



UMiMAP

**RHEOLOGICAL AND THERMAL PROPERTIES
OF PALM KERNEL SHELL FILLED LOW
DENSITY POLYETHYLENE COMPOSITES**

by

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LIST OF ABBREVIATIONS, SYMBOLS OR NOMENCLATURES

3-APE	3-aminopropyltriethoxysilane
AA	Acrylic acid
ABS	Acrylonitrile–butadiene–styrene
ASTM	American Society for Testing and Materials
ATR	Attenuated total reflectance
CMCs	Ceramic matrix composites
COCA	Coconut oil coupling agent
DP	Degree of polymerization
DTG	Derivative thermogravimetry
FTIR	Fourier transform infrared
GPa	Giga Pascal
HDPE	High density polyethylene
HDPE-g-MAH	Maleic anhydride grafted HDPE
HEMA	2-hydroxyl ethyl methacrylate
L/D	Length to diameter
LaCOLX	Glucuronoxylan laurate
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
LMDPE	Low medium density polyethylene
LX	Glucuronoxylan
MAPE	Maleic anhydride grafted polyethylene
MAPP	Maleic anhydride grafted polypropylene
MFA	Multifunctional additive

MFI	Melt flow index
MFR	Melt flow rate
MI	Melt index
MMCs	Metal matrix composites
MPa	Mega Pascal
N-H	Amide II
NMR	Nuclear magnetic resonance
PA6	Polyamide 6
PBS	Polybutylene succinate
PC	Polycarbonate
PCL	Polycaprolactone
PEAA	Poly(ethylene-co-acrylic acid)
PLLA	Poly(L-lactide)
PMCs	Polymer matrix composites
PVC	Polyvinyl chloride
php	Part per hundred of polymer
PP	Polypropylene
PKS	Palm kernel shell
PS	Polystyrene
SANMA	Styrene-acrylonitrile-maleic anhydride copolymer
TGA	Thermogravimetric analysis
ULDPE	Ultra low density polyethylene
VLDPE	Very low density polyethylene
A	Coefficient related to melt viscosity
CO ₂	Carbon dioxide

$^{\circ}\text{C}$	Degree Celsius
E	Activation energy
F	Force
H_2O	Water
K	Melt consistency index
kJ/mol	Kilo joule per mole
n	Power law index
η	Viscosity
$-\text{OH}$	Hydroxyl group
τ	Shear stress
$\dot{\gamma}$	Shear rate
Q	Volumetric flow rate
R_0	Linear correlation coefficient
$T_{\text{end deg}}$	End degradation temperature
T_{onset}	Onset temperature
v/v	Volume/volume
V	Velocity
$\text{wt}\%$	Weight percent

Sifat-sifat Reologi dan Terma Komposit Tempurung Kelapa Sawit Terisi Polietilena Berketumpatan Rendah

ABSTRAK

Komposit tempurung kelapa sawit (TKS) terisi polietilena berketumpatan rendah (PEBR) telah disediakan dengan menggunakan pencampur bilah-Z pada suhu 180 °C dan kelajuan rotor 50 rpm. Kesan pembebanan TKS dan pelbagai jenis modifikasi kimia terhadap sifat reologi dan terma komposit telah dikaji. Modifikasi kimia seperti polietilena ko-akrili asid (PKAA), asid akrilik (AA), 3-aminopropiltrioksisilana (3-APE), agen pengkupel minyak kelapa (APMK) dan eko-rosotan telah digunakan dalam kajian ini. Penambahan TKS ke dalam PEBR mengubah sifat-sifat reologi dan terma komposit. Keputusan menunjukkan bahawa peningkatan pembebanan TKS telah mengurangkan nilai-nilai indeks aliran lebur (IAL) dan indeks bukan Newtonian komposit, tetapi konsisten leburan, kelikatan dan tenaga pengaktifan komposit PEBR/TKS meningkat. Peningkatan suhu telah meningkatkan nilai-nilai IAL komposit. Kelikatan komposit yang dijanakan dari reometer kapilari telah berkurang dengan peningkatan suhu. Tegasan ricih ketara komposit meningkat dengan kadar ricih ketara dan pembebanan TKS. Komposit yang ditambah dengan PKAA, AA, APMK dan eko-rosotan menunjukkan nilai-nilai IAL yang lebih tinggi tetapi komposit yang dirawat dengan 3-APE menunjukkan nilai-nilai IAL yang lebih rendah berbanding dengan komposit tanpa rawatan. Tenaga pengaktifan untuk komposit dengan PKAA dan 3-APE lebih rendah, di mana tenaga pengaktifan untuk komposit dengan AA, APMK dan eko-rosotan lebih tinggi berbanding dengan komposit yang tanpa modifikasi kimia. Komposit dengan eko-rosotan memberi kelikatan yang paling rendah, dengan itu, ia menyenangkan pemprosesan komposit yang mempunyai pembebanan pengisi yang tinggi. Sifat-sifat terma komposit menunjukkan bahawa penambahan PKS telah mengurangkan suhu awal degradasi dan kehilangan berat secara keseluruhan komposit. Modifikasi-modifikasi kimia telah meningkatkan kestabilan terma komposit, di mana suhu awal degradasi yang lebih tinggi dan kehilangan berat secara keseluruhan yang lebih rendah pada suhu tinggi telah diperhatikan. Spektra FTIR menunjukkan bahawa kumpulan berfungsi untuk komposit telah berubah dengan modifikasi kimia.

Rheological and Thermal Properties of Palm Kernel Shell Filled Low Density Polyethylene Composites

ABSTRACT

The palm kernel shell (PKS) filled low density polyethylene (LDPE) composites were prepared by Z-blade mixer at temperature of 180 °C and rotor speed of 50 rpm. The effects of PKS loading and different types of chemical modifications on the rheological and thermal properties of the composites were studied. Chemical modification such as poly(ethylene-co-acrylic acid) (PEAA), acrylic acid (AA), 3-aminopropyltriethoxysilane (3-APE), coconut oil coupling agent (COCA) and eco-degradant were used in this study. The addition of PKS into LDPE matrix changed the rheological and thermal properties of the composites. The results showed that increasing PKS loading had decreased the melt flow index (MFI) values and non-Newtonian index but increased the melt consistency, viscosity and activation energy of the LDPE/PKS composites. The increasing temperature had increased the MFI values of composites. The viscosity of composites that was generated from capillary rheometer decreased with rise of temperature. The apparent shear stress of the composites increased with apparent shear rate and PKS loading. The composites with addition of PEAA, AA, COCA and eco-degradant showed higher MFI values but the composites treated with 3-APE exhibited lower MFI values than untreated composites. The activation energy for the composites with PEAA and 3-APE decreased, whereas the activation energy for the composites with AA, COCA and eco-degradant increased as compared to composites without chemical modifications. The composites with eco-degradant gave lowest viscosity, thus eased the composite processing at high filler loading. The thermal properties of composites showed that addition of PKS had decreased the onset temperature and the total weight loss of composites. The chemical modifications had increased the thermal stability of composites, whereas higher onset temperature and lower total weight loss at high temperature were observed. The FTIR spectra of composites showed that the functional groups of the composites changed with chemical modification.

CHAPTER 1

INTRODUCTION

1.6 Research Background

Rheology is defined as the science of deformation and flow. The term “rheology” is derived from the Greek word “rheos” meaning “the river”, “flowing”, or “streaming”. Thus, rheology is literally “flow science” (Mezger, 2006). Generally, it plays crucial role in many industries that involve fluids including polymers, paints, printing inks, detergents, oils, juices, etc. Han (2007) defined polymer rheology as the science that deals with the deformation and flow of polymeric materials. In order to turn the polymeric materials into usable products, forming processes such as injection moulding, extrusion, compression moulding or blow moulding are employed. The polymeric materials are subjected to different levels of shear stress in these forming processes. For thermoplastic, they are melted and forced to flow in confined geometries before they are reformed into solid products of various shape.

All soften or molten polymers are viscoelastic materials, their response to external load lies in varying extent between that of a viscous liquid and an elastic solid (Shenoy, 1999). A number of parameters such as flow rate, pressure and temperature may influence the rheological behaviours of the melts (Sambatsompop, 1999). Through the rheological characterization, the optimum processing parameters of polymeric materials can be selected. Meanwhile, the sensitivity of materials during processing can be determined as well (Mohanty & Nayak, 2007). Moreover, the flow behaviours of