UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

THE EFFECT OF SILANE COUPLING AGENT ON THE TRIBOLOGICAL PROPERTIES OF RECYCLED CARBON FIBER REINFORCED POLYPROPYLENE

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

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DECLARATION

I hereby, declared this report entitled 'The Effect of Silane Coupling Agent on the Tribological Properties of Recycled Carbon Fiber Reinforced Polypropylene' is the results of my own research except as cited in references.

Signature : ……

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Date : 2th JULY 2015

ABSTRAK

Kajian ini adalah satu kajian untuk mengetahui lebih dalam tentang kesan agen gadingan terhadap silena dalam ciri-ciri tribologi bagi bahan komposit serat karbon dikitar semula (rCF) polipropilena diperkukuhkan (PP) . Kajian ini mengfokuskan tentang polipropilena (PP) sebagai bahan matrik dan untuk menyokong evonasi terhadap teknologi hijau terhadap bahan kitar semula. Komposit PP/rCF disediakan oleh proses pengkompaunan leburan melalui pengadun dalaman. Terdapat tiga nisbah untuk rCF yg mengadungi perbezaan peratusan terhadap berat rCF dan juga setiap perbezaan nisbah peratusan berat rCF mengandugi element utama iaitu peratusan agen gadingan terhadap silena yang mengandungi tiga perbezaan nisbah. Terdapat juga beberapa uji kaji yang dijalankan terhadap komposit PP/rCF iaitu termasuk ketumpatan, kekerasan, Pin pada Cakera , dan Mikroskop Elektron Imbasan. Sifat Tribologi daripada rCF / PP komposit menganalisis oleh Pin pada Cakera di mana untuk mencirikan haus dan geseran komposit untuk dirawat dan tidak dirawat. Berdasarkan pemahaman , berat bahan yang lebih tinggi kehilangan akan mendapatkan yang lebih tinggi kadar haus tertentu dan pekali rendah geseran akan mendapatkan prestasi yang lebih tinggi geseran. Berdasarkan keputusan , apabila menambah peratusan berat rCF akan meningkatkan ciri-ciri pada kekerasan dan kepadatan. Sementara itu, rCF / PP dirawat semakin meningkat harta mereka untuk untuk kekerasan dan kepadatan. Tambahan pula, untuk menguji Tribologi pada pekali geseran dan haus kadar, meningkatkan peratusan berat rCF akan mengurangkan pekali geseran dan kadar dipakai. Tetapi bagi pengubahsuaian kimia yang berbeza pada dirawat dan tidak dirawat, pekali geseran yang tidak dirawat rCF kurang . Sementara itu , kadar haus untuk dirawat rCF adalah lebih tinggi daripada rCF dirawat.

ABSTRACT

This research is an effort to explore the effect of silane coupling agent on tribology properties of recycled carbon fiber (rCF) reinforced polypropylene (PP). The versatility of PP in general purpose products was addressed to support green environmental by recycling materials. This composite of rCF/PP was being prepared by melt compounding process via internal mixer. Three ratio that being come out for different rCF and three different ratio for silane coupling agent. Some testing and analysis including density, hardness, Pin on Disk, and Scanning Electron Microscope was performed to characterize the properties of rCF/PP composites. The tribology properties of rCF/PP composite is analyze by Pin on Disk in order to characterize the wear and friction analysis of composite for treated and untreated rCF/PP. Based to the result, when adding more weight percentage rCF will increase properties on hardness and density. Meanwhile, the rCF/PP treated is increasing their properties to for hardness and density. Furthermore, for testing tribology on coefficient of friction and wear rate, increase weight percentage rCF will decrease coefficient of friction and wear rate. But for different chemical modification on treated and untreated, the coefficient of friction for untreated rCF is less. Meanwhile, the wear rate for untreated rCF is higher than treated rCF. Due to that, this researched had achieved the objective for producing recycled carbon fiber reinforced polypropylene via melt compounding, comparing tribology properties between treated and untreated recycled carbon fiber reinforced polypropylene, and learn the correlation between tribology properties and morphological characteristic of treated and untreated recycled carbon fiber reinforced polypropylene.

DEDICATION

Thank you, Allah for the opportunity to accomplish this Final Year Project and for the mercies you laid upon me.

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TABLE OF CONTENT

ABSTRAK` i

ABSTRACT ii

DEDICATION iii

ACKNOWLEDGEMENT iv

TABLE OF CONTENT v

LIST OF TABLE ix

LIST OF FIGURE x

LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES xiii

CHAPTER 1: INTRODUCTION

1.1 Background 1

1.2 Problem Statement 3

1.3 Objectives 5

1.4 Scope 5

1.5 Overview Chapter 6

CHAPTER 2: LITERATURE REVIEW

2.1 Composite 7

2.2 Polymer Matrix Composite 9

2.3 Matrix 11

2.3.1 Thermoplastic 11

2.3.2 Polypropylene 12
2.3.3 Fiber Arrangement In Discontinuous Random Fiber 13
2.3.4 Current Development Of Thermoplastic Composite 15
2.4 Fiber 16
2.4.1 Carbon Fiber 16
2.4.2 Recycled Carbon Fiber 17
2.4.3 The Performance Of Recycled Carbon Fiber Reinforced Plastics 20
2.5 Processing 20
2.5.1 Surface Treatment 21
2.5.1.1 Modification Of Thermoplastic Composites For Tribo Properties Improvement 22
2.5.2 Process Via Internal Mixture And Hot Pressing 23
2.6 Tribology Of Polymer 24
2.6.1 Type And Mechanism Of Tribology 25
2.6.1.1 Wear On Tribology 26
2.6.1.2 Friction On Tribology 27
2.6.2 Tribological Properties Of Material 28
2.6.3 Tribology Testing For Thermoplastic Composite 29

CHAPTER 3: METHODOLOGY

3.1 Raw Material 32
3.1.1 Polypropylene 32
3.1.2 Recycled Carbon Fiber Prepreg (rCF) 33
3.1.3 Nitric Acid (HNO_3) 33
3.1.4 Silane A-174 ($C_{10}H_{20}O_5Si$) 34
3.1.5 Ethanol 35

3.2 Sample Preparation 36
3.2.1 Raw Material Preparation 37
3.2.1.1 Cutting 37
3.2.1.2 Wash With Acetone 37
3.2.1.3 Chemical Modification 38
3.2.1.4 Crushing Process 38
3.2.1.5 Sieve Process 39
3.2.2 Compounding Preparation 40
3.2.2.1 Melt Compounding Via Internal Mixer 40
3.2.2.2 Pelletizing Process 43
3.2.2.3 Hot Pressing Molding 44
3.2.2.4 Injection Molding 45
3.3 Testing And Analysis 47
3.3.1 Testing 47
3.3.1.1 Hardness Testing via Durometer 47
3.3.1.2 Tribology Testing via Pin On Disk 48
3.3.1.3 Physical Testing via Electronic Densitometer 49
3.3.2 Analysis 50
3.3.2.1 Scanning Electron Microscopy (SEM) 51

CHAPTER 4: RESULT AND DISCUSSION

4.1 Background 53
4.2 Raw Material Characterization 53
4.2.1 Density Test for Recycled Carbon Fiber 54
4.3 Observation Of Sample Preparation Process 54
4.4 Hardness Test 57

4.5 Density Test 59

4.6 Tribological Testing 61

4.6.1 Coefficient Of Friction 61

4.6.2 Wear Rate 63

4.7 Morphology via SEM 65

4.7.1 Morphology For Hardness And Density 65

4.7.2 Morphology For Tribology 68

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion 73

5.2 Recommendation 74

REFERENCES 75

APPENDICES

APPENDIX A 79

APPENDIX B 80

LIST OF TABLE

2.1	Properties of PMC	10
2.2	Different of carbon fiber and recycled	18
2.3	Comparison of tensile properties of single virgin and recycled carbon fiber in average of 20 single fibers	19
2.4	Mechanical properties of plain and 30% recycled carbon fiber reinforced polypropylene	19
3.1	Physical properties of polypropylene	32
3.2	Physical properties of recycled carbon fiber prepregs	33
3.3	Physical properties of nitric acid (HNO_3)	34
3.4	Silane A-174 ($C_{10}H_{20}O_5Si$)	35
3.5	Physical properties of ethanol	36
3.6	The compounding formulation of sample	41
4.1	Measurement of recycled carbon fiber density	54
4.2	The hardness properties of sample A, sample B, and sample C	57
4.3	The density properties of sample A, sample B, and sample C	59
4.4	The coefficient of friction result of sample A, sample B, sample C, and pure PP	61
4.5	The wear rate result of sample A, sample B, sample C, and pure PP	64

LIST OF FIGURES

2.1	Classification of composite	8
2.2	Schematic figure of discontinuous fiber arrangement	13
2.3	Result of graph of rCF/PP A) low modulus, And B) tensile profile	14
2.4	Illustration of composite molding	24
2.5	Chart of wear polymer	26
2.6	Schematic view of pin on disc tribology test machine	29
3.1	Flow chart of overall process	31
3.2	Polypropylene in pallet form	32
3.3	Woven fabric of recycled carbon fiber prepregs	33
3.4	Nitric acid (HN_3)	34
3.5	Silane A-174 ($C_{10}H_{20}O_5Si$)	35
3.6	Ethanol form of liquid	36
3.7	Acetone as solvent agent	38
3.8	Pulveriser machine	39
3.9	Vibratory sieve-shaker	40
3.10	Analytical balance excellent model Metler Toledo International INC., US	42
3.11	HAAKE Rheomix OS	43
3.12	Crusher machine TW-SC-400F	44

3.13	Hot press GO-7014-A30 Model Gotech Testing Machine Inc., Taiwan	45
3.14	Mold for injection molding	46
3.15	Ray-Ran test sample injection molding machine	46
3.16	Durometer tester shore D type	48
3.17	Pin On Disk Tester	49
3.18	DH-300 direct reading type of Electronic Densitometer	50
3.19	Zeiss EVO 50 Scanning Electron Microscope (SEM)	52
3.20	Scanning Electron Microscope (SEM) Stubs	52
4.1	The rCF condition A)After acetone modification (rough), B)After nitric acid modification (smooth), and C)After silane coupling agent modification (rough)	55
4.2	Composite of PP/rCF after fabricate by melt compounding	56
4.3	Sample tribology for pure PP by injection molding	56
4.4	Graph of hardness Vs rCF weight percentage	58
4.5	Density properties for sample A, sample B, and sample C	59
4.6	Coefficient of friction result of sample A, sample B, sample C, and pure PP	62
4.7	Wear rate of sample A, sample B, sample C, and pure PP	64
4.8	SEM for rCF	66
4.9	SEM on different weight percentage rCF a)Sample A1, and b)Sample A3	67
4.10	SEM for different percentage coupling agent. a) Sample B3, and b) Sample C3	68
4.11	SEM for pure PP surface failure	69

4.12 SEM on surface failure. a) Sample A1, and b) Sample A3 70

4.13 SEM on Surface Failure. a) Sample B3, and b) Sample C3 71

LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

PP	-	Polypropylene
rCF	-	Recycled Carbon Fiber
sCF	-	Short Carbon Fiber
Si	-	Silane
SEM	-	Scanning Electron Microscope
DSC	-	Differential Scanning Electron
FTIR	-	Fourier Transform Infrared
XRD	-	X-Ray Diffraction
ISO	-	International Standard Organization
ASTM	-	American Society for Testing and Material
UV	-	Ultra Violet
%	-	Percentage
In	-	Inch
mm	-	Millimeter
μm	-	Micrometer
N	-	Newton
J	-	Joules
MPa	-	Mega pascal
GPa	-	Giga Pascal

±	-	Plus minus
min	-	Minute

CHAPTER 1

INTRODUCTION

1.1 Background

In aerospace, military, automobile, and sports industry is widely use of fiber reinforced polymer composites as high performance materials. The compulsory material used for application is carbon fiber. The use of carbon fiber reinforced polymers is growing and diversifying. Since 2010, the demand for carbon fiber is 39,280 metric tons for high application such as aerospace to sport equipment and it will increase the demand into 89,260 metric tons in 2015 (Wong, 2012).

Based on the demand for industry, the high grade carbon fiber is expensive and valuable due to economically and effectively to recycle and recover (Park, 2013). Most of carbon fiber before or after processing is producing scraps as known as wasted carbon fiber. The form is usually seen like cuts-off the manufacturing process, out of life prepreg, and end life of components. Nowadays, the wasted carbon fibers have already reached a significant limits and it will increase for the future. In theoretical, composite material is not applicable to recycled. Recently the increased of cost of landfill for requirements legislative and around 85% demanded of vehicles disposed must recycled after 2015 was

reported (Meredith, 2012). In fact, carbon fiber reinforced polymers (CFRP) have come into practical use for the aerospace and automotive industries instead of iron and aluminum alloys. Due to their properties and behavior of composite been contributed to higher fuel efficiency and lower levels of emissions. Therefore, the demand for CFRPs has dramatically increased in recent years (Okayasu, 2013).

The cost for manufacturing the carbon fibers are limited and usually it used to the area in high cost application in which to gain a good performance in mechanical and weight saves. Therefore, by recycled the wasted carbon fibers may have potential to get a cheaper cost than virgin fiber and it will give a new market change and opportunities in industry (Wong, 2012). Consequently, the carbon fiber is commercialize in raw and recycled but mostly a new development for recycled is been conducted which to getting a good properties as raw material. However, a few studies have been reported on in this report about the composite of recycled carbon fiber with reinforcement of polymer (PMC).

According to Nirmal (2011), the tribology is related to relative motion in which to study the friction, wear, and lubricants of the interacting surfaces. Nowadays, the tribology is important since most of design applications are related to wear and friction. In other words, the meaning of tribology is contacting of solid mechanism and nature of surface interaction. Many researches have been introduced for advance material as substitute to conventionally used materials as these modified material are excellent in wear and friction, light weight, and longer life span.

For this study, the focus on tribology of polymer and based on Rymuza (2007), the tribology of polymer is different between metal and ceramic material in many kind of application. The friction contacts in comparison to metal and ceramic materials are related to chemical and physical structures as well as surface and bulk properties. Therefore, the usage of polymer are easy to modified for both surface and bulk because the polymer have very low surface free energy and also low viscoelastic properties.

Based on Tarmo (2012), most of study on tribology mechanism is concerning the wear and friction properties of material. Meanwhile to reduce the coefficient of friction (COF) and increase wear performance, they carried to study the mechanism of tribology properties. Others, it also focuses in searching alternative choice in order to increase the static or sliding COF and wear friction.

1.2 Problem Statement

Mostly the carbon fiber is expensive to manufacture from point of raw material which need high energy cost to converting the polymer base into carbon fiber. The composite have a behavior in long life spend in the landfill or industry. Therefore, the benefits is resealing the value of reclaimed fiber opens the door for economically interesting business. The usage of carbon fiber composite increase, it concerns the end life of product and wasted from manufacturing is potential tonnage usage of carbon fiber. The disadvantage that might can see or happen in term of increasing of usage carbon fiber composite in sector of heavy industry such as aeronautic industry, it will forced to disposed of large quantities of scrap carbon fiber composite by dumping in landfill site. The wasted of carbon fiber composite product will quickly reach a significant limits to become important environment issues of product such as biodegradable product. Due to this awareness of increasing of waste carbon fiber composite, it will reduce the landfill capacity to work and also will enforce of regulations for wasted carbon fiber. The amount of effort and attention need to devoted globally in significant limits. Therefore, some development of variety for recycling needs to attend for these valuable materials.

The challenging situation for recycled composite that composed with multiple phases is the behavior of thermosetting matrix are cannot be remolded and the resin mostly containing other material which might produce noxious combustion from product. In previous study, the wasted disposal issued have been solve by recycled the waste of material. Meanwhile, it has some several defect or lack to recycling fiber reinforced

polymer due to method and experience. The scrap must be cured and subsequently being use as filler for the material of polymer. Therefore, the method that might be carried for the study is expensive and insufficient demand for milled CFRP (Park, 2013). Although CFRPs have been employed in various industries, the recycling issue for CFRPs has not perfectly been solved yet. In fact, post-use CFRPs seem to be thrown away into landfill without any consideration of environmental problems. This occurrence will be a significant issue in the future, since the amount of waste CFRPs will increase dramatically (Okayasu, 2013). To develop the efficiency in order to recycled those material is extensive the usage of composite material in which to outstanding the properties result that may increase the amount of wasted product. The difficulty of composite material in term of fractionate into component. Besides, the composited wasted are typically being disposed in landfills or incinerated without recycling. The composite wasted is related to inert compared to others wasted because the produce no methane gas and leachate gas. Therefore, the new development should be develop in order to reduce the amount of the wasted disposal and also reduce the impact for environment (Morin, 2012).

According to Tarmo (2012), the usage of polymer composite is being widely spread out in industry, and science. The relative motion is intensive to study the wear and friction mechanism as known as tribology mechanism. Most of the studies are concentered of polymer-metal contact pairs and polymer-polymer contact has been focus to study the experiment and theoretical method. By implement polymer with surface treatment will modified the surface properties because the wear and friction behavior are influenced by profile of the surface. The influence of periodic textures and structure of different size scales is related to wear and friction behavior of metallic surface and inorganic material.

Based on Nirmal (2011), most of design application is involved wear and friction via processing when it subjected to relative motion. It was reported that around 63% of wear has distributed to total cost of industries in tribology factor such as friction, wear, heat, adhesion, and etc. It cannot be completely removed or eliminated the behavior of wear and friction but it can be minimized.

1.3 Objectives

There are three objectives that need to be achieved in this project which are:

a) To produce the recycled carbon fibers reinforced polypropylene via melt compounding.

b) To compare the tribology properties between treated and untreated rCF reinforced polypropylene.

c) To study the correlation between tribology (wear and friction) properties and morphological characteristic of treated and untreated rCF reinforced polypropylene.

1.4 Scope

Scope of this research is to produce the composite of polymer in which the matrix is polypropylene and the reinforcement is recycled carbon fiber via melt compounding. Furthermore, the study also focusing on the effect of surface treatment of recycled carbon fiber to compare the treated recycled carbon fiber using silane coupling agent and untreated carbon fiber prepreg reinforced with polypropylene. Last but not least, the result of this research is undergoes the tribology testing in order to study the correlation between tribology properties and morphological characteristic of treated and untreated rCF reinforced polypropylene. Some mechanical and physical properties such as hardness and density will be carried out to support the tribology test. The data gathered for the properties of the composites were analyzed using Scanning Electron Microscopy (SEM).

1.5 Overview Chapter

This report is divided into five parts which are; Chapter 1 covers the introduction of the research. There are several elements that involve in Chapter 1 which is background study of the research, problem statement, objective of the research, scope of the research and lastly is the report organization. In Chapter 2, it discuss the literature review of the research based on the previous study on the silane coupling agent, recycled carbon fiber, polypropylene, testing and analysis that will be used on this research. Chapter 3 presents the whole methodology that used in the research such as flow chart, raw materials, sample preparation, testing and analysis. In Chapter 4, it present the testing and analysis of the result and discuss the result obtain. Lastly, Chapter 5 discussed the conclusion and recommendation for the improvement of the research in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 COMPOSITE

According to Callister (2007), the advent of composite is distinct classified of materials started in the middle of 20th century that involve in manufacturing of design and multiphase material such as clay, , wood, seashells and alloys steel. The composite material also known as composition of material are made from two or more material with different properties such as physical, mechanical, chemical and etc. When the material is combine its will produce a material with different properties or characteristic between individual material. It also been classified into five family of matrix used which is Ceramic Matrix Composite (CMC), Metal Matrix Composite (MMC), Polymer Matrix Composite (PMC), Carbon-Carbon Composite, and Hybrid Composite (Wong, 2012).

Based on the research that focuses on PMC, by Brunner (2015), fiber reinforcement polymer matrix composite is increasing the usage as high performance application such as aerospace structure and also their element due to light weight and high specific strength and stiffness rather than other matrix used for composite. It also been consider

the cost used for matrix of composite and it showed that PMC mostly less cost used for application rather than usage of other matrix composite.

Based on our understanding, the recycled carbon fiber reinforcement can be obtained on scrap of material used. According to Shi (2012), said that many years ago, fiber reinforced polymer material had been incinerated or used for landfill without any recycling and also the price for reinforced fiber much higher especially for carbon fiber. Therefore, when the reinforced carbon fibers can be remanufacture and recycled into recycled carbon fiber reinforcement with high performance as possible, it will reduce the cost used for high performance application.

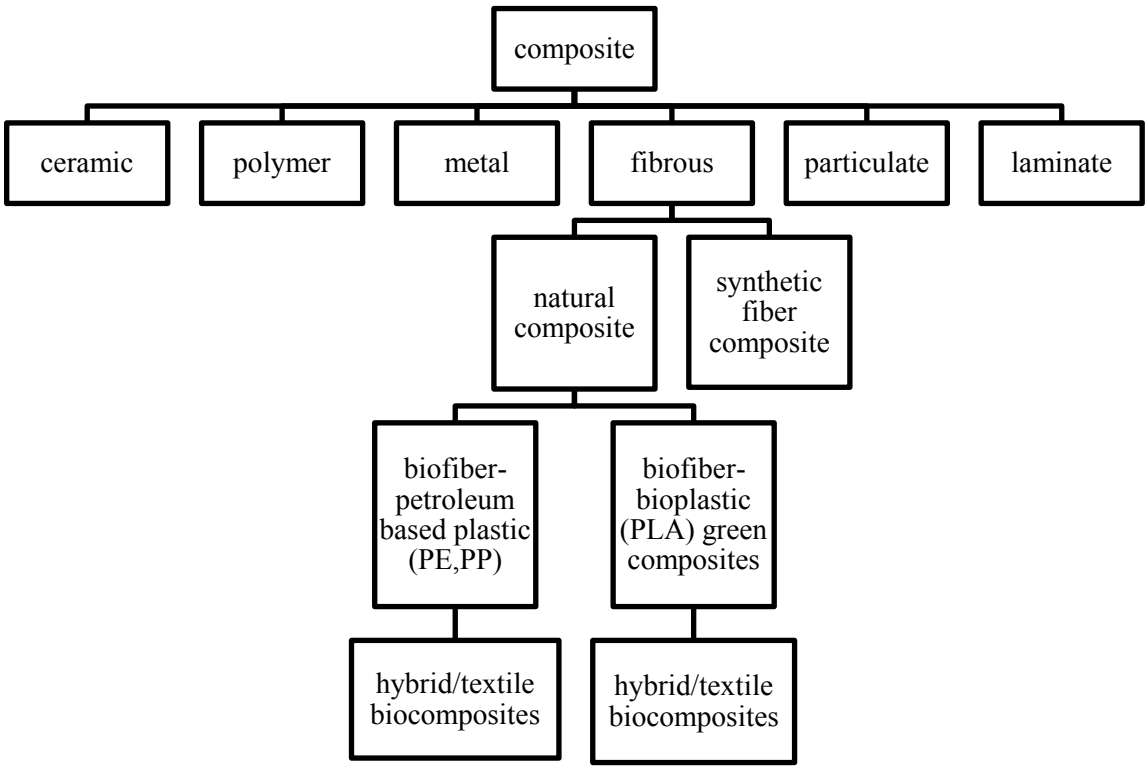

Figure 2.1 Classification of composite (Jasmin ,2012).