	RAW MATERIAL SPECIFICATIONS	245
APPENDIX D	GLOSSARY	249
CITED REFERENCES	259
SUPPLEMENTARY REFERENCES	276

ILLUSTRATIONS

1	Estimated Sales of ABS Resins in the United States	13
2	SAN Copolymer Composition by Mass Polymerization	30
3	SAN Polymer Composition versus Conversion for Various Monomer Feed Mixtures	32
4	Heat of Polymerization of SAN Copolymer versus Monomer Feed Composition	34
5	Properties of Molded SAN Copolymers versus Monomer Feed Mixture	36
6	Mass Copolymerization of Styrene-Acrylonitrile versus Time . .	39
7	Effect of Temperature upon the Rate of Mass Polymerization of SAN	41
8	SAN Copolymer Composition by Emulsion Polymerization	47
9	Rate of Emulsion Polymerization	48
10	Viscosity versus Conversion in SAN Emulsion Polymerization . .	49
11	SAN by Mass Polymerization (flowsheet)	89
12	SAN by Emulsion Polymerization (flowsheet)	109
13	Instantaneous Composition of Styrene-Acrylonitrile (SAN) Copolymers Formed at Different Conversions	119
14	ABS Graft Resins by Emulsion Polymerization (flowsheet). . . .	167
15	ABS Graft Resins by Mass-Suspension Polymerization(flowsheet). .	189
16	Effect of Raw Material Costs on Production Cost of ABS Graft Resin Made by Emulsion Polymerization	211
17	Effect of Polybutadiene Content on Production Cost of ABS Graft Resin Made by Emulsion Polymerization	212
18	ABS Resin by Emulsion Polymerization Effect of Operating Level and Plant Capacity on Production Cost	213
19	Effect of Raw Material Costs on Production Cost of ABS Graft Resin Made by Mass-Suspension Polymerization	229
20	Effect of Polybutadiene Content on Production Cost of ABS Graft Resin made by Mass-Suspension Polymerization	230
21	ABS Resin by Mass-Suspension Polymerization Effect of Operating Level and Plant Capacity on Production Cost	231

TABLES

1	Estimated Sales of ABS	12
2	Plant Capacities, Americas	17
3	Plant Capacities, Europe	19
4	Plant Capacities, Japan	21
5	Properties of ABS Resins	67
6	SAN by Mass Polymerization Summary of Processes	79
7	SAN by Mass Polymerization Major Process Equipment and Utilities Summary	89
8	SAN by Mass Polymerization Stream Flows	91
9	SAN by Emulsion Polymerization Summary of Processes	99
10	SAN by Emulsion Polymerization Major Process Equipment and Utilities Summary	109
11	SAN by Emulsion Polymerization Stream Flows	113
12	SAN by Suspension Polymerization Summary of Processes	125
13	ABS Resins--Polyblends Summary of Processes	137
14	ABS Graft Resins by Emulsion Polymerization Summary of Processes	151
15	ABS Graft Resins by Emulsion Polymerization Major Process Equipment List and Utilities Summary	167
16	ABS Graft Resins by Emulsion Polymerization Stream Flows	173
17	ABS Graft Resins by Mass-Suspension Polymerization Major Process Equipment and Utilities Summary	189
18	ABS Graft Resins by Mass-Suspension Polymerization Stream Flows	193

TABLES

19	ABS Graft Resin: SAN Copolymer by Emulsion Polymerization and ABS Graft by Emulsion Polymerization Process Unit and Utilities Investment	205
20	ABS Graft Resin: SAN Copolymer by Emulsion Polymerization and ABS Graft by Emulsion Polymerization Total Capital Investment	207
21	ABS Graft Resin: SAN Copolymer by Emulsion Polymerization and ABS Graft by Emulsion Polymerization Production Costs	209
22	ABS Graft Resin: SAN Copolymer by Emulsion Polymerization and ABS Graft by Emulsion Polymerization Process Unit and Utilities Investment	215
23	ABS Graft Resin: SAN Copolymer by Emulsion Polymerization and ABS Graft by Emulsion Polymerization Total Capital Investment	217
24	ABS Graft Resin: SAN Copolymer by Emulsion Polymerization and ABS Graft by Emulsion Polymerization Production Costs	219
25	ABS Graft Resins by Mass-Suspension Polymerization Process Unit and Utilities Investment	223
26	ABS Graft Resins by Mass-Suspension Polymerization Total Capital Investment	225
27	ABS Graft Resins by Mass-Suspension Polymerization Production Costs	227