

**UNIVERSITI TEKNOLOGI MARA**

**PREPARATION AND  
CHARACTERIZATION OF MICRO  
BEARING  
FROM  
EPOXY FILLED  
UHMWPE  
POLYMER COMPOSITE**

**AHMAD AIZUDDIN BIN ARIFFIN**

Thesis submitted in fulfillment  
of the requirements for the degree of  
**Master of Science**  
**(Polymer Science and Technology)**

**Faculty of Applied Sciences**

**August 2022**

## ABSTRACT

Significance modification of polymer composite to the conventional ways involving metal, ceramic and polymer alone gave effective solution to obtain the desired properties especially on the application related to alternative bearing surfaces. The limitations on the bearing materials which are relatively too hard, that can cause high wear rate or relatively too soft, which can cause pitting and failure in repeated cycle. Thus, this research project focuses on the objectives of improvising the limitations of the existing physical and tribological properties of existing application by the introduction of a new micro bearing concept of polymer composite. The usage of Ultra High Molecular Weight Polyethylene (UHMWPE) as the particulate filler into the epoxy resin where the density and low wear rate of UHMWPE and high physical encapsulation of epoxy matrix are exploited for the micro bearing concept. The presence of acetone as diluent on the formation of the layer can be supported by the theory of particulate fillers in suspensions according to Modified Mooney-Einstein's Theory of Viscosity. In short, micro-bearing concept, which can be called as solid lubricant, is a type of material that can provide the lubrication or minimizing the abrasion without the usage of lubricating agent such as wax, grease or oil. For the study of the formation of micro bearing layer, reliable testings in term of surface topography and morphology were conducted by varying the acetone ratio of 1:1/4, 1:1/3, 1:1/2 and 1:1 to the high viscosity resin. For the study on the physical and tribological properties of the micro bearing concept, the selected acetone ratio from the previous study will be used as the control parameter while varying filler loadings percentage of 1%, 3%, 5%, 7% and 10%, accordingly. The surface topography and morphology were tested using Alicona Infinite Focus and Polarised Optical Microscope to determine the surface profile measurement. Based on the results observed, EpUPE3 (epoxy and UHMWPE with acetone ratio of 1:1/2) showed better surface distribution and morphology with relatively low value of surface roughness (Ra) which is 1.41  $\mu\text{m}$  and low pseudocolour value of surface height which is around 6.76-6.77 cm compared to other formulation ratio. While for the tribological and physical properties, the respective tests involved are wear abrasion test, viscosity test, hardness test, density test, FTIR test and water absorption test. Based on the results obtained, there were increment up to 41.7% for viscosity value. For the wear test, the results showed decrease in the wear rate up to 72.0%. For the hardness test, the results indicate increment in the hardness value up to 94% compared to UHMWPE alone. For the density test, the results showed decrease in the density value up to 3.8%. The relation between physical to mechanical properties had been achieved whereas the density plays the important role that altered the distribution of micro-bearing UHMWPE to be deposited on the surface which influenced the tribological behavior of the polymer composite. The characterization in term of physical and mechanical properties for polymer composites were analyzed in term of the polymer rheology which involve the filler-filler interaction and filler-matrix interaction. The outcomes of this study can be used as a parameter to for future works improve the bearing surfaces material involving polymer composite in solid lubricant applications due to the simple fabrication process and yield balanced in the bearing properties.

## **ACKNOWLEDGEMENT**

First and foremost, I want to express my sincere gratitude to my supervisor, Dr Ahmad Zafir bin Romli and to my co-supervisor, Dr Nik Noor Idayu binti Nik Ibrahim for their endless support and encouragement. They inspired me with their valuable guidance and constant supervision as well as providing necessary information for me to complete this research. I also would like to thank them for their time to guide me all the way for this research.

Moreover, I would like to give special thanks to my friends for their guidance and willing to help me in getting the information, sharing knowledge and give moral support throughout this research. My appreciation goes to the staff and colleagues at Polymer Composite Research Lab (PocResT) who provided facilities and assistance during the period project. Without them, the research would never be in quality of outcomes, and thus their supports have been essential.

Last but not least, I would like to express my appreciation to my parents, Ariffin bin Jamaludin and Nor Asiah binti Md Husin for their understanding and encouragement which help me to complete the research, accordingly.

# TABLE OF CONTENTS

	<b>Page</b>
<b>CONFIRMATION BY PANEL OF EXAMINERS</b>	<b>ii</b>
<b>AUTHOR'S DECLARATION</b>	<b>iii</b>
<b>ABSTRACT</b>	<b>iv</b>
<b>ACKNOWLEDGEMENT</b>	<b>v</b>
<b>TABLE OF CONTENTS</b>	<b>vi</b>
<b>LIST OF TABLES</b>	<b>ix</b>
<b>LIST OF FIGURES</b>	<b>x</b>
<b>LIST OF PLATES</b>	<b>xii</b>
<b>LIST OF SYMBOLS</b>	<b>xiv</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xv</b>
<b>LIST OF NOMENCLATURE</b>	<b>xvi</b>
<b>CHAPTER ONE INTRODUCTION</b>	<b>1</b>
1.1 Research Background	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Significance of Study	4
1.5 Scope of Study	4
<b>CHAPTER TWO LITERATURE REVIEW</b>	<b>5</b>
2.1 Introduction to Bearing and Solid Lubricant	5
2.1.1 Bearings	5
2.1.2 Solid Lubricants	6
2.1.3 Micro bearing concept as solid lubricant	8
2.2 Fundamentals of UHMWPE (Ultra-high-molecular-weight polyethylene)	11
2.2.1 Applications of UHMWPE	14
2.2.2 Challenges for UHMWPE	17
2.3 Fundamentals of polymer composites	18
2.3.1 Matrix Phase	20

2.3.2	Particulate Fillers	22
2.4	Principle of Testing	23
2.4.1	Viscosity test	24
2.4.2	Surface profile measurement	25
2.4.3	Wear test	27
2.4.4	Hardness test	30
2.4.5	Density test	33
2.4.6	Water absorption test	35
<b>CHAPTER THREE RESEARCH METHODOLOGY</b>		<b>37</b>
3.1	Introduction	37
3.2	List of materials	38
3.3	Fabrication process	40
3.3.1	Preliminary study on the optimisation of fabrication process by varying acetone ratio	40
3.3.2	Fabrication process by varying acetone ratio	42
3.3.3	Preliminary study on the optimisation of fabrication process by varying filler loadings	44
3.3.4	Fabrication process by varying the filler loadings	46
3.4	Experimental testing	48
3.4.1	Viscosity test	48
3.4.2	Surface profile measurements	50
3.4.3	Optical microscopy measurements	51
3.4.4	Scanning electron microscopy measurements	52
3.4.5	FTIR analysis	53
3.4.6	Wear test	53
3.4.7	Hardness test	54
3.4.8	Density test	55
3.4.9	Water absorption test	56
<b>CHAPTER FOUR RESULTS AND DISCUSSIONS</b>		<b>57</b>
4.1	Introduction	57
4.2	Discussions on the optimization method of fabrication process	57