Abstract

Process Economics Program Report 20C

ABS RESINS

(May 1995)

This supplementary report, PEP Report 20C, reviews the technology for producing graft resins of acrylonitrile, butadiene, and styrene (ABS), and copolymer resins of styrene and acrylonitrile (SAN [or ANS if the acrylonitrile content exceeds 50 wt%]) or of \( \mu \)-methyl styrene and acrylonitrile (MSA). Also presented are the economics for producing ABS resins by continuous mass polymerization, emulsion polymerization, and emulsion-mass polymerization; and for producing SAN or MSA resins by continuous mass polymerization.

In recent years, continuous mass polymerization has become the most widely employed process by ABS producers worldwide. With its improved technology, the process can produce resins with enhanced color consistency, thereby making painting unnecessary for certain applications. The mass polymerization process is the most desirable technology from the standpoint of capital investment and environmental issues. However, the emulsion polymerization process, which is still commonly used in the industry in plants built before mid-1980, provides more flexibility in product range than the mass polymerization process. The emulsion-mass polymerization process, which was developed during the late 1970s, was attractive to the industry in the 1980s. According to SRI's evaluation, the process' production costs are lower than those for the continuous mass process; however, it is less environmentally friendly that the continuous mass process, and it is more expensive to build.

ABS/SAN resin consumption worldwide in 1993 was 2.9 million tons, with demand highest in the Asia-Pacific region at more than 55% of the total. Mainland China had the highest growth in demand for ABS resins—an increase from 70,000 t/yr in 1988 to 490,000 t/yr in 1993, for an annual growth rate of 38%. The other markets for ABS resins were mixed, with regional growth estimates for 1993 ranging from 7.6% in the United States, to -2.8% in Japan and -10.6% in Western Europe.
## CONTENTS (Concluded)

5 **ABS RESIN BY EMULSION POLYMERIZATION** 5–1  
**PROCESS DESCRIPTION** 5–1  
- Raw Material Preparation 5–3  
- SAN by Emulsion Polymerization 5–3  
- Butadiene Emulsion Polymerization 5–4  
- ABS by Emulsion Polymerization 5–4  
- Latex Blending and Drying 5–4  
- Product Finishing and Bulk Handling 5–5  
**PROCESS DISCUSSION** 5–18  
**COST ESTIMATES** 5–18

6 **ABS RESINS BY MASS POLYMERIZATION OR EMULSION–MASS POLYMERIZATION** 6–1  
**PROCESS DESCRIPTION** 6–1  
**RAW MATERIAL PREPARATION** 6–3  
- Polymerization, Monomer Recovery, and Product Finishing 6–3  
- Compounding and Bulk Handling 6–3  
**PROCESS DISCUSSION** 6–8  
**COST ESTIMATES** 6–8

7 **SAN RESINS BY MASS POLYMERIZATION OR EMULSION POLYMERIZATION** 7–1  
**UPDATED ECONOMICS FOR SAN RESIN BY CONTINUOUS MASS POLYMERIZATION** 7–1  
**MSA RESIN BY CONTINUOUS MASS POLYMERIZATION** 7–8  
**COST ESTIMATES** 7–14

**APPENDIX A: PATENT SUMMARY TABLES** A–1  
**APPENDIX B: DESIGN AND COST BASES** B–1  
**APPENDIX C: CITED REFERENCES** C–1  
**APPENDIX D: PATENT REFERENCES BY COMPANY** D–1  
**APPENDIX E: PROCESS FLOW DIAGRAMS** E–1
ILLUSTRATIONS

3.1 U.S. Consumption of ABS Resins 3–8
3.2 U.S. Consumption of SAN Resins 3–8
3.3 Western European Consumption of ABS Resins 3–9
3.4 Japanese Consumption of ABS Resins 3–10
5.1 ABS Resin by Emulsion Polymerization Process Flow Diagram E–3
5.2 ABS Resin by Emulsion Polymerization Effect of Operating Level and Plant Capacity on Product Value 5–25
5.3 ABS Resin by Emulsion Polymerization Effect of Monomer Unit Prices on ABS Product Value 5–26
6.1 ABS Resin by Continuous Mass Polymerization Process Flow Diagram E–11
6.2 ABS Resin by Continuous Mass Polymerization Effect of Operating Level and Plant Capacity on Product Value 6–14
6.3 ABS Resin by Continuous Mass Polymerization Effect of Major Raw Material Costs on ABS Product Value 6–15
7.1 SAN Resin by Continuous Mass Polymerization Effect of Operating Level and Plant Capacity on Product Value 7–6
7.2 SAN Resin by Continuous Mass Polymerization Effect of Monomer Unit Prices on SAN Resin Product Value 7–7
7.3 MSA Resin by Continuous Mass Polymerization Process Flow Diagram E–13
7.4 MSA Resin by Continuous Mass Polymerization Effect of Operating Level and Plant Capacity on Product Value 7–10
7.5 MSA Resin by Continuous Mass Polymerization Effect of Monomer Unit Prices on MSA Resin Product Value 7–19
# TABLES

2.1 Polymerization Processes for ABS Resins  
Design Bases and Assumptions 2–4

2.2 Economics of ABS Resins  
Summary of Investment and Production Costs 2–5

2.3 Polymerization Processes for SAN and MSA Resins  
Design Bases and Assumptions 2–6

2.4 Economics of SAN and MSA Resins 2–7

3.1 1993 World Supply and Demand for ABS/SAN Resins 3–6

3.2 U.S. Consumption of ABS Resins 3–7

3.3 U.S. Consumption of SAN Resins 3–7

3.4 Western European Consumption of ABS Resins 3–9

3.5 Japanese Consumption of ABS Resins 3–10

3.6 North American Producers of ABS Resins 3–11

3.7 Western European Producers of ABS Resins 3–13

3.8 Asian Producers of ABS Resins 3–15

3.9 Producers of ABS Resins in Other Regions 3–19

4.1 ABS Resins by Emulsion Polymerization  
Patent Summary A–3

4.2 ABS Resins by Mass or Solution Polymerization  
Patent Summary A–10

4.3 ABS Resins by Emulsion–Mass or Emulsion–Suspension Polymerization  
Patent Summary A–13

4.4 ABS Resins by Mass–Suspension Polymerization  
Patent Summary A–15

4.5 SAN Resins by Mass or Solution Polymerization  
Patent Summary A–16

4.6 SAN Resins by Emulsion Polymerization  
Patent Summary A–18

4.7 SAN Resins by Suspension Polymerization  
Patent Summary A–21

4.8 ABS Resin Compositions  
Patent Summary A–23
### TABLES (Continued)

5.1 ABS Resin by Emulsion Polymerization  
Design Bases and Assumptions 5–2  

5.2 ABS Resin by Emulsion Polymerization  
Stream Flows 5–6  

5.3 ABS Resin by Emulsion Polymerization  
Major Equipment 5–14  

5.4 ABS Resin by Emulsion Polymerization  
Utilities Summary 5–17  

5.5 ABS Resin by Emulsion Polymerization  
Total Capital Investment 5–20  

5.6 ABS Resin by Emulsion Polymerization  
Capital Investment by Section 5–21  

5.7 ABS Resin by Emulsion Polymerization  
Production Costs 5–23  

5.8 ABS Resin by Emulsion Polymerization  
Production Costs for Three ABS Grade 5–27  

5.9 ABS Resin by Emulsion Polymerization  
(Without Butadiene Recovery)  
Total Capital Investment 5–28  

5.10 ABS Resin by Emulsion Polymerization  
(Without Butadiene Recovery)  
Production Costs 5–29  

5.11 ABS Resin by Emulsion Polymerization  
(Without Butadiene Recovery)  
Production Costs for Three ABS Grades 5–31  

6.1 ABS Resin by Continuous Mass Polymerization  
Design Bases and Assumptions 6–2  

6.2 ABS Resin by Continuous Mass Polymerization  
Stream Flows 6–4  

6.3 ABS Resin by Continuous Mass Polymerization  
Major Equipment 6–5  

6.4 ABS Resin by Continuous Mass Polymerization  
Utilities Summary 6–7
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5</td>
<td>ABS Resin by Continuous Mass Polymerization Total Capital Investment</td>
<td>6–10</td>
</tr>
<tr>
<td>6.6</td>
<td>ABS Resin by Continuous Mass Polymerization Capital Investment by Section</td>
<td>6–11</td>
</tr>
<tr>
<td>6.7</td>
<td>ABS Resin by Continuous Mass Polymerization Production Costs</td>
<td>6–12</td>
</tr>
<tr>
<td>6.8</td>
<td>ABS Resin by Emulsion–Mass Polymerization Total Capital Investment</td>
<td>6–16</td>
</tr>
<tr>
<td>6.9</td>
<td>ABS Resin by Emulsion–Mass Polymerization Capital Investment by Section</td>
<td>6–17</td>
</tr>
<tr>
<td>6.10</td>
<td>ABS Resin by Emulsion–Mass Polymerization Production Costs</td>
<td>6–19</td>
</tr>
<tr>
<td>7.1</td>
<td>SAN Resin by Continuous Mass Polymerization Total Capital Investment</td>
<td>7–2</td>
</tr>
<tr>
<td>7.2</td>
<td>SAN Resin by Continuous Mass Polymerization Capital Investment by Section</td>
<td>7–3</td>
</tr>
<tr>
<td>7.3</td>
<td>SAN Resin by Continuous Mass Polymerization Production Costs</td>
<td>7–4</td>
</tr>
<tr>
<td>7.4</td>
<td>Continuous Mass Polymerization Design Bases and Assumptions</td>
<td>7–9</td>
</tr>
<tr>
<td>7.5</td>
<td>MSA Resin by Continuous Mass Polymerization Stream Flows</td>
<td>7–11</td>
</tr>
<tr>
<td>7.6</td>
<td>MSA Resin by Continuous Mass Polymerization Major Equipment</td>
<td>7–12</td>
</tr>
<tr>
<td>7.7</td>
<td>MSA Resin by Continuous Mass Polymerization Utilities Summary</td>
<td>7–13</td>
</tr>
<tr>
<td>7.8</td>
<td>MSA Resin by Continuous Mass Polymerization Total Capital Investment</td>
<td>7–15</td>
</tr>
<tr>
<td>7.9</td>
<td>MSA Resin by Continuous Mass Polymerization Capital Investment by Section</td>
<td>7–16</td>
</tr>
<tr>
<td>7.10</td>
<td>MSA Resin by Continuous Mass Polymerization Production Costs</td>
<td>7–17</td>
</tr>
</tbody>
</table>