

PROCESS ECONOMICS PROGRAM

SRI INTERNATIONAL
Menlo Park, California
94025

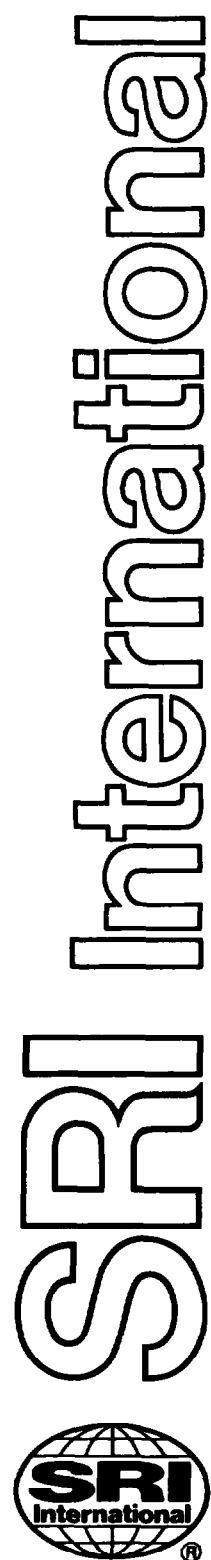
Abstract

Process Economics Program Report No. 83A

ADHESIVES

(January 1986)

This report reviews the technology and summarizes relevant patents relating to anaerobic, cyanoacrylate, epoxy, urethane, pressure sensitive, hot melt (including pressure sensitive hot melt and foamed hot melt), and reactive and "aerobic" acrylic adhesives. The process economics for the production of selected hot melt adhesives and reactive and "aerobic" acrylic adhesives are estimated. Summaries of patents on adhesive tapes, automotive adhesives, building and related adhesives, electronic and electroconductive adhesives, laminating adhesives, metal adhesives, radiation curable adhesives, and water-based adhesives are included.



Report No. 83A

ADHESIVES

SUPPLEMENT A

by **WING SIEN FONG**

January 1986

A private report by the
PROCESS ECONOMICS PROGRAM

Menlo Park, California 94025

For detailed marketing data and information, the reader is referred to one of the SRI programs specializing in marketing research. The CHEMICAL ECONOMICS HANDBOOK Program covers most major chemicals and chemical products produced in the United States and the WORLD PETROCHEMICALS Program covers major hydrocarbons and their derivatives on a worldwide basis. In addition, the SRI DIRECTORY OF CHEMICAL PRODUCERS services provide detailed lists of chemical producers by company, product, and plant for the United States and Western Europe.

CONTENTS

1	INTRODUCTION	1
2	SUMMARY	3
	Technical Aspects	4
	Economics	8
3	INDUSTRY STATUS	11
4	ANAEROBIC ADHESIVES	21
	Chemistry	22
	Formulations	24
	Properties	26
	Uses	27
5	CYANOACRYLATE ADHESIVES	29
	Chemistry	30
	Production of the Alkyl α -Cyanoacrylate	33
	Formulations	33
	Properties	36
	Uses	39
6	EPOXY RESIN ADHESIVES	41
	Chemistry	41
	Formulations	44
	Properties and Uses	47
7	URETHANE ADHESIVES	53
	Chemistry	53
	Formulations	59
	Preparation	62
	Uses	64
8	PRESSURE SENSITIVE ADHESIVES	65
	Formulations	65
	Rubber Based	66
	Acrylics	70
	Silicones	74
	Others	75
	Radiation Curable Pressure Sensitive Adhesives	77

CONTENTS

9	HOT MELT ADHESIVES	79
	Hot Melt Adhesive Formulations	79
	Base Polymers	81
	Tackifiers	86
	Waxes	86
	Plasticizers	86
	Antioxidants	87
	Fillers	87
	Hot Melt Adhesive Processes	87
	Salient Features of Hot Melt Adhesives	90
	Pressure Sensitive Hot Melt Adhesives Formulations	91
	Foamed Hot Melt Adhesives	95
	Hot Melt Adhesives by a Continuous Extrusion Process	98
	Process Description	98
	Process Discussion	101
	Cost Estimates	101
	Hot Melt Adhesives by a Batch Process (Kneader-Extruder and a Kettle)	114
	Process Description	114
	Process Discussion	119
	Cost Estimates	119
10	REACTIVE AND "AEROBIC" ACRYLIC ADHESIVES	127
	Formulations	127
	Application Method	130
	Advantages and Limitations	130
	Process Description	131
	Process Discussion	136
	Cost Estimates	137
	APPENDIX A DESIGN AND COST BASIS	147
	APPENDIX B SOME OF THE PERFORMANCE TESTS FOR ADHESIVES	149
	PATENT SUMMARY TABLES	151
	SUPPLEMENTARY PATENT SUMMARY TABLES	219
	CITED REFERENCES	253
	PATENT REFERENCES	293

ILLUSTRATIONS

9.1	Hot Melt Adhesives by a Continuous Extrusion Process Flow Sheet	307
9.2	EVA-Based Hot Melt Adhesives by a Continuous Extrusion Process	113
9.3	Hot Melt Adhesives by a Batch Process (Kneader-Extruder and Kettle) Flow Sheet	309
10.1	Reactive and "Aerobic" Acrylic Adhesives Production	134

TABLES

2.1	Process Economics for Hot Melt Adhesives, and Reactive and "Aerobic" Acrylic Adhesives	10
3.1	Estimated Adhesives Markets in the United States and Western Europe for 1983	11
3.2	The 1983-1984 Hot Melt Adhesives Market in Great Britain	13
3.3	The 1982 Adhesives Consumption and Adhesives and Sealant Markets in the United States	14
3.4	The 1983 Hot Melt Adhesives Market in the United States	15
3.5	The 1983 Structural and Specialty Adhesives and Sealants Markets in the United States	16
3.6	Predicted Growths for Some Adhesives in the United States	17
3.7	The Percentages of Water-Based, Hot Melt, and Solvent-Based Adhesives Used in Packaging, Nonrigid Bonding, and Tapes in 1983 in the United States	18
3.8	Estimated Production and Demand of Adhesives in Japan . .	20
4.1	Anaerobic Adhesives Patent Summary	153
5.1	Cyanoacrylate Adhesives Patent Summary	161
5.2	Physical Properties of Alkyl Cyanoacrylates	35
5.3	Physical Properties of Some Commercial Cyanoacrylate Adhesives	37
5.4	Bond Strength of Cyanoacrylate Adhesives	40
6.1	Epoxy Resin Adhesives Patent Summary	169
6.2	Effect of Temperature on the Tensile Shear Strength on an Epoxy Resin Adhesive Bond Formed with Various Hardeners	49

TABLES

7.1	Urethane Adhesives Patent Summary	173
8.1	Pressure Sensitive Adhesives Patent Summary	177
8.2	Performance Properties of Rubber-Based, Acrylic-Based, and Silicone-Based Pressure Sensitive Adhesives	73
8.3	Typical Properties and Uses of Silicone Pressure Sensitive Adhesives	76
9.1	Hot Melt Adhesives Based on Copolymers of Ethylene and Vinyl Acetate, Polyamides, Polyesters, Polyolefins, Rubbers, and Other Materials Patent Summary	195
9.2	Hot Melt Pressure Sensitive Adhesives Patent Summary	211
9.3	Hot Melt Adhesives Raw Material Flow Rates	99
9.4	Hot Melt Adhesives by a Continuous Extrusion Process Major Equipment	100
9.5	Hot Melt Adhesives by a Continuous Extrusion Process Utilities Summary	100
9.6	Hot Melt Adhesives by a Continuous Extrusion Process Total Capital Investment	104
9.7	Production of a Hot Melt Adhesive Based on an EVA Copolymer by a Continuous Extrusion Process Production Costs	105
9.8	Production of a Hot Melt Adhesive Based on a Mixture of Two EVA Copolymers by a Continuous Extrusion Process Production Costs	107
9.9	Production of a Hot Melt Adhesive Based on a LDPE by a Continuous Extrusion Process Production Costs	109
9.10	Production of a Hot Melt Adhesive Based on a Styrene Block Copolymer by a Continuous Extrusion Process Production Costs	111

TABLES

9.11	Hot Melt Adhesives by a Batch Process (Kneader-Extruder and Kettle) Formulation and Cycle Time	115
9.12	Hot Melt Adhesives by a Batch Process (Kneader-Extruder and Kettle) Major Equipment	117
9.13	Hot Melt Adhesives by a Batch Process (Kneader-Extruder and Kettle) Utilities Summary	118
9.14	Hot Melt Adhesives by a Batch Process (Kneader-Extruder and Kettle) Total Capital Investment	121
9.15	Combined Production of Two EVA Based Hot Melt Adhesives by a Batch Process (Kneader-Extruder and Kettle) Production Costs	122
9.16	Hot Melt Adhesives by a Batch Process (Kneader-Extruder and Kettle) Production Costs for the Individual Products in the Product Mix	124
9.17	Combined Production of a Styrene Block Copolymer Based and an EVA Based Hot Melt Adhesive by a Batch Process (Kneader-Extruder and Kettle) Production Costs	125
10.1	Reactive and "Aerobic" Acrylic Adhesives Patent Summary	214
10.2	Formulation and Cycle Time for a Reactive Acrylic Adhesive	133
10.3	Reactive and "Aerobic" Acrylic Adhesives Production Major Equipment	135
10.4	Reactive and "Aerobic" Acrylic Adhesives Production Utilities Summary	135
10.5	Reactive and "Aerobic" Acrylic Adhesives Production Total Capital Investment	139
10.6	Production of a Reactive Acrylic Adhesive Production Costs	140

TABLES

10.7	Production of a Heat Resistant Reactive Acrylic Adhesive Production Costs	142
10.8	Production of an "Aerobic" Acrylic Adhesive Production Costs	144
S.1	Adhesive Tapes Summary of Some Recent Patents	221
S.2	Automotive Adhesives Summary of Some Recent Patents	224
S.3	Building and Related Adhesives Summary of Some Recent Patents	227
S.4	Electronic and Electroconductive Adhesives Summary of Some Recent Patents	230
S.5	Laminating Adhesives Summary of Some Recent Patents	235
S.6	Metal Adhesives Summary of Some Recent Patents	239
S.7	Radiation Curable Adhesives Summary of Some Recent Patents	246
S.8	Water-Based Adhesives Summary of Some Recent Patents	249