THE EFFECTS OF FILLER LOADING AND COUPLING AGENTS ON PROPERTIES OF RECYCLED HIGH DENSITY POLYETHYLENE/ WOOD FIBER COMPOSITES

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LIST OF ABBREVIATIONS

AHA	Alpha-hydroxy acid
AKD	Alkyl ketene dimer
ASTM	American Society for Testing and Materials
BF	Banana fiber
BP	Bamboo powder
DSC	Differential Scanning Calorimetry
EPDM	Ethylene propylene diene monomer
EPM	Ethylene propylene rubber
ESP	Eggshell powder
EVA	Ethylene vinyl acetate
FDT	Final Decomposition Temperature
FTIR	Fourier transforms infrared spectroscopy
HDPE	High density polyethylene
HMDIC	Hexamethylene diisocyanate
HW	High length
ICI	Imperial Chemical Industries
KBr	Potassium Bromide

KF	Kenaf fiber
KP	Kenaf powder
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
MAH	Maleic anhydride
MAPE	Maleic anhydride-grafted-polyethylene
MAPP	Maleated polypropylene
MDPE	Medium density polyethylene
MMA	Methyl methacrylate
MW	Molecular length
NaOH	Sodium hydroxide
NBR	Acrylonitrile butadiene-rubber
NDE	Non-destructive evaluation
NFPC	Natural fiber reinforced polymer composite
NR	Natural rubber
OH	Hydroxyl groups
PAH	Phthalic anhydride
PE	Polyethylene
PE-g-MAH	Polyethylene-grafted-maleic anhydride

PEO-g-MAH	Maleic anhydride grafted Poly(ethylene octane)
PLA	Poly (lactic acid)
PP	Polypropylene
PP-g-MAH	Polypropylene-grafted-maleic anhydride
PS	Polystyrene
PVC	Poly (vinyl chloride)
rHDPE	Recycled high density polyethylene
RHP	Rice husk powder
rLDPE	Recycled low density polyethylene
rNBR	Recycled acrylonitrile butadiene-rubber
rPP	Recycled polypropylene
SA	Salicylic acid
SCB	Sugarcane bagasse
SEM	Scanning electron microscopy
SEBS-g-MAH	Maleic anhydride grafted styrene-(ethylene-co-butylene)-styrene
SW	Short length
TGA	Thermogravimetric analysis
UHMWPE	Ultra-high molecular weight polyethylene
UV	Ultra-violet

VPP	Virgin isotactic polypropylene
WPC	Wood polymer composite
vHDPE	Virgin high density polyethylene
VLDPE	Very low density polyethylene
WHF	Water hyacinth fiber
WHF	Wheat hush fiber
WF	Wood fiber
WF_m	Wood fiber treatment with salicylic acid
WPC	Wood plastic composite
XRD	X-ray diffraction analysis

LIST OF SYMBOLS

cm^3	Cubic centimeter
cm^{-1}	Reciprocal centimeter
CPS	Count per second
g/cm^3	Gram per cubic centimeter
kV	Kilovolt
mA	Milliampere
MPa	Mega Pascals
ml/min	Milliliter per minute
O_c	Organic content
phr	Part per hundred resins
rpm	Rotation per minute
T_g	Glass transition temperature
T_m	Melting temperature
%	Percentage
%T	Transmittance
°C	Degree Celsius
2θ	Two theta

Kesan-Kesan Pembebanan Pengisi dan Agen-Agen Gandingan Terhadap Sifat-Sifat Komposit Polietilena Ketumpatan Tinggi Kitar Semula/Serat Kayu.

ABSTRAK

Polietilena ketumpatan tinggi kitar semula (rHDPE)/serat kayu (WF) komposit telah disediakan menggunakan Brabender Plasticorder pada suhu 160˚C dengan kelajuan rotor pada 50 rpm. Kesan pembebanan serat kayu dan agen gandingan ke atas sifat tegangan, penyerapan air, ciri-ciri morfologi, pencirian spektroskopi infra merah (FTIR), sifat degradasi terma (TGA) dan pencirian (XRD) terhadap komposit rHDPE/WF telah dikaji. Keputusan menunjukkan bahawa penambahan serat kayu telah mengurangkan kekuatan tegangan, pemanjangan pada takat putus dan jarak antara zarah, manakala modulus keanjalan, peratus keseimbangan penyerapan air, kestabilan terma dan nisbah orientasi kristal komposit meningkat. Agen-agen gandingan seperti asid salisilik, maleik anhidrida dan phthalik anhdrida telah digunakan, di mana kesan positif pada sifat tegangan, penyerapan air, kestabilan terma dan peratusan penghabluran komposit rHDPE/WF telah dihasilkan. Kehadiran agen-agen gandingan meningkatkan kekuatan tegangan, modulus keanjalan, kestabilan terma dan nisbah orientasi kristal, akan tetapi menurunkan pemanjangan pada takat putus, penyerapan air dan jarak di antara zarah (d). Keputusan pelbagai agen gandingan pada rHDPE/WF30 komposit telah diperiksa. Kajian mendapati komposit rHDPE/WF_m/MAH menunjukkan kekuatan tegangan, modulus keanjalan, kestabilan terma dan nisbah orientasi hablur yang lebih tinggi diikuti dengan komposit rHDPE/WF_m/PAH > rHDPE / WF_m (serat kayu yang dirawat dengan asid salisilik) komposit > rHDPE / WF komposit mengikut turutan. Tambahan pula, lebih rendah pemanjangan pada takat putus, rendah peratusan keseimbangan penyerapan air dan jarak diantara zarah menjadi lebih kecil (d). Mikroskop penskanan elektron (SEM) permukaan patah tegangan bagi komposit dengan agen-agen gandingan menggunakan asid salisilik, maleik anhidrida, dan phthalik anihdrida menunjukkan bahawa interaksi antara permukaan dan lekatan di antara WF dengan permukaan rHDPE adalah lebih baik daripada komposit rHDPE/WF.

The Effects of Filler Loading and Coupling Agents on Properties of Recycled High Density Polyethylene/Wood Fiber Composites

ABSTRACT

The recycled high density polyethylene (rHDPE)/wood fiber (WF) composites had been prepared using Brabender Plasticorder at temperature 160˚C with rotor speed of 50 rpm. The effect of wood fiber loading and coupling agents on tensile properties, water absorption, morphology, spectroscopy infrared (FTIR) analysis, thermogravimetric analysis (TGA) and x-ray diffraction (XRD) of rHDPE/WF composites were investigated. The results show that the addition of wood fiber reduced the tensile strength, elongation at break and interparticle spacing (*d*), whereas the modulus of elasticity, equilibrium water absorption percentage, thermal stability, and the crystal orientation ratio of composites increased. The coupling agents such as salicylic acid, maleic anhydride, and phthalic anhydride were used, which resulted in positive effect on tensile properties, water absorption, thermal stability and percentages of crystallinity of rHDPE/WF composites. Whereas the presence of coupling agents had increased the tensile strength, modulus of elasticity, thermal stability and crystal orientation ratio but decreased the elongation at break, water absorption and interparticle spacing (*d*). The results of various coupling agents on properties of rHDPE/WF30 composites have been examined. The study was showed that rHDPE/WF_m/MAH composites showed higher tensile strength, modulus of elasticity, thermal stability and crystal orientation ratio followed by rHDPE/WF_m/PAH composites > rHDPE/WF_m (wood fiber treated salicylic acid) composites > rHDPE/WF composites in orders. Furthermore, lower the elongation at break, lower percentage equilibrium water absorption and lower interparticle spacing (*d*). The scanning electron microscopy (SEM) micrographs of tensile fracture surfaces for the composites with coupling agents of salicylic acid, maleic anhydride, and phthalic anhydride indicated that the interfacial interaction and adhesion between WF and rHDPE phases were better than rHDPE/WF composites.

CHAPTER 1

INTRODUCTION

1.1. Research Background

High amount of waste generated, non-biodegradability and fast depletion of natural resources was the reason of plastic becomes major problem nowadays. Wood also implies the problem with lesser degree than plastic where trees and forests are becoming more depleted and its waste are either burned or disposed resulting in extra consumption, depletion and pollution of nature (Bovea et al., 2010; Astrup et al., 2009).

Wood plastic composite (WPC) is a product which can be produced from plastic and wood. WPC is a composite that consisted of mixture of wood waste and polymeric materials and WPC composite also has rapid growing usage nowadays (Soury et al., 2009). This WPC composite can help reduce solid waste content and conserves the natural resources thus allow of saving costs, energy and reduce depletion virgin materials. In addition, sustainability of materials over incoming years can be assured for future generation's use (Talbot, 2013).

It is well known that recycling contributes to a reduction in resources consumption and pollution. For example, the technology developed by Waste and Resources Action Programme (WRAP) for the recycling HDPE milk bottles from kerbside and brings scheme collections in the United Kingdom reported by Kosior, (2006). The results from the rheological tests, processing tests and the mechanical tests show that the recycled HDPE is technically very similar to the virgin resin used to make milk bottles.

The recycled HDPE content was lowered 30 % of transparency compared to virgin HDPE. The other differences that were noted are the presence of gels and black specks and the odor after processing, however, these were not at a level that detracted from us as a commercially acceptable bottle. According to Adhikary et al., (2008a) reported that the composites made from post-consumer recycled HDPE are shown better mechanical properties than composites from virgin HDPE in similar to or in some cases.

Earlier studies show that the recycled HDPE properties were not largely different than the virgin HDPE and the cost also less expensive from those of virgin HDPE. Therefore, recycled HDPE can be used for many applications while offering the vision of subsiding waste disposals and decreasing the costs of product (Adhikary et al., 2008a; Lu & Oza, 2013) studied the mechanical properties of hemp fiber with virgin and recycled high density polyethylene matrix. From the findings, they indicated that hemp fiber composites with recycled HDPE matrix performed better than composites with virgin HDPE in mechanical and thermo-mechanical properties.

Rheological analysis shows the normal flow of recycled LDPE can be promoted by virgin LDPE and thus mobility of chain segments in flow are improved. As a result, blend with recycled LDPE and virgin LDPE has better rheological and processing properties compared to recycled LDPE (Zhao et al., 2013). One of the most important advantages of recycled high density polyethylene is its consistent density and melt flow index in majority of the recycling plants (Mishra & Yagci, 2008).