

**BIODEGRADATION OF PALM-BASED POLYURETHANE  
FILLED WITH CELLULOSE BY USING *Bacillus subtilis***

**HANIS AHMAD**

**BACHELOR OF SCIENCE (Hons.) CHEMISTRY  
FACULTY OF APPLIED SCIENCES  
UNIVERSITI TEKNOLOGI MARA**

**JULY 2016**

This final Year Project Report entitled “**Biodegradation of Palm-based Polyurethane Filled with Cellulose by Using *Bacillus subtilis***” was submitted by Hanis Ahmad, in partial fulfilment of the requirements for the Degree of Bachelor of Science (Hons.) Chemistry, in the Faculty of Applied Sciences and was approved by

---

Jamil Mohamed Sapari  
Supervisor  
B. Sc. (Hons.) Chemistry  
Faculty of Applied Sciences  
Universiti Teknologi MARA  
Kuala Pilah Campus  
72000 Kuala Pilah Negeri Sembilan

---

Mohd Zaini Nawahwi  
Co-supervisor  
B. Sc. (Hons.) Biology  
Faculty of Applied Sciences  
Universiti Teknologi MARA  
Kuala Pilah Campus  
72000 Kuala Pilah Negeri Sembilan

---

Dr. Sheikh Ahmad Izaddin Sheikh  
Mohd Ghazali  
Project Coordinator  
B. Sc. (Hons.) Chemistry  
Faculty of Applied Sciences  
Universiti Teknologi MARA  
Kuala Pilah Campus  
72000 Kuala Pilah Negeri Sembilan

---

Mazni Musa  
Head of Programme  
B. Sc. (Hons.) Chemistry  
Faculty of Applied Sciences  
Universiti Teknologi MARA  
Kuala Pilah Campus  
72000 Kuala Pilah Negeri Sembilan

Date: \_\_\_\_\_

## TABLE OF CONTENTS

	<b>Page</b>
<b>ACKNOWLEDGEMENTS</b>	iii
<b>TABLE OF CONTENTS</b>	iv
<b>LIST OF TABLES</b>	vi
<b>LIST OF FIGURES</b>	vii
<b>ABBREVIATIONS</b>	viii
<b>ABSTRACT</b>	x
<b>ABSTRAK</b>	xi
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Background of study	1
1.2 Problem statement	5
1.3 Significance of study	6
1.4 Objectives of the study	6
<b>CHAPTER 2 LITERATURE REVIEW</b>	<b>7</b>
2.1 Synthesis of polyurethane	7
2.1.1 Petroleum-based polyurethane	7
2.1.2 Palm-based polyurethane	8
2.1.3 Polyurethane from castor oil polyol	10
2.1.4 Polyurethane from soybean oil polyol	10
2.1.5 Polyurethane from waste cooking oil polyol	11
2.2 Polyurethane with Filler	11
2.2.1 Cellulose	11
2.2.2 Other Filler	12
2.3 PU Degradation	13
2.3.1 Degradation of PU by Bacteria	13
2.3.2 Degradation of PU by Fungus	14
2.3.3 Biodegradation of PU with Filler	14
<b>CHAPTER 3 METHODOLOGY</b>	<b>16</b>
3.1 Materials	16
3.2 Chemicals	16
3.3 Apparatus	17
3.4 Methods	17
3.4.1 Preparation of polyurethane palm-based polyol with cellulose derivatives	17
3.4.2 Characterization and test	18
3.4.3 Degradation of polyurethane filled with cellulose	20

<b>CHAPTER 4 RESULTS AND DISCUSSION</b>	24
4.1 Preparation of PU-CEL	24
4.2 Media and bacteria culture	26
4.3 Carbon dioxide (CO <sub>2</sub> ) test	28
4.4 Morphology analysis	29
4.5 Weight loss analysis	32
4.6 Fourier transform infrared (FTIR) analysis	35
<b>CHAPTER 5 CONCLUSION AND RECOMMENDATIONS</b>	40
5.1 Conclusion	40
5.2 Recommendations	41
<b>CITED REFERENCES</b>	42
<b>APPENDIX A</b>	47
<b>APPENDIX B</b>	50
<b>PUBLICATION</b>	54
<b>AWARD</b>	55
<b><i>CURRICULUM VITAE</i></b>	56

## ABSTRACT

### **BIODEGRADATION OF PALM-BASED POLYURETHANE FILLED WITH CELLULOSE BY USING *Bacillus subtilis***

The degradation ability of *Bacillus subtilis* to degrade Palm-based polyurethane foam filled with cellulose (PU-CEL) was evaluated by reacting monoester-OH from palm-kernel oil and isocyanate with ratio 1:1. Addition of microcrystalline cellulose in PU systems was at 0 %, 20 % and 40 % by weight, mixed using the mechanical stirrer. Rate of biodegradation of PU-CEL foam was measured by calculation of weight loss and FTIR analysis. The weight loss of PU-CEL of 0 %, 20 % and 40 % of PU-Cel foam was taken after week 4 and week 8. The results showed differences of 2.06 %, 3.00 % and 3.12 % from its initial weight. The IR spectra analysis shows the loss of peaks from ester functional group (-N-CO-O-). The morphological surfaces of PU-Cel foam were analyzed at 20x and 50x magnifications using digital microscope. Limewater test was used to determine the presence of carbon dioxide when the PU-CEL foam was digested by the *Bacillus subtilis*. The clear limewater turned cloudy indicating the presence of carbon dioxide. This study provides the evidence on how the susceptibility of cross-linked polymer over degradation can be tailored by substituting the petroleum-based polyol to palm-based polyol and the addition of suitable biodegradable filler such as cellulose.