

การเพิ่มความเข้มข้นสารละลายของน้ำเสียจากโรงงานสับปรด
กระป๋องโดยกระบวนการอัลตราฟิลเตรชันและรีเวอร์สออสโมซิส



นางสาวฉล่องศรี วานิชกร

005631

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญา วิทยาศาสตร์มหาบัณฑิต

ภาควิชาเคมีเทคนิค

บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

พ.ศ. 2525

ISBN 974-561-494-7

Concentrating of Pineapple Cannery Liquid Waste
by Ultrafiltration and Reverse Osmosis System

Miss Chalongsri Warnitchakorn

A thesis submitted in partial fulfillment of the requirements

for the Degree of Master of Science

Department of Chemical Technology

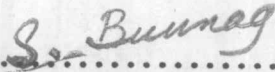
Graduate School

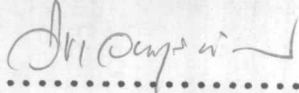
Chulalongkorn University

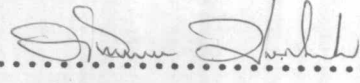
1982

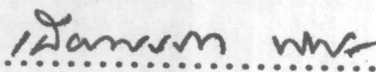
Thesis Title : Concentrating of Pineapple Cannery Liquid Waste
by Ultrafiltration and Reverse Osmosis System
Name : Miss Chalongsri Warnitchakorn
Department : Chemical Technology
Thesis Advisor : Assist. Prof. Sakarindr Bhumiratana

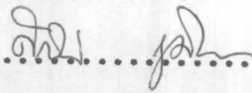
Accepted by the Graduate School, Chulalongkorn University in Partial
fulfillment of the requirements for the Master's Degree.


.....Dean of Graduate School
(Associate Professor Supradit Bunnag, Ph.D.)


.....Chairman
(Associate Professor Vicha Vanadurongwan Docteur de
Specialite)


.....Member
(Pattarapan Prasassarakich, Ph.D.)


..... Co-advisor
(Pienpak Tasakorn, Ph.D.)


.....Advisor
(Assistant Professor Sakarindr Bhumiratana, Ph.D.)

Copyright of the Graduate School, Chulalongkorn University.

หัวข้อวิทยานิพนธ์	การเพิ่มความเข้มข้นสารละลายของน้ำเสียจากโรงงานสับปรด กระป๋องโดยกระบวนการอัลตราฟิเตรชันและรีเวอร์สออสโมซิส
ชื่อนิสิต	นางสาวดวงศรี วานิชกร
ภาควิชา	เคมีเทคนิค
อาจารย์ที่ปรึกษา	ผู้ช่วยศาสตราจารย์ ดร. ศักรินทร์ มุมิรัตน์
ปีการศึกษา	2525

บทคัดย่อ



ศึกษาการแยกน้ำตาลและโปรตีนจากน้ำเสียจากโรงงานสับปรดกระป๋องโดยใช้ระบบอัลตราฟิเตรชันและรีเวอร์สออสโมซิส ซึ่งเป็นวิธีการที่สามารถแก้ปัญหาที่ทิ้งและนำสิ่งที่มีประโยชน์กลับมาใช้ใหม่

ในการทดลองนี้ใช้น้ำเสียจากโรงงาน 2 ประเภท คือ จากน้ำเสียโดยตรงซึ่งมีความเข้มข้น 0.5 ถึง 1.0 บริกส์ และน้ำที่บีบมาจากเปลือกสับปรดความเข้มข้นประมาณ 5-7 บริกส์ โดยผ่านระบบอัลตราฟิเตรชันก่อน แล้วจึงนำน้ำใสผ่านเข้าระบบรีเวอร์สออสโมซิสจนได้ความเข้มข้นสูงสุดประมาณ 25 บริกส์

ตัวแปรที่ใช้ในการทดลองได้แก่ ความเข้มข้นเริ่มต้นของน้ำเสีย, ชนิดของแผ่นเยื่อสังเคราะห์ของอัลตราฟิเตรชัน ความดัน และ pH ซึ่งจากการทดลองพบว่าในระบบรีเวอร์สออสโมซิส อัตราการคั่งน้ำออก แปรผันตามความดันและแปรผกผันกับ pH และความเข้มข้นของสารละลายเริ่มต้น สำหรับระบบอัลตราฟิเตรชัน อัตราการคั่งน้ำใสออกจะแปรผันตามความดันและอุณหภูมิ ในขณะที่แผ่นเยื่อสังเคราะห์ชนิด ที่ 6/ปี ให้อัตราการคั่งน้ำใสได้ดีกว่าชนิด ที่ 2/เอ

จากผลการทดลองนี้ทำให้เราเชื่อมั่นว่า เทคโนโลยีแผ่นเยื่อสังเคราะห์นั้นจะสามารถนำมาประยุกต์กับน้ำทิ้งจากโรงงานประเภทอื่น ๆ ได้เช่นกัน

Thesis Title : Concentrating of Pineapple Cannery Liquid
Waste by Ultrafiltration and Reverse Osmosis System
Name : Miss Chalongsri Warnitchakorn
Department : Chemical Technology
Thesis Advisor : Assistant Professor Sakarindr Bhumiratana
Academic Year : 1982

ABSTRACT

Ultrafiltration and Reverse Osmosis have been used in concentrating pineapple cannery liquid waste. This method can solve water pollution problems and at the same time recover valuable materials such as sugar and protein from the liquid waste.

Two types of liquid waste were used in this experiment, liquid waste directly from the plant and the liquid squeezed from solid waste. The liquid waste were passed through the ultrafiltration system; the permeate collected was then passed through reverse osmosis system. The maximum achievable concentration of the retentate was approximately was 25 Brix.

The variables studied in the experiments are initial concentration of feed, type of membrane, pressure, temperature, and pH. The reverse osmosis permeate flux increases with increasing pressure but decreases with increasing initial concentration and pH. For ultrafiltration, permeate flux increases with increasing pressure and temperature while membrane type T6/B gave higher permeate flux than membrane type T2/A.

It was concluded that ultrafiltration and reverse osmosis processes are an effective system for concentrating liquid waste for further utilization.



Acknowledgement

The author wishes to express sincere thanks to her advisor, Assistant Professor Dr. Sakarindr Bhumiratana for his advice, encouragement, patience, and helpful criticism. She is grateful to the approval committee, particularly to Dr. Pienpak Tasakorn, Associate Professor Vicha Vanadurongwan and Dr. Pattarapan Prasassarakich for their useful suggestions and comments.

Thanks also are extended to Dr. Ratana Putranon and to the technicians of the Department of Chemical Engineering, Faculty of Engineering, KMIT for their help with the equipment.

The gratitude is extended to the management and personnel of Siam Food Company Limited for their assistance of all kinds in the running of the experiments.

Above all she would like to thank Mr. Boonruk Chipipop for his encouragement and unceasing help toward the completion of this thesis.

CONTENTS

	Page
THAI ABSTRACT	IV
ENGLISH ABSTRACT	V
ACKNOWLEDGEMENT	VII
LIST OF TABLES	
LIST OF FIGURES	
CHAPTER	
I. INTRODUCTION	1
1.1 Reverse Osmosis and Ultrafiltration	2
1.2 Purpose of this work	3
1.3 Working programmes	4
1.4 Characteristics of pineapple cannery waste	4
II. THEORY	
2.1 Reverse Osmosis	14
2.1.1 Membrane types	15
2.1.2 Module designs	18
2.1.3 Solute and solvent transport relationships ..	23
2.1.4 Membrane fouling, deterioration pretreatment	29
2.2 Ultrafiltration	33
2.2.1 Definition	33
2.2.2 Typical characteristics	34
2.2.3 UF membrane	34
2.2.4 Concentration polarization and UF theory	38
2.2.5 System design	47
2.2.6 Factors affecting membrane performance and service life	53



III. LITERATURE SURVEYS

3.1.5	Reverse Osmosis	58
3.1.1	Reverse osmosis for treatment of hard water .	58
3.1.2	Reverse osmosis for production of ultrapure water	63
3.1.3	Reverse osmosis for treatment of plating waste	64
3.1.4	Reverse osmosis for treatment of sewage water	66
3.1.5	Reverse osmosis for treatment of waste waters from the pulp and paper industry	68
3.1.6	Reverse osmosis for treatment of whey	69
3.1.7	Reverse osmosis for treatment of skim milk ..	70
3.1.8	Reverse osmosis for treatment of egg white ..	71
3.1.9	Juice concentration by reverse osmosis	71
3.2	Ultrafiltration	76
3.2.1	Ultrafiltration in sewage treatment systems .	76
3.2.2	Ultrafiltration in electropainting	80
3.2.3	Ultrafiltration applications in recovery of protein from cheese whey	83
3.2.4	Ultrafiltration in concentration of milk	87
3.2.5	Ultrafiltration in the concentration of egg white	88
3.2.6	Ultrafiltration in concentration of gelatin and glue	90
3.2.7	Ultrafiltration in treatment of animal blood .	92
3.2.8	Ultrafiltration in sugar processing	96

IV. EXPERIMENTAL EQUIPMENTS

4.1 Ultrafiltration 98

4.2 Ultrafiltration membranes 105

4.3 Reverse osmosis 108

4.4 Reverse osmosis membranes 115

4.5 Module details 118

V. EXPERIMENTAL CONSIDERATION

5.1 Experimental variables 119

5.2 Experimental procedure

5.2.1 Reverse osmosis plant 120

5.2.2 Ultrafiltration plant 123

VI. EXPERIMENTAL RESULTS

6.1 Pure water permeation study on reverse osmosis system 124

6.2 Treatment of reverse osmosis on sugar solution 126

6.3 Liquid waste study on Reverse osmosis system 130

6.4 Liquid waste study on Ultrafiltration and Reverse osmosis 138

6.5 Liquid waste study on Ultrafiltration and Reverse osmosis system with membrane T6/B. 145

6.6 Liquid waste study on Ultrafiltration 156

6.7 Liquid from solid waste study on Ultrafiltration system 159

6.8 Liquid from solid waste study on Reverse osmosis system 162

6.9 Liquid from solid waste study on Ultrafiltration and Reverse osmosis system 166

	Page
6.10 Effect of pH on Reverse osmosis system	172
6.11 Energy requirement	176
VII. DISCUSSIONS AND CONCLUSIONS	
Discussions	
7.1 Pure water permeability	178
7.2 Pressure variation of flux	179
7.3 Variation of flux with increasing concentration	180
7.4 Variation of flux with increasing feed pH	181
7.5 Rejection characteristics.....	182
7.6 Ultrafiltration system	182
7.7 Energy concentration	183
Conclusions	184
Suggestions	185
REFERENCES	186
APPENDICES	188
VITA	199

LIST OF TABLES

	Page
Table 1.1 Analysis of pineapple cannery liquid waste	6
Table 1.2 Effect of variation in seasons on pineapple constituents	7
Table 1.3 Chemical compositions and vitamins of pineapple fruit	8
Table 1.4 Analysis of juice squeeze from pineapple shell ...	9
Table 2.1 RO module designs	19
Table 2.2 Membrane configuration, packing density and flux density	21
Table 2.3 Mass transfer correlations for use in equation 2.19 for various hydrodynamic conditions	45
Table 3.1 Separation of calcium and magnesium ions in aqueous solution	60
Table 3.2 Separation of iron, manganese, strontium and aluminium ions in aqueous solution	60
Table 3.3 Softening of natural hard waters	62
Table 3.4 Results of repeated reverse osmosis operation	64
Table 3.5 Separation of some salts present in plating wastes	65
Table 3.6 Reverse osmosis for sewage water treatment	67
Table 3.7 Reverse osmosis for treatment of paper mill waste waters	69
Table 3.8 Measured properties of the feed juices	72
Table 3.9 Experimental osmotic pressure and permeation rate coefficients of orange juice and a cellulose acetate membrane	74
Table 3.10 Details of some UF membranes	79
Table 3.11 Composition of cheese whey	84
Table 3.12 Ultrafiltration of cottage cheese whey	85

	Page
Table 3.13 Gross chemical composition of liquid egg white	90
Table 6.1-6.10 Experimental results	125
Table 7.1 Osmotic pressure and resistant values	180
Table A.1 Analysis of permeate from RO plant	189
Table A.2 Analysis of concentrate from RO	189
Table A.3 Analysis of concentrate from UF	190
Table A.4 Analysis of pineapple juice	190
Table A.5 Proximate analysis of Hawaiian beverage pineapple juice	191
Table A.6 Osmotic pressure of aqueous sucrose solutions	192

Figure 1.1	Flow chart of pineapple cannery.....	10
Figure 1.2	Process lines of pineapple cannery plant	11
Figure 1.3	Pineapple cannery liquid waste from the plant about 2-3,000 m ³ /day	11
Figure 1.4	Peeling and coring machine (GINACA)	12
Figure 1.5	Squeezer	12
Figure 1.6	Crusher	13
Figure 1.7	Pineapple shells before and after crushing	13
Figure 2.1	Spiral-wound membrane modules partially inrolled	21
Figure 2.2	Schematic of molecular fractionation by UF membranes	34
Figure 2.3	Idealised anisotropic UF membrane	35
Figure 2.4	Pore diameter vs. relative frequency for Amicon XM- 100	36
Figure 2.5	Relationship between rejection ($\bar{\alpha}$) and MW (M)	37
Figure 2.6	Pre-gel polarisation	39
Figure 2.7	Gel-polarisation	39
Figure 2.8-2.9	Two schemes for batch concentration of UF	50
Figure 2.10	Batch volume vs. time	50
Figure 2.11	Parallel flow	51
Figure 2.12	Series flow equal sized stages	51
Figure 2.13	Flux-time plot of water	54
Figure 2.14	Decay of ultrafiltration flux with time	55
Figure 2.15	Flux-concentration plot for wheat starch	57
Figure 3.1	Effect of pressure on membrane performance for reverse osmosis water softening	58
Figure 3.2	Channel and circulation system	74

Figure 3.3	Permeation rate through cellulose acetate membrane from orange juice	74
Figure 3.4	Typical permeation rates for a new cellulose acetate membrane	75
Figure 3.5	Sewage treatment	78
Figure 3.6	Electroceat flowsheet	82
Figure 3.7	Operating costs for concentrating whey by-products	85
Figure 3.8	Equipment costs for concentrating whey by-products	86
Figure 3.9	Cocentration of whey with PM-10 membrane	86
Figure 3.10	Concentration of skim milk proteins with PM-30 membrane	88
Figure 3.11	Concentration of egg albumen	90
Figure 3.12	Concentration of gelatin with PM-30 membrane at 70°C	92
Figure 3.13	Effect of fluid shear rate on ultrafiltration rate	94
Figure 3.14	Effect of concentration on the ultrafiltration rates of human blood plasma	94
Figure 3.15	Concentration of bovine serum in TC-20 with PM-30 membrane	95
Figure 3.16	Separation of whole blood into red cells and plasma with diapore 0.6 filter	95
Figure 4.1	18-tube module	101
Figure 4.2	Ultrafiltration plant (front view)	102
Figure 4.3	Ultrafiltration plant (profile view)	103
Figure 4.4	Ultrafiltration system	104
Figure 4.5	Ultrafiltration plant	104
Figure 4.6	Reverse osmosis plant (front view)	111
Figure 4.7	Ultrafiltration and reverse osmosis system	112

	Page
Figure 4.8 Reverse osmosis system	112
Figure 4.9 Back view of reverse osmosis plant	113
Figure 4.10 Front view of reverse osmosis plant	113
Figure 4.11 UF & RO tubular module	114
Figure 4.12 Tubular module in parts	114
Figure 5.1 Ultrafiltration - reverse osmosis system	123
Figure 6.1-6.15 Experimental results	129
Figure B.1 Flow rate vs. pressure drop	195
Figure B.2 Graphical integration	196