

Report No. 70

**ETHYLENE GLYCOLS,
GLYCOL ETHERS
AND ETHANOLAMINES**

by **HAROLD W. SCHEELINE**

August 1971

A private report by the

PROCESS ECONOMICS PROGRAM



STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

CONTENTS

1	INTRODUCTION	1
2	SUMMARY	3
	General Aspects	3
	Economics	5
	Technical Aspects	15
3	INDUSTRY STATUS	19
	Ethylene Glycols	20
	Glycol Ethers	25
	Ethanolamines	30
4	ETHYLENE GLYCOLS BY HYDRATION OF OXIDE	35
	Chemistry	35
	Review of Processes	40
	Process Description	43
	Process Discussion	49
	Cost Estimates	51
	Capital Costs	51
	Production Costs	51
	Changing Plant Operation To Obtain Higher Diglycol Production Ratio	58
5	ETHYLENE GLYCOLS BY CARBONATION PROCESS	61
	Chemistry	61
	Review of Process	62
	Process Description	64
	Process Discussion	70
	Cost Estimates	73
	Capital Costs	73
	Production Costs	73
6	COMBINED ETHYLENE OXIDE--ETHYLENE GLYCOLS ECONOMICS	79
7	ETHYLENE GLYCOL BY OTHER PROCESSES	85

CONTENTS

8	POLYESTER GRADE ETHYLENE GLYCOL	91
	Chemistry	91
	Review of Processes	93
	Process Description	97
	Process Discussion	101
	Cost Estimates	102
	Capital Costs	102
	Purification Costs	102
9	GLYCOL ETHERS	105
	Chemistry	105
	Review of Processes	110
	Process Description	112
	Process Discussion	123
	Cost Estimates	125
	Capital Costs	125
	Production Costs	125
10	ETHANOLAMINES	137
	Chemistry	137
	Review of Processes	141
	Process Description	145
	Process Discussion	151
	Cost Estimates	153
	Capital Costs	153
	Production Costs	153
APPENDIX A	DESIGN AND COST BASIS	161
APPENDIX B	PHYSICAL DATA	165
APPENDIX C	PRODUCT SPECIFICATIONS	169
APPENDIX D	PRODUCT TOXICITY AND HANDLING	171
CITED REFERENCES	175
PATENT REFERENCES BY COMPANY	193

ILLUSTRATIONS

4.1	Ethylene Glycols by Hydration of Oxide	45
4.2	Ethylene Glycols by Hydration of Oxide Effect of Operating Level and Plant Capacity on Production Cost	56
4.3	Ethylene Glycols by Hydration of Oxide Effect of Ethylene Oxide Transfer Price on Production Cost	57
5.1	Ethylene Glycols by Carbonation Process	67
5.2	Ethylene Glycols by Carbonation Process Effect of Operating Level and Plant Capacity on Production Cost	78
8.1	Polyester Grade Ethylene Glycol Purification	99
9.1	Glycol Ethers	117
9.2	Glycol Methyl Ethers Effect of Methanol and Ethylene Oxide Transfer Prices on Production Cost	132
9.3	Glycol Ethyl Ethers Effect of Anhydrous Ethanol and Ethylene Oxide Transfer Prices on Production Cost	133
9.4	Glycol Butyl Ethers Effect of n-Butanol and Ethylene Oxide Transfer Prices on Production Cost	134
10.1	Ethanolamines	147
10.2	Ethanolamines Effect of Operating Level and Plant Capacity on Production Cost	158
10.3	Ethanolamines Effect of Ethylene Oxide Transfer Price on Production Cost	159

TABLES

2.1	Ethylene Glycols and Ethanolamines Summary of Economics	7
2.2	Glycol Ethers Summary of Economics	13
3.1	Plants for Ethylene Glycols in the United States	22
3.2	Plants for Ethylene Glycols in Japan	23
3.3	Production of Ethylene Glycols in the United States	24
3.4	Plants for Glycol Ethers in the United States	27
3.5	Plants for Glycol Ethers and Ethanolamines in Japan	28
3.6	Production of Glycol Ethers in the United States	29
3.7	Plants for Ethanolamines in the United States	31
3.8	Production of Ethanolamines in the United States	32
4.1	Ethylene Glycols by Hydration of Oxide Patent Summary	42
4.2	Ethylene Glycols by Hydration of Oxide Major Process Equipment and Utilities Summary	45
4.3	Ethylene Glycols by Hydration of Oxide Stream Flows	48
4.4	Ethylene Glycols by Hydration of Oxide Total Capital Investment	54
4.5	Ethylene Glycols by Hydration of Oxide Production Costs	55
5.1	Ethylene Glycols by Carbonation Process Major Process Equipment and Utilities Summary	67
5.2	Ethylene Glycols by Carbonation Process Stream Flows	69
5.3	Ethylene Glycols by Carbonation Process Total Capital Investment	76
5.4	Ethylene Glycols by Carbonation Process Production Costs	77
6.1	Combined Ethylene Oxide-Ethylene Glycol Units Capital Investments	82

TABLES

6.2	Combined Ethylene Oxide--Ethylene Glycols Units Production Costs	83
8.1	Ethylene Glycol Specifications	92
8.2	Polyester Grade Ethylene Glycol Purification Patent Summary	95
8.3	Polyester Grade Ethylene Glycol Purification Major Process Equipment and Utilities Summary	99
8.4	Polyester Grade Ethylene Glycol Purification Total Capital Investment	103
8.5	Polyester Grade Ethylene Glycol Purification Production Costs	104
9.1	Theoretical Requirements of Alcohols and Ethylene Oxide for Various Glycol Ethers	108
9.2	Glycol Ethers Operating Temperatures and Pressures for Design Case . . .	117
9.3	Glycol Ethers Major Process Equipment and Utilities Summary	120
9.4	Glycol Ethers Stream Flows	121
9.5	Glycol Ethers Total Capital Investment	128
9.6	Glycol Methyl Ethers Production Costs	129
9.7	Glycol Ethyl Ethers Production Costs	130
9.8	Glycol Butyl Ethers Production Costs	131
9.9	Feed Requirements and Costs of Individual Glycol Ethers .	135
10.1	Ethanolamine Manufacture Patent Summary	143
10.2	Ethanolamines Major Process Equipment and Utilities Summary	147

TABLES

10.3	Ethanolamines	
	Stream Flows	149
10.4	Ethanolamines	
	Total Capital Investment	156
10.5	Ethanolamines	
	Production Costs	157
B.1	Ethylene Glycols Physical Data	165
B.2	Ethylene Carbonate Physical Data	166
B.3	Glycol Ethers Physical Data	166
B.4	Ethanolamines Physical Data	167
C.1	Ethylene Glycols Specifications	169
C.2	Glycol Ethers Specifications	169
C.3	Ethanolamines Specifications	170