

Abstract
Process Economics Program Report 15B
VINYL ACETATE/POLYVINYL ACETATE
(January 1996)

Vinyl acetate monomer (VAM) is used primarily to produce polyvinyl acetate (PVAc) homopolymers and copolymers. This report presents preliminary process designs and economics for VAM manufacture by three processes, as well as for VAM emulsion polymerization. The three VAM processes evaluated are the oxyacetylation of ethylene, the reaction of acetic acid with acetylene, and a process based on synthesis gas (syngas). An emulsion polymerization process for the preparation of vinyl acetate homopolymers and copolymers is also evaluated.

This supplementary report reviews the market conditions and important technical progress made regarding VAM since PEP Report 15A *Vinyl Acetate* was issued in 1972. We include a description of the major VAM and PVAc markets and a list of the world's VAM producers, along with their estimated plant capacities. This report will be useful to producers and purchasers of VAM emulsions, as well as to producers of VAM itself.

CONTENTS

1	INTRODUCTION	1-1
2	SUMMARY	2-1
	GENERAL ASPECTS	2-1
	TECHNICAL ASPECTS	2-2
	Vinyl Acetate by Vapor Phase Oxyacetylation of Ethylene	2-2
	Vinyl Acetate from Acetylene	2-2
	Vinyl Acetate from Methanol and Synthesis Gas	2-3
	Polyvinyl Acetate by Emulsion Polymerization	2-3
	ECONOMIC ASPECTS	2-3
3	INDUSTRY STATUS	3-1
	VINYL ACETATE	3-1
	Production	3-1
	Consumption	3-3
	Pricing	3-4
	PVAC	3-6
	Production	3-6
	Consumption	3-6
	Pricing	3-8
4	VINYL ACETATE BY VAPOR PHASE OXYACETYLATION OF ETHYLENE	4-1
	PROCESS REVIEW	4-1
	PROCESS DESCRIPTION	4-2
	Reaction	4-8
	Vapor Recovery	4-8
	Vinyl Acetate Recovery	4-8
	PROCESS DISCUSSION	4-14
	Selection of Design Patent	4-14
	Process Yield	4-14
	Polymerization Inhibition	4-14
	Waste Treatment	4-14
	Carbon Dioxide Recovery	4-15
	Materials of Construction	4-15

CONTENTS (Continued)

4 VINYL ACETATE BY VAPOR PHASE OXYACETYLATION OF ETHYLENE (Concluded)	
CAPITAL AND PRODUCTION COSTS	4-15
DISCUSSION OF CAPITAL COST AND PRODUCT VALUE	4-15
5 VINYL ACETATE FROM ACETYLENE	5-1
PROCESS REVIEW	5-1
PROCESS DESCRIPTION	5-2
Reaction Section	5-4
Recovery Section	5-4
PROCESS DISCUSSION	5-9
Selection of Design Bases	5-9
Process Yield	5-9
Polymerization Inhibition	5-9
Waste Treatment	5-9
Materials of Construction	5-10
CAPITAL AND PRODUCTION COSTS	5-10
DISCUSSION OF CAPITAL COST AND PRODUCT VALUE	5-10
6 VINYL ACETATE BY OTHER PROCESSES	6-1
PROCESS REVIEW	6-1
Vinyl Acetate from Acetaldehyde	6-1
Vinyl Acetate from Methyl Acetate	6-1
Vinyl Acetate from Dimethyl Ether	6-4
PROCESS DESCRIPTION	6-5
Methyl Acetate	6-5
Diacetate	6-7
Vinyl Acetate	6-7
Catalyst	6-8
PROCESS DISCUSSION	6-18
Selection of Design Bases	6-18
Waste Treatment	6-18
CAPITAL AND PRODUCTION COSTS	6-18
DISCUSSION OF CAPITAL COST AND PRODUCT VALUE	6-19

CONTENTS (Concluded)

7 POLYVINYL ACETATE BY EMULSION POLYMERIZATION	7-1
PROCESS REVIEW	7-1
PROCESS DESCRIPTION	7-4
Raw Material Purification	7-5
Polymerization	7-5
PROCESS DISCUSSION	7-11
Selection of Design Bases	7-11
Copolymerization Capability	7-11
Waste Treatment	7-11
CAPITAL AND PRODUCTION COSTS	7-12
DISCUSSION OF CAPITAL COST AND PRODUCT VALUE	7-12
COPOLYMER PRODUCT VALUE	7-12
APPENDIX A: PATENT SUMMARY TABLES	A-1
APPENDIX B: DESIGN AND COST BASES	B-1
APPENDIX C: PRODUCT DATASHEETS	C-1
APPENDIX D: EQUIPMENT SUPPLIERS	D-1
APPENDIX E: CITED REFERENCES	E-1
APPENDIX F: PATENT REFERENCES BY COMPANY	F-1
APPENDIX G: PROCESS FLOW DIAGRAMS	G-1

ILLUSTRATIONS

3.1	VAM Cash Margin Versus Industry Operating Rate	3-5
4.1	VAM Selectivity Versus the Gold/Palladium Ratio	4-3
4.2	VAM Space-Time Yield Versus the Gold/Palladium Ratio	4-4
4.3	Ethylene Acetate By-Product Versus the Gold/Palladium Ratio	4-5
4.4	Predicted Effect of Sodium on Space-Time Yield and Selectivity	4-6
4.5	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Process Flow Diagram	E-3
4.6	Vinyl Acetate Plant Cash Cost Versus Acetic Acid Price	4-17
4.7	Vinyl Acetate Plant Cash Cost Versus Ethylene Price	4-18
5.1	Vinyl Acetate from Acetylene Process Flow Diagram	E-5
5.2	Vinyl Acetate Plant Cash Cost Versus Acetylene Price	5-11
6.1	VAM from Methyl Acetate: Halcon Process	6-3
6.2	Vinyl Acetate via Dimethyl Ether Process Flow Diagram	E-7
6.3	Vinyl Acetate from Methanol and Synthesis Gas Process Flow Diagram	E-9
7.1	Polyvinyl Acetate by Emulsion Polymerization Process Flow Diagram	E-13

TABLES

2.1	Vinyl Acetate Manufacturing Cost Summary	2-5
2.2	Polyvinyl Acetate Manufacturing Cost Summary	2-6
3.1	U.S. Vinyl Acetate Monomer Capacity, Production, and Operating Rate	3-1
3.3	U.S. Vinyl Acetate Monomer Consumption	3-3
3.4	U.S. Vinyl Acetate Monomer List Price and Unit Sales Value	3-4
3.8	1991 PVAc Consumption	3-7
3.2	World Vinyl Acetate Producers as of January 1995	3-9
3.5	North American Polyvinyl Acetate Producers as of January 1995	3-12
3.6	Major Western European Producers of Polyvinyl Acetate Annual Capacity as of January 1992	3-16
3.7	Major Japanese Producers of Polyvinyl Acetate, Mid-1992	3-21
4.2	Vinyl Acetate from Ethylene Design Bases	4-7
4.3	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Stream Flows	4-10
4.4	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Major Equipment	4-11
4.5	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Utilities Summary	4-13
4.6	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Total Capital Investment	4-19
4.7	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Capital Investment by Section	4-20
4.8	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Production Costs	4-21
4.9	Vinyl Acetate by the Vapor Phase Acetoxylation of Ethylene Direct Costs by Section	4-23
5.2	Vinyl Acetate from Acetylene Design Bases	5-3

TABLES (Continued)

5.3	Vinyl Acetate from Acetylene Stream Flows	5-5
5.4	Vinyl Acetate from Acetylene and Acetic Acid Major Equipment	5-6
5.5	Vinyl Acetate from Acetylene and Acetic Acid Utilities Summary	5-8
5.6	Vinyl Acetate from Acetylene and Acetic Acid Total Capital Investment	5-12
5.7	Vinyl Acetate from Acetylene and Acetic Acid Capital Investment by Section	5-13
5.8	Vinyl Acetate from Acetylene and Acetic Acid Production Costs	5-14
5.9	Vinyl Acetate from Acetylene and Acetic Acid Direct Costs by Section	5-16
5.10	Vinyl Acetate Production Cost Comparisons	5-17
6.2	Vinyl Acetate from Methanol and Synthesis Gas Design Bases	6-6
6.3	Vinyl Acetate from Methanol and Acetic Acid Stream Flows	6-9
6.4	Vinyl Acetate from Methanol and Synthesis Gas Stream Flows	6-10
6.5	Vinyl Acetate from Methanol and Acetic Acid Major Equipment	6-12
6.6	Vinyl Acetate from Methanol and Acetic Acid Utilities Summary	6-17
6.7	Vinyl Acetate from Methanol and Acetic Acid Total Capital Investment	6-20
6.8	Vinyl Acetate from Methanol and Acetic Acid Capital Investment by Section	6-21
6.9	Vinyl Acetate from Methanol and Acetic Acid Production Costs	6-23

TABLES (Concluded)

6.10	Vinyl Acetate from Methanol and Acetic Acid Direct Costs by Section	6-25
6.11	Vinyl Acetate Production Cost Comparison	6-26
7.2	Polyvinyl Acetate by Emulsion Polymerization Design Bases	7-5
7.3	Polyvinyl Acetate by Emulsion Polymerization Stream Flows	7-7
7.4	Polyvinyl Acetate by Emulsion Polymerization Major Equipment	7-8
7.5	Polyvinyl Acetate by Emulsion Polymerization Utilities Summary	7-10
7.6	Polyvinyl Acetate by Emulsion Polymerization Total Capital Investment	7-14
7.7	Polyvinyl Acetate by Emulsion Polymerization Capital Investment by Section	7-15
7.8	Polyvinyl Acetate by Emulsion Polymerization Production Costs	7-16
7.9	Polyvinyl Acetate by Emulsion Polymerization Direct Costs by Section	7-18
4.1	Vinyl Acetate from Ethylene Patent Summary	A-3
5.1	Vinyl Acetate from Acetylene Patent Summary	A-16
6.1	Vinyl Acetate by Other Processes Patent Summary	A-19
7.1	Polyvinyl Acetate by Emulsion Polymerization Patent Summary	A-21
C.1	VINAC® XX	C-3
C.2	UCAR®	C-4