

**EFFECT OF FILLER LOADING AND CHEMICAL  
MODIFICATION ON PROPERTIES OF LOW  
DENSITY POLYETHYLENE/CORN STALK  
BIOCOMPOSITES**

**AZIMAH BINTI ISMAIL**

**UNIVERSITI MALAYSIA PERLIS**

**2014**

© This item is protected by original copyright



**EFFECT OF FILLER LOADING AND CHEMICAL  
MODIFICATION ON PROPERTIES OF LOW  
DENSITY POLYETHYLENE/CORN STALK  
BIOCOMPOSITES**

by

**AZIMAH BINTI ISMAIL**

**(0930410411)**

A thesis submitted in fulfillment of the requirements for the degree of  
Master Science (Materials Engineering)

**School of Material Engineering  
UNIVERSITI MALAYSIA PERLIS**

**2011**

# UNIVERSITI MALAYSIA PERLIS

## DECLARATION OF THESIS

Author's full name : AZIMAH BINTI ISMAIL  
Date of birth : 08<sup>TH</sup> AUGUST 1980  
Title : EFFECT OF FILLER LOADING AND CHEMICAL MODIFICATION ON PROPERTIES OF LOW DENSITY POLYETHYLENE/CORN STALK BIOCOMPOSITES.  
Academic Session : 2010 - 2014

I hereby declare that the thesis becomes the property of Universiti Malaysia Perlis (UniMAP) and to be placed at the library of UniMAP. This thesis is classified as :

- CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)\*
- RESTRICTED** (Contains restricted information as specified by the organization where research was done)\*
- OPEN ACCESS** I agree that my thesis is to be made immediately available as hard copy or on-line open access (full text)

I, the author, give permission to the UniMAP to reproduce this thesis in whole or in part for the purpose of research or academic exchange only (except during a period of \_\_\_\_\_ years, if so requested above).

Certified by:

\_\_\_\_\_  
**SIGNATURE**

\_\_\_\_\_  
**SIGNATURE OF SUPERVISOR**

\_\_\_\_\_  
800802025740

\_\_\_\_\_  
ASSOC. PROF. DR.IR. SALMAH HUSSIENSYAH

**(NEW IC NO. / PASSPORT NO.)**

**NAME OF SUPERVISOR**

**NOTES :** \* If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

## ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful. First and foremost, I would like to thank Allah S.W.T for giving me the strengths and His blessing in completing this thesis. Alhamdulillah, all praises to Allah. Special appreciation goes to my supervisor, Assoc. Prof Ir. Dr. Salmah binti Hussienyiah for providing me the knowledge and whom never failed and stops giving me support from the beginning until the end which makes this research possible to be completed. Her guidance and motivations always keep me focused on the objective of the research and choosing the right way in accomplishing it. Special thanks towards my second supervisor, Dr Hakimah Osman and not forgetting Dean School of Materials Engineering, Dr Khairul Rafezi Ahmad.

Special thank to the helpful staff Mr Nasir & Mr Zaidi in the School of Material Engineering of University Malaysia Perlis for their assistance in my Master project and POLIMAS colleogues for being encouraging and helpful.

I would like to express my deepest gratitude to my beloved husband Ahmad Johari bin Junus, my father Ismail bin Haji Ahmad, my mother Haminah binti Din and my son Muhammad Amjad bin Ahmad Johari, and the rest of my family for the prayer, love, motivation and encouragement that inspire me to strive harder for achieving the dreams.

Thank you.

## TABLE OF CONTENTS

	PAGE
<b>THESIS DECLARATION</b>	i
<b>ACKNOWLEDGEMENT</b>	ii
<b>TABLE OF CONTENTS</b>	iii
<b>LIST OF TABLES</b>	viii
<b>LIST OF FIGURES</b>	x
<b>LIST OF ABBREVIATIONS</b>	xv
<b>LIST OF SYMBOLS</b>	xvii
<b>ABSTRAK</b>	xviii
<b>ABSTRACT</b>	xix
<b>CHAPTER 1 INTRODUCTION</b>	
1.1 Research background	1
1.2 Problem Statement	4
1.3 Research objectives	5
1.4 Scope of Study	5
<b>CHAPTER 2 LITERATURE REVIEW</b>	
2.1 Polymer biocomposites	7
2.2 Matrix	15
2.3 Matrix Filler Interface	19

2.4	Low Density Polyethylene	23
2.5	Filler	26
2.5.1	Functional fillers	27
2.6	Natural Filler	31
2.6.1	Corn Stalk	40
2.7	Chemical Modifications	41
2.7.1	Compatibilizer	44
2.7.1.1	Maleic anhydride polyethylene (MAPE)	46
2.7.2	Coupling Agent	
2.7.2.1	Coconut Coupling Agent (COCA)	50
2.7.3	Eco-degradant PD 04	51

### **CHAPTER 3 RESEARCH METHODOLOGY**

3.1	Materials	53
3.1.1	Low Density Polyethylene	53
3.1.2	Filler	54
3.1.3	Maleic Anhydride Polyethylene (MAPE)	54
3.1.4	Coconut Oil Coupling Agent (COCA)	54
3.1.5	Filler treatment with COCA	55
3.1.6	Eco-degradant PD 04	55
3.2	Preparation of LDPE/CS biocomposites with different filler loading	56
3.3	Measurement of Tensile Properties	57

3.3.1	Tensile Test	57
3.3.2	Differential Scanning Calorimetry (DSC)	58
3.3.3	Thermogravimetric Analysis (TGA)	58
3.3.4	Water Absorption Test	59
3.3.5	Morphology Study (SEM)	59
3.3.6	Fourier Transform Infrared Spectroscopy Analysis	60

## **CHAPTER 4 RESULT AND DISCUSSIONS**

4.1	Effect of Corn Stalk Loading on Properties of Low Density Polyethylene LDPE/CS biocomposites	
4.1.1	Tensile Strength	61
4.1.1.1	Elongation at break	63
4.1.1.2	Young Modulus	64
4.1.2	Morphology Study	65
4.1.3	Water Absorption	68
4.1.4	Thermal Properties	
4.1.4.1	Differential Scanning Calorimetry (DSC)	70
4.1.4.2	Thermogravimetric Analysis (TGA)	72
4.2	The effect of Compatibilizer Maleic Anhydride Grafted Polyethylene (MAPE) on LDPE/CS biocomposites	
4.2.1	Tensile Strength	74
4.2.1.1	Elongation at Break	76
4.2.1.2	Young's modulus	77
4.2.2	Morphology Study	79

4.2.3	Water Absorption	80
4.2.4	Fourier Transform Infrared Spectroscopy Analysis	82
4.2.5	Thermal Properties	
4.2.5.1	Differential Scanning Calorimetry (DSC)	84
4.2.5.2	Thermogravimetric Analysis (TGA)	86
4.3	Properties of LDPE/CS Biocomposites of Coupling Agent (COCA)	
4.3.1	Tensile Strength	88
4.3.1.1	Elongation at Break	90
4.3.1.2	Young's Modulus	91
4.3.2	Morphology Study	92
4.3.3	Water Absorption	93
4.3.4	Fourier Transform Infrared Spectroscopy Analysis	95
4.3.5	Thermal Properties	
4.3.5.1	Differential Scanning Calorimetry (DSC)	97
4.3.5.2	Thermogravimetric Analysis (TGA)	99
4.4	The Effect of Eco-degradant on Properties LDPE/CS biocomposites	
4.4.1	Tensile Strength	101
4.4.1.1	Elongation at Break	102
4.4.1.2	Young's Modulus	103
4.4.2	Morphology Study	104



4.4.3	Water Absorption	106
4.4.4	Fourier Transform Infrared Spectroscopy Analysis	108
4.4.5	Thermal Properties	
4.4.5.1	Differential Scanning Calorimetry (DSC)	109
4.4.5.2	Thermogravimetric Analysis (TGA)	111
<b>CHAPTER 5 CONCLUSIONS AND FUTURE WORK</b>		
5.1	Conclusions	113
5.2	Suggestion for Future Research	114
<b>REFERENCES</b>		115
<b>LIST OF PUBLICATIONS</b>		129

## LIST OF TABLES

NO.		PAGE
2.1	The properties of Low Density Polyethylene	24
2.2	Polyethylene suitable for fiber composite matrix	26
2.3	Chemical families of fillers for plastics	28
2.4	Fiber characteristics corn stalks materials	41
2.5	Composition of Virgin Coconut Oil	50
3.1	Properties of Low Density Polyethylene	53
3.2	The properties of maleic anhydride grafted polyethylene	54
3.3	Properties of Eco-degradant PD 04	56
3.4	Formulation of LDPE/CS biocomposites	57
4.1	Data DSC analysis of LDPE/CS biocomposites at different filler loading	71
4.2	Percentage weight loss of LDPE/CS biocomposites at different filler loading and temperature	74
4.3	Parameter DSC analysis of uncompatibilized and compatibilized LDPE/CS biocomposites at different filler loading	86
4.4	Percentage weight loss of uncompatibilized and compatibilized LDPE/CS biocomposites at different loading and temperature	88
4.5	Data DSC analysis of untreated and treated LDPE/CS biocomposites with COCA at different loading	99
4.6	Percentage of weight loss for untreated and treated LDPE/CS biocomposites with COCA at different loading	100

4.7	Data DSC of LDPE/CS biocomposites with and without eco-degradant at different loading	111
4.8	Percentage of weight loss for LDPE/CS biocomposites without and with eco-degradant at different loading	112

© This item is protected by original copyright

## LIST OF FIGURES

NO.		PAGE
2.1	A classification scheme for various composites types	9
2.2	Classification of composite materials	10
2.3	The interface and interphase between filler and matrix	20
2.4	Structure polyethylene	24
2.5	Types of basic particle shapes and the ratio of filler	30
2.6	Types Natural Fibers	34
2.7	Structure of cellulose	35
2.8	Structure of hemicelluloses	36
2.9	Structure of lignin	37
2.10	Structure of pectin	37
2.11	The part of corn stalk	40
2.12	Chemical structure of MAPE	46
3.1	Schematic reaction of COCA	55
4.1	The effects of filler loading on tensile strength of LDPE/CS biocomposites	62
4.2	Scanning electron micrograph of corn stalk at magnification 200X	62
4.3	The effects of filler loading on elongation at break of LDPE/CS biocomposites	64
4.4	The effects of filler loading on Young's Modulus of LDPE/CS biocomposites.	65
4.5	SEM micrograph of tensile fracture surface of LDPE	66

4.6	SEM micrograph of tensile fracture surface of LDPE/CS biocomposite (20 php CS)	67
4.7	SEM micrograph of tensile fracture surface of LDPE/CS biocomposite (40 php CS)	67
4.8	The percentage of water absorption versus time of LDPE/CS biocomposites at different loading	69
4.9	The percentage of equilibrium water absorption of LDPE/CS biocomposites at different loading	69
4.10	Differential scanning calorimetric (DSC) curve of LDPE/CS biocomposites at different filler loading	71
4.11	Thermogravimetric analysis (TGA) curve of LDPE/CS biocomposites at different filler loading	73
4.12	The effect filler loading on tensile strength of uncompatibilized and compatibilized LDPE/CS biocomposites	76
4.13	The effect of filler loading on elongation at break of uncompatibilized and compatibilized LDPE/CS biocomposites	77
4.14	The effect of filler loading on Young's modulus of uncompatibilized and compatibilized LDPE/CS biocomposites	78
4.15	Scanning electron micrograph(SEM) of tensile fracture surface of compatibilized LDPE/CS biocomposite with MAPE (20 php CS)	79
4.16	Scanning electron micrograph(SEM) of tensile fracture surface of compatibilized LDPE/CS biocomposite with MAPE (40 php CS)	80
4.17	The comparison of water absorption of uncompatibilized and compatibilized LDPE/CS biocomposites at 0, 20, and 40 php	81

4.18	The percentage of equilibrium water absorption of uncompatibilized and compatibilized LDPE/CS biocomposites at different filler loading	82
4.19	FTIR spectra of uncompatibilized and compatibilized LDPE/CS biocomposites	83
4.20	Schematic reaction between CS and MAPE	84
4.21	Differential scanning calorimetric (DSC) curve of uncompatibilized and compatibilized LDPE/CS biocomposites at different filler loading	85
4.22	Thermogravimetric analysis (TGA) curve of uncompatibilized and compatibilized LDPE/CS biocomposites different filler loading	87
4.23	The effect of filler loading on tensile strength of untreated and treated LDPE/CS biocomposites with COCA	89
4.24	The effect of filler loading on elongation at break of untreated and treated LDPE/CS biocomposites with COCA	90
4.25	The effect of filler loading on Young's modulus of untreated and treated LDPE/CS biocomposites with COCA	91
4.26	SEM micrograph of tensile fracture of treated LDPE/CS biocomposite with COCA (20 phr CS)	92
4.27	SEM micrograph of tensile fracture surface of treated LDPE/CS biocomposite with COCA (40 phr CS)	93
4.28	The water absorption of untreated and treated LDPE/CS biocomposites COCA at different filler loading	94
4.29	The percentage of equilibrium water absorption of untreated and	95

	treated LDPE/CS biocomposites with COCA at different filler loading	
4.30	FTIR spectra of untreated and treated LDPE/CS biocomposites with COCA	96
4.31	Schematic reaction between CS and COCA	97
4.32	Differential scanning calorimetric (DSC) curve of untreated and treated LDPE/CS biocomposites with COCA at different filler loading	98
4.33	Thermogravimetric analysis (TGA) curve of untreated and treated LDPE/CS biocomposites with COCA	100
4.34	The effect of filler loading on tensile strength of LDPE/CS biocomposites with and without eco-degradant	102
4.35	The effect of filler loading on elongation at break of LDPE/CS biocomposites with and without eco-degradant	103
4.36	The effect of filler loading on Young's modulus of LDPE/CS biocomposites with and without eco-degradant	104
4.37	SEM micrograph of tensile fracture surface of LDPE/CS biocomposite with eco-degradant (20 php CS)	105
4.38	SEM micrograph of tensile fracture surface of LDPE/CS biocomposite with eco-degradant (40 php CS)	105
4.39	The water absorption of LDPE/CS biocomposites with and without eco-degradant at different filler loading	107
4.40	The percentage of equilibrium water absorption of with and without eco-degradant LDPE/CS biocomposites at different filler loading	107

4.41	FTIR spectra of LDPE/CS biocomposites without and with eco-degradant	108
4.42	Schematic reaction between CS and PD04	109
4.43	Differential scanning calorimetric (DSC) curve of without and with eco-degradant LDPE/CS biocomposites at different filler loading	110
4.44	Thermogravimetric analysis curve of LDPE/CS biocomposites without and with eco-degradant	112

© This item is protected by original copyright



## LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
ATR	Attenuated total reflectance
CAPE	Carboxylated polyethylene
CS	Corn Stalk
COCA	Coconut Oil Coupling Agent
DMA	Dynamic mechanical analysis
DPW	Date palm wood
DSC	Differential scanning calorimetric
EDD	Ethylene diamine dilaurate
FTIR	Fourier transform infrared spectroscopy
HDPE	High density polyethylene
HPLC	High performance liquid chromatography
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
MA	Maleic Anhydride
MAPE	Maleated polyethylene
MAPP	Maleated polypropylene
NFPC	Natural fiber polymer composite
OHF	Olive Husk Flour
PALF	Pineapple leaf fiber
PE	Polyethylene

PET	Polyethylene terephthalate
PE-g-MA	Polyethylene grafted maleic anhydride
PKS	Palm kernel shell
POFA	Palm oil fatty acid
PP	Polypropylene
PP-g-MA	Polypropylene grafted maleic anhydride
RHDPE	Recycled high density polyethylene
SEM	Scanning electron microscopy
TDM	Titanium derived mixture
TGA	Thermogravimetric analysis
TPRS	Thermoplastic rice starch
TS	Tensile strength
WOWP	Waste office white paper
WP	Waste paper
XPS	X-ray photoelectron spectroscopy

## LIST OF SYMBOLS

$M_t$	Percentage of water absorption
$T_c$	Crystallization temperature
$T_g$	Glass transition temperature
$T_m$	Melting point temperature
$W_d$	Original dry weight
$W_n$	Weight after immersed
$X_{\text{biocom}}$	Crystallinity of biocomposites
$X_c$	Degree crystallinity of eco-composites

© This item is protected by original copyright

**Kesan Pembebanan Pengisi Dan Modifikasi Kimia Ke-Atas Sifat-Sifat Biokomposit  
Polietilena Ketumpatan Rendah/Batang Jagung**

**Abstrak**

Di dalam kajian ini, penggunaan batang jagung (BT) sebagai pengisi di dalam polietilena ketumpatan rendah (PEKR) telah dikaji. Kesan pembebanan pengisi BT dan modifikasi kimia ke atas sifat-sifat kekuatan tensil, morfologi, penyerapan air dan sifat-sifat terma biokomposit PEKR/BT telah dikaji. Tiga jenis-jenis modifikasi kimia telah digunakan, seperti maleik anhidrida polietilena (MAPE), agen pengganding kelapa (APK) dan eko-rosotan PD-04. Biokomposit disediakan menggunakan *Brabender Plasticorder EC PLUS* pada suhu 160<sup>0</sup>C dan kelajuan rotor 50 rpm. Keputusan menunjukkan bahawa dengan semakin meningkatnya pembebanan pengisi BT didapati kekuatan tensil dan pemanjangan pada takat putus biokomposit PEKR/BT berkurang, di mana modulus Young dan penyerapan air didapati meningkat. Morfologi patahan permukaan tensil biokomposit menunjukkan pelekatan dan interaksi antara muka yang lemah diantara pengisi hidropilik BT dan hidropobik matrik PEKR. Biokomposit PEKR/BT pada kandungan BT 20 bsp menunjukkan penghabluran yang paling tinggi diikuti PEKR tulen dan biokomposit dengan pembebanan BT 40 bsp. Jumlah pengurangan berat biokomposit berkurang dengan meningkatnya kandungan pengisi. Ini menunjukkan pada suhu yang lebih tinggi biokomposit mempunyai ketahanan terma yang lebih baik. Modifikasi-modifikasi kimia dengan MAPE, APK dan eko-rosotan telah meningkatkan sifat-sifat tensil dan terma biokomposit. Kehadiran MAPE telah meningkatkan kekuatan tensil dan modulus Young biokomposit dengan pengserasi, tetapi pemanjangan pada takat putus didapati berkurang. Biokomposit terawat dengan APK atau eko-rosotan mempunyai kekuatan tensil dan pemanjangan takat putus yang lebih tinggi, manakala modulus Young yang lebih rendah dibandingkan biokomposit tanpa rawatan. Biokomposit terawat dengan MAPE, APK dan eko-rosotan menunjukkan ketahanan terhadap penyerapan air yang lebih baik daripada biokomposit tanpa rawatan. Didapati penghabluran dan kestabilan terma biokomposit terawat adalah lebih tinggi berbanding biokomposit tanpa rawatan. Kajian SEM biokomposit yang dirawat dengan MAPE, APK dan eko-rosotan telah meningkatkan interaksi antara muka BT dan matrik PEKR. Kehadiran MAPE, APK dan eko-rosotan di dalam biokomposit telah dibuktikan dengan kumpulan berfungsi yang baru pada spektra FTIR.

## **Effect Of Filler Loading And Chemical Modification On Properties Of Low Density Polyethylene/Corn Stalk Biocomposites**

### **Abstract**

In this study, the utilization of corn stalk (CS) as a filler in low density polyethylene (LDPE) was investigated. The effect of CS loading and chemical modification on tensile properties, morphology, water absorption and thermal properties of LDPE/CS biocomposites were studied. The three types of chemical modification were used, such as maleic anhydride polyethylene (MAPE), coconut coupling agent (COCA), and eco-degradant PD-04. The biocomposites were prepared using Brabender Plasticorder EC PLUS at temperature 160 °C and rotor speed 50 rpm. The results showed that the increased of CS loading caused decreased in the tensile strength and elongation at break of LDPE/CS biocomposites, whereas the Young's modulus and water absorption increased. The morphology of tensile fracture surface of biocomposites showed the poor adhesion and interfacial interaction between hydrophilic CS and hydrophobic matrix. The LDPE/CS biocomposites at 20 php CS loading indicated highest crystallinity followed pure LDPE and biocomposites at 40 php CS loading. The total weight loss biocomposites decreased with increases CS loading. This indicates at higher temperature the biocomposites have better thermal stability. The chemical modifications with MAPE, COCA or eco-degradant had enhanced the tensile and thermal properties of biocomposites. The presence of MAPE has increased the tensile strength and Young's modulus of compatibilized biocomposites, but elongation at break decreased. The treated biocomposites with COCA or eco-degradant have higher tensile strength and elongation, while Young's modulus lower compared to untreated biocomposites. The treated biocomposites with MAPE, COCA and eco-degradant exhibit better water resistance than untreated biocomposites. It was found the crystallinity and thermal stability of treated biocomposites higher than untreated biocomposites. The SEM study of treated biocomposites with MAPE, COCA and eco-degradant showed an enhanced interfacial interaction between CS and LDPE matrix. The presence of MAPE, COCA and eco-degradant in biocomposites were evident by the new functional group from FTIR spectra.

## CHAPTER 1

### INTRODUCTION

#### 1.1 Research background

Biocomposites from plant derived fiber (natural/biofiber) and crop derived plastics (bioplastic) are novel materials of the twenty first century and would be a great importance to the materials world, not only as a solution to growing environmental threat but also as a solution to the uncertainty of petroleum supply (Mohanty et al., 2002). The development of natural fibers such as kenaf, flax, jute, hemp and sisal has attracted a lot of researchers because of their advantage in that they can be used in a variety of applications and their effectiveness is similar to traditional fillers such as carbon, aramid and glass (Takasu et al., 2002; Thakur et al., 2011). The ease of processing, cost reduction and productivity are the most significant advantages that the polymers offers other materials (Wang et al., 2003; Murugan et al., 2004; Kuboki et al., 2007). The advantages of natural fiber/filler are low cost, low density, low health hazards, biodegradability, better wear resistance and high degree of flexibility, renewability, and high specific strength (Panthapulakkal et al., 2006; Jia et al., 2007). These biocomposites are being extensively used for the production of cost effectively ecofriendly biocomposites.

It is observed that natural fibers/fillers have properties similar to traditional synthetic fiber reinforced biocomposites (Nagaito & Yano, 2005; Bhatnagar & Sain, 2005). A number of significant industries such as the automotive, construction or

packaging industries have shown massive interest in the progress of new biocomposites materials. In automotive industry, Mercedes Benz has forge ahead against the rest in the industry by using jute reinforced plastic for the interior door panels of its E-class vehicles because of lower cost and lower density. All these properties have made natural fibers/fillers very attractive for various industries currently engaged in searching for new and alternate products to synthetic fiber reinforced biocomposites (Singha & Thakur, 2008).

Biocomposites role in variety of applications is very domineering for a long period of time now due to their specific strength and modulus (Cao et al., 2006). Biocomposites will become commercial application of the future that would unravel the potential of these underutilized renewable materials and offer a non food based market for agricultural industry (Alemdar & Sain, 2008).

The polyolefins such as polypropylene (PP) and polyethylene (PE) have been widely used as synthetic polymers in the commercial plastic industry but their non biodegradability and consequently waste disposal problem in nature environment have caused various forms of environmental pollution (Kim et al., 2006; Kim & Kim, 2008). Plastic matrix which comes from a group of polyethylene thermoplastic has been used broadly in daily life (Pollanen et al., 2013). Low density polyethylene resins are once again known as valuable product family. Its combination of superior clarity with a stiffness and density is much preferred by converters for down gauging. Low density polyethylene (LDPE) is commonly used for manufacturing various containers, dispensing bottles, wash bottles, tubing, plastic bags for computer components and packaging applications (Yang et al., 2007).

Corn stalk is one agriculture crops that is widely cultivated around the world and greater weight of corn produced each year. After harvesting of corn, the residue like leaves, cob, stalk and husks were left as part of corn stover in the field (Yeng et al., 2013). The utilization of corn stalk has potential to be incorporated into value product for plastic industry as natural filler.

Some of the researchers has been reported the utilization of lignocellulosic material or natural filler and thermoplastics group as matrices such as LDPE with doum (Arrakhiz et al., 2013), LDPE with palm kernel shell (Salmah et al., 2011b), LDPE with kenaf (Behjat et al., 2010), HDPE with flax fiber (Li et al., 2009), PE with curaua (Araujo et al., 2008), HDPE with bamboo flour (Liu et al., 2008), LLDPE with wood flour (Kuan et al., 2006), PE with sisal (Torress et al., 2005), and PE with wood flour (Farid et al., 2002).

In general, natural fibers provide many advantages for biocomposites but they pose a problem as the usually polar fibers have inherently low compatibility with non polar polymer matrices, especially hydrocarbon matrices such as polypropylene (PP) and polyethylene (PE). The incompatibility may cause problems in composite processing and material properties. To overcome this incompatibility problem, various physical and chemical methods have been employed to modify the natural fibers (Bledzki & Gassan, 1999). There have been several chemical modification used in earlier research such as by grafting polymers onto the fibers (Xie et al., 2010; Beg & Pickering, 2008), treatment with silane (Girones et al., 2007; Xie et al., 2010), bleaching (Aisaeed et al., 2013), and alkali treatment (Alawar et al., 2009; Roy et al., 2012). One study uses a compatibilizer and coupling agent. The addition of MAPP and MAPE as compatibilizing agents has been used in polyolefins such as polypropylene and