

UNIVERSITI TEKNOLOGI MARA

**WASTE COOKING OIL BASED
EMULSION LIQUID MEMBRANE
FOR ZINC EXTRACTION FROM
AQUEOUS SOLUTION**

AFIQAH TASNEEM BINTI ABD KHALIL

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science
(Chemical Engineering)

College of Engineering

August 2022

ABSTRACT

Zinc was identified as one of the most toxic heavy metals and often found contaminating the water sources as a result of inefficient treatment of industrial effluent. In this work, Emulsion Liquid Membrane (ELM) was proposed as a method to minimize the concentration of zinc ions in an aqueous solution. Instead of the common petroleum-based diluent, the emulsion is reformulated with waste cooking oil (WCO) which was collected from the food sector as a sustainable and cost-effective diluent. The formulation also includes Bis(2-ethylhexyl) phosphate (D2EHPA) as carrier, Span 80 as surfactant, sulfuric acid (H_2SO_4) as internal phase while zinc sulfate ($ZnSO_4$) solution was used as the external phase. The WCO characterization and emulsion formation studies were first carried out by utilizing an electronic rheometer, microscope and FTIR analysis. The liquid-liquid extraction (LLE) method was then used to confirm the compatibility of WCO with D2EHPA for the extraction of zinc ions from the external phase, as well as to investigate the extraction equilibria of zinc extraction in ELM and the external phase pH. To obtain the best-operating conditions for zinc extraction using the newly formulated ELM, the extraction time and speed, carrier, surfactant and internal phase concentrations, and W/O ratio were varied. 95.17% of zinc ions were removed under the following conditions; 0.001M of H_2SO_4 in external phase, 700 rpm extraction speed for 10 minutes, 8 wt% of carrier and 4 wt% of surfactant concentrations, 1:4 of W/O ratio and 1 M of internal phase concentration. The use of WCO was proven as the alternative green diluent in ELM method substituting the toxic petroleum-based diluents. The findings of this study shall serve as a milestone in the development of a safer technology to treat heavy metal ions from aqueous solutions.

ACKNOWLEDGEMENT

First and foremost, I would like to express gratitude to Allah, Lord of the World who has granted me the opportunity to further my study in Master of Science and the strength to finally complete my research.

Special thanks to my supervisors, Dr Wahidah Binti Puasa and Prof Ir Dr Abd Latif Ahmad who have supported me in their best way to ease my journey. My utmost gratitude is to Mr Meor Muhammad Hafiz Bin Shah Buddin who has been relentlessly guiding me with patience despite all the setbacks and failures along the way.

My appreciation goes to my parents and sister for their unwavering faith in me throughout all my study phases. Thank you for being my biggest supporters and best friends who have always been there. May Allah bestow all of you with the best rewards possible.

Finally, greatest love for myself for not giving up and staying strong no matter what life has thrown at her.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xiii
LIST OF ABBREVIATIONS	xv
LIST OF NOMENCLATURE	xvii
CHAPTER ONE INTRODUCTION	1
1.1 Research Background	1
1.2 Problem Statement	3
1.3 Objectives	6
1.4 Scope and Limitation of Research	6
1.5 Significance of Research	7
CHAPTER TWO LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Liquid Membrane Configurations	8
2.2.1 Bulk Liquid Membrane	11
2.2.2 Supported Liquid Membrane	11
2.2.3 Emulsion Liquid Membrane	12
2.3 ELM Formulation	13
2.3.1 Internal phase	15
2.3.2 Membrane phase	15

2.3.3	Carrier	16
2.3.4	Surfactant	17
2.3.5	Diluent	19
2.4	Green Diluent in ELM	21
2.4.1	Characteristics of Vegetable Oils as Diluent in ELM	24
2.4.2	Palm Waste Cooking Oil as Green Diluent	26
2.5	Transport Mechanism in Liquid Membrane	30
2.5.1	Simple Transport	31
2.5.2	Facilitated Transport	32
2.6	Extraction Equilibria	34
CHAPTER THREE METHODOLOGY		37
3.1	Research Flowchart	37
3.2	Chemicals	39
3.3	Diluent Compatibility Study	39
3.4	Waste Cooking Oil (WCO) Characterization Study	40
3.5	Performance Evaluation of ELM	40
3.5.1	Surfactant Compatibility Study	41
3.5.2	Water-Oil (W/O) Emulsion Preparation	42
3.5.3	Zinc Extraction using ELM	42
3.5.4	Determination of Zinc Extraction Efficiency	43
CHAPTER FOUR RESULTS AND DISCUSSION		44
4.1	WCO Characteristics and Emulsion Formation	44
4.1.1	Surfactant Compatibility	46
4.2	Interactions of Component in ELM	47
4.2.1	Liquid-liquid Extraction	50
4.2	ELM for Zinc Extraction	54
4.2.1	Effect of extraction time and speed	55
4.2.2	Effect of carrier concentration	58
4.2.3	Effect of surfactant concentration	60
4.2.4	Effect of water-oil (W/O) ratio	63