DEGRADATION BEHAVIOR OF PINEAPPLE LEAF FIBRE (PALF) REINFORCED BIOCOMPOSITES

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APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Material).

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DECLARATION

I declare that this project entitled "Degradation behavior of Pineapple Leaf Fibre (PALF) Reinforced Biocomposites" is the result of my own work except as cited in the references.

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DEDICATION

This report is dedicated to my beloved parents,

Sivakumar Muthiah and Suseela Sinnappan.

ABSTRACT

This project investigates the degradation behavior of Pineapple leaf fibre (PALF) reinforced PLA composite when subjected to water immersion test. Samples of treated PALF reinforced PLA composite were prepared and subjected to water immersion test to study the water absorption rate by manipulating the duration of immersion period. The specimens were immersed in distilled water solution and incubated at 40 °C for three different immersions period; week 0, 2 and 4. Upon reaching respective immersion period, the specimens were subjected to physical testing, flexural testing, and thermal analysis. The physical and mechanical properties of the specimens reduced as the water absorption rate and the immersion period increased. Moisture induced degradation has significant impact on the mechanical properties such as flexural strength and flexural modulus of the specimen while no drastic changes were observed in terms of the thermal properties.

ABSTRAK

Projek ini mengkaji kesan kemerosotan bahan komposit matrik poli laktid acid diperkuat serat daun nanas apabila dikenakan ujian rendaman air . Sampel komposit PLA diperkuat serat daun nanas telah disediakan dan dikenakan ujian rendaman air untuk mengkaji kadar penyerapan air dengan memanipulasi jangka masa tempoh rendaman. Spesimen telah direndam dalam larutan air suling pada 40 °C untuk tiga tempoh rendaman yang berbeza; minggu 0 , 2 dan 4. Setelah mecapai tempoh rendaman masing-masing, spesimen dikenakan kepada ujian fizikal , ujian lenturan, dan analisis terma. Didapati bahawa sifat-sifat fizikal dan mekanikal spesimen berkurang dengan peningkatan kadar penyerapan air dan tempoh rendaman. Kelembapan dalam komposit yang menyebabkan degradasi mempunyai kesan besar ke atas sifat-sifat mekanikal seperti kekuatan lenturan dan modulus lenturan manakala tiada perubahan yang ketara ke atas sifat-sifat termal bahan komposit tersebut.

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TABLE OF CONTENTS

			PAGE
DECLARATION			
DEDICATION			
ABSTRACT			**i**
ABSTRAK			**ii**
ACKNOWLEDGEMENTS			**iii**
TABLE OF CONTENTS			**iv**
LIST OF TABLES			**vii**
LIST OF FIGURES			**ix**
LIST OF APPENDICES			**xiii**
LIST OF ABBREVIATIONS			**xiv**
LIST OF SYMBOLS			**xv**
CHAPTER			
1	**INTRODUCTION**		
	1.1	Background	1
	1.2	Problem statement	3
	1.3	Objective	5
	1.4	Scope of project	5
	1.5	Planning and execution	6
2	**LITERATURE REVIEW**		
	2.1	Introduction	9
	2.2	Composites	9
		2.2.1 Classification of Composites	10
	2.3	Biocomposites	11
		2.3.1 Natural Fibres	14
		2.3.1.1 Pineapple leaf fibre	17
		2.3.2 Polymer matrix material	19

		2.3.2.1 PLA as the biodegradable polymer	20
	2.4	Properties of biocomposites	23
		2.4.1 Mechanical properties	23
		2.4.1.1 Tensile	25
		2.4.1.2 Impact	27
		2.4.1.3 Flexural	28
		2.4.2 Thermal properties	29
		2.4.3 Physical properties	30
		2.4.3.1 Density test	30
		2.4.3.2 Water absorption test	31
	2.5	Alkaline treatment	35
3	**METHODOLOGY**		
	3.1	Overview of research	37
	3.2	Raw materials	39
		3.2.1 PLA 6100D	39
		3.2.2 Pineapple leaf fibre	41
	3.3	Fibre surface modification	42
	3.4	Composite preparation	44
		3.4.1 PLA thin plate fabrication	44
		3.4.2 Fabrication of Unidirectional PLA/ PALF Composite	47
		3.4.3 Specimen Preparation	50
	3.5	Degradation test	52
	3.6	Flexural testing	55
	3.7	Thermal testing	58
	3.8	Physical testing	60
	3.9	Surface morphology study	61
4	**RESULTS AND DISCUSSION**		
	4.1	Introduction	62
	4.2	Water absorption test	63

	4.3	Physical test	73
	4.4	Flexural test	76
	4.5	Thermal analysis	82
	4.6	Surface morphology study	83
5	**CONCLUSION AND RECOMMENDATION**		
	5.1	Conclusion	88
	5.2	Recommendation	90
REFERENCES			**92**
APPENDICES			**99**

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	General composition of the constituents in natural fibre	16
2.2	Mechanical properties of natural fibres	17
2.3	Chemical compositions of different types of fibres	18
2.4	Advantages and disadvantages of PLA	22
2.5	Mechanical properties of natural and synthetic fibre	24
2.6	Mechanical properties of PLA	24
2.7	Comparison of PLA with PS and PET	25
2.8	Results for monotonic test	34
2.9	Mechanical properties of treated and untreated fibre biocomposite	36
3.1	Properties of Polylactic Acid (6100D)	41
3.2	Ratio of constituents	50
4.1	pH value of distilled water that has been recorded	64
4.2	Initial mass of the specimens, respective wet weight and corresponding dry mass	67
4.3	Water absorption percentage (WA) and mass loss of the specimen	70
4.4	Physical test results	74
4.5	Comparison of density values of degraded PALF-PLA samples and different types of biocomposites	74

4.6	Flexural strength and flexural modulus of specimens from week 0, 2 and 4 immersion period.	79
4.7	Simplified average values of flexural strength and modulus	80
4.8	Average results calculated from DSC analysis	83
4.9	Micrographs from SEM analysis tabulated according to respected immersion period.	85
5.1	Summary of the prime findings from the relevant test conducted for the degradation study.	89

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Gantt chart detailing research activities and their respected time frame for PSM I.	7
1.2	Gantt chart detailing research activities and their respected time frame for PSM II	8
2.1	Classification of biocomposites	13
2.2	Classification of natural fibres	15
2.3	Pineapple plant	17
2.4	Classification of biodegradable polymers and their nomenclature	20
2.5	The life cycle of biodegradable polymers	21
2.6	Synthesis and chemical structure of PLA	22
2.7	Tensile properties of PALF/PLA composites	26
2.8	Tensile stress and tensile modulus of PLA/flax composite compared to PP/flax	27
2.9	Notched Izod impact properties of the neat polymers and the fibre reinforced composites	28
2.10	Flexural properties of the neat polymers and the fibre reinforced composites	29

2.11	Moisture absorption as a function of time for core and bast kenaf fibre	32
2.12	Percentage of fluid absorption versus degradation time for PLA-PLA-TCP composites	33
2.13	Percentage of mass loss in PLA-PLA-TCP samples versus various degradation time	34
3.1	Flow chart of the research project	38
3.2	Steps of PLA process with ring opening polymerization	40
3.3	PLA 6100D (pellets form)	40
3.4	Diluting NaOH in distilled water	42
3.5	PALF immersed in alkaline solution	43
3.6	Drying process of treated PALF and Prepared PALF for composite fabrication	44
3.7	Drying Oven	45
3.8	Placement of PLA and Mila sheets in the plate mould	46
3.9	Graph of temperature versus time for PLA plate fabrication process	47
3.10	Hydraulic Hot Moulding Machine	48
3.11	Arrangement of PALF in between PLA plates	48
3.12	Graph of Temperature versus time for PALF reinforced PLA composite	49
3.13	Fabricated PALF reinforced PLA composite	49
3.14	Shearing Machine	50
3.15	Specimen prepared for degradation test	51

3.16	Schematic diagram of the specimens prepared for water absorption test	52
3.17	Samples placed in the bottle containing distilled water to be incubated	53
3.18	Samples placed in the Incubator	54
3.19	An Instron Universal Testing Machine Model 5585	55
3.20	Allowable range of loading nose and support radii in accordance with ASTM D790	56
3.21	Deflection of the specimen when load was applied	56
3.22	Differential Scanning Calorimetry Equipment	58
3.23	Electronic Densimeter	60
4.1	Change in pH of distilled water versus degradation time	64
4.2	Top view of specimen after water uptake tests	65
4.3	Side view of specimen after water uptake test	66
4.4	Water absorption versus degradation time of PALF reinforced PLA composites	71
4.5	Mass loss versus drying period of PALF-PLA	71
4.6	Mass loss of specimen with their respective immersion period	72
4.7	Comparison of fluid uptake rate for PALF-PLA specimen and PLA-PLA-TCP specimen	73
4.8	Comparison of density	75
4.9	Top view of specimens	78
4.10	Side view of specimens	78

4.11	Flexural strength versus degradation time for PALF reinforced PLA composites	80
4.12	Flexural modulus versus degradation time for PALF reinforced PLA composites	81
4.13	Flexural strength of samples before and after immersion test	82

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Results of flexural test	99
B	Results from DSC analysis	109
C	NatureWorks Ingeo Biopolymer 6100D Technical Data Sheet	114

LIST OF ABBEREVATIONS

CCM	Carbon-Carbon Composites
CMC	Ceramic Matrix Composites
DSC	Differential Scanning Calorimetry
MMC	Metal Matrix Composites
NaOH	Sodium Hydroxide
PALF	Pineapple leaf fibre
PET	Polyethylene Terephthalate
PLA	Polylactic Acid
PMC	Polymer Matrix Composites
PP	Polypropylene
PS	Polystyrene
RNCF	Recycled Newspaper Fiber
ROP	Ring Opening Polymerization
SEM	Scanning Electron Microscope
TCP	Tricalcium Phosphate
TG	Glass Transition Temperature
WC	Water Content

LIST OF SYMBOL

m_w	=	Wet weight of specimen after immersion test (g)
m_d	=	Dry mass of specimen (g)
m_o	=	Initial mass of specimen (g)
WA	=	Water absorption percentage (%)
R	=	Rate of cross head motion, mm/min
Z	=	Rate of straining of the outer fibre, mm/min = 0.01
L	=	Support span, mm
d	=	Depth of beam, mm
E_b	=	Modulus of elastic in bending, MPa
m	=	Slope of the tangent to the initial straight line portion of the load deflection curve
B	=	Width of the beam tested, mm
X_c	=	Degree of crystallinity
T_m	=	Melting Temperature
ΔH	=	Crystallization enthalpy of composite sample
ΔHm	=	Crystallization enthalpy of 100% crystalline PLA
ρ_c	=	Density of the composite
M_b	=	Buoyancy of the specimen
M_a	=	Weight of the specimen in air
ρ_w	=	Density of the distilled water at room temperature

CHAPTER I

INTRODUCTION

1.1 BACKGROUND

The exploration for the seeking of materials with attractive features such as high performance level, quality assured, environmentally-friendly and competetive price has surged researches to study and develop further on the function and capabilities of composites [1].

Composites are being widely used in the engineering & manufacturing world. Composites can be manipulated to ones' benefit. The researcher/ designer can combine materials to prevail their maximum use of their traits/ virtues by altering the composition and ratio of the materials affecting its mechanical, physical and thermal properties to what they desire for [2]. Through this, the materials deficiency can be minimized.

Tapping into the diversity of composites, studies and innovation has motivated the development of biocomposites. Biocomposites are composites that are products from polymers and natural fibres [3]. Polymers can be classified into synthetic polymers and also natural polymers. Polylactic acid (PLA) is a natural polymer that is being explored vastly due to its environmentally friendly properties. Due to the superseding of advancement in industrial technologies, PLA has been generated to possess high molecular weight that contributes the sustainability as for structural materials with sufficient lifespan and good weatherability to maintain its mechanical properties [4].

Natural fibres on the contrary are opted as they are renewable and a much cheaper substitute for synthetic fibres. Possessing a number of advantages such as low density, high toughness, acceptable specific strength properties not neglecting its ease of separation and biodegradability has prompted researches to cultivate the growth of natural fibre-reinforced composites [4].

All the advantages that the combination of polymers and natural fibres which results in biocomposites is very generous, however they still do have a few major drawbacks. Amongst them would be its poor resistance towards water absorption and how it affects the biocomposites degradation behaviour [6]. Water absorption of natural fibre reinforced composites are mostly because of the hydrophilic nature of the natural fibre itself and it is proportionally dependent with the volume fractions of fibres [13]. A change by the improvement of water resistance of natural fibre reinforced composite would altogether improve their qualities and mechanical properties. Other than that, water content influences the dielectric properties of composites to be utilized for insulation purpose.

1.2 PROBLEM STATEMENT

The consumption of petroleum assets to the extreme causing depletion of petroleum resources, plastic disposal issues and emission amid incineration along increasing environment regulations has prompted development of materials that are compatible with the environment and independent of fossil fills [5].

New materials with high efficiency at accessible costs are progressively required with the raising of environment conscience. Exploration has been focused specifically on materials respectful of environment [10]. The environment friendly materials include the fields of green chemistry, biodegradable and bio-based materials at the structural, chemical and physical level, as well as the utilization of principles to and the usage of standards to diminish or dispose of hazardous substances in the outline, assembling and application of chemical products.

Numerous successful attempts have prompted opening up an extensive scope of materials leading to the advancement of biodegradable materials, which brought great impetus for the improvement of industrial viable biodegradable composites with expanded focus in eco-friendliness. Natural polymers such as polylactic acid (PLA) which are typically biodegradable is a vital outline parameter for opening up new materials opportunities for the advancement of value added products from natural polymer feed stocks [5, 11].

However, biocomposites undergo degradation that is the change in the properties (tensile, strength, odour, shape and etc) under the impact of one or more ecological elements for example light, water, heat or chemicals. These progressions are normally undesirable for instance changes during use, cracking and depolymerisation of products and it is desirable as in biodegradation or deliberately bringing down the molecular weight of the composite for reusing or decomposing purpose. The changes in properties are frequently termed as 'aging'. In a finished product, such as a change is to be prevented or delayed.

Degradation can be induced to assist structure determination. Polymeric molecules are huge (on the atomic scale) and their unique and useful properties is a result of their size thus a loss in chain length brings down their tensile strength and it is the essential driver of premature cracking. Composites poor resistance towards water absorption that disrupts their mechanical properties and ways to improve the resistance is yet and still being studied. Water absorption is caused by hydrogen bonding between free hydroxyl groups in cellulose molecules and water molecules as well as the adhesion between fibre and the matrix. Considering these aspects gives rise to the water content in natural fibre reinforced biocomposite as a critical parameter to be concentrated on [44].

The percentage/ rate of water resided in a biocomposite can be examined by distinctive technique, such as water absorption test and thermogravimetric analysis. Results on water absorption behaviour should be studied heavily about when designing a part on the grounds that moisture prompts an increment in dimensions as previously seen to a reduction in tensile and flexural properties of the biocomposite. Before searching for solutions to lessen the water absorption of the biocomposite their behaviour needs to be completely understood hence the suitable solution can be recommended.

Thus, this study aims to study the degradation behaviour of PALF reinforced biocomposite via water absorption test and followed by mechanical tests conducted on the biocomposite specimens after is has been immersion in distilled water solution for a specific period of time (0, 2, 4 weeks).

1.3 OBJECTIVE

The objectives for pursuing the current research topic are:

1. To fabricate of biocomposites where PLA is the matrix and long fibre from pineapple leaves (PALF) acts as the reinforcement.
2. To study the degradation behaviour of the biocomposite due to the effects of water absorption.
3. To study the effect of degradation on the mechanical properties (flexural strength) of the biocomposites.

1.4 SCOPE OF PROJECT

The scope of this project is listed as below:

i. PALF pretreatment.
ii. Fabrication of PLA thin films.
iii. Producing the biocomposite plate.