PREPARATION AND CHARACTERISATION OF HEAT-TREATED AND UNTREATED RED BALAU/LDPE COMPOSITES

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ABSTRAK

Serbuk kayu Balau Merah dirawat pada suhu 180°C dan 200°C selama satu jam dan diadun dengan polietilena berketumpatan rendah (LDPE) menggunakan pensemperit pada peratusan berat 9, 20 dan 37%, seterusnya digunakan untuk menghasilkan spesimen ujian dengan mesin acuan suntikan. Spesimen komposit yang didedahkan kepada persekitaran yang berbeza kemudiannya dilakukan pencirian terhadap sifat termal, mekanik dan mekanik dinamik. Analisis termogravimetri menunjukkan rawatan haba dapat memperbaiki sifat termal serbuk kayu dan komposit. Melalui ujian pengimbasan kalorimetri, serbuk kayu tidak menunjukkan berubahan ketara ke atas takat lebur komposit. Walau bagaimanapun, darjah penghabluran komposit yang mengandungi serbuk kayu yang tidak dirawat meningkat dengan peningkatan komposisi serbuk kayu, manakala komposit serbuk kayu yang dirawat, berlaku penurunan apabila komposisi serbuk kayu meningkat. Analisis mekanikal dinamik menunjukkan komposit daripada serbuk kayu dirawat mempamerkan modulus penyimpanan dan modulus kehilangan yang lebih tinggi berbanding dengan serbuk kayu yang tidak dirawat. Nilai tan delta juga didapati lebih rendah bagi komposit sebuk kayu yang dirawat berbanding yang tidak dirawat. Penambahan serbuk kayu dirawat menunjukkan peningkatan modulus tegangan LDPE tulen sebanyak 400% lebih tinggi berbanding serbuk kayu tidak dirawat (309%) kerana rawatan haba pada serbuk kayu dapat meningkatkan pembasahan antara permukaan serbuk kayu dan matriks, yang membawa kepada lekatan antara muka yang lebih baik. Di samping itu, komposit yang mengandungi serbuk kayu dirawat pada 180°C menunjukkan nilai kekuatan tegangan lebih tinggi berbanding serbuk kayu tidak dirawat dan serbuk kayu yang dirawat pada 200°C. Sifat lenturan juga didapati meningkat dengan penambahan serbuk kayu dirawat berbanding dengan komposit serbuk kayu yang dirawat. Beban puncak dan faktor intensti tekanan kritikal meningkat dengan peningkatan komposisi serbuk kayu dan suhu rawatan. Tenaga kegagalan dan kadar lepas tenaga kritikal menurun dengan peningkatan komposisi serbuk kayu. Namun begitu, nilai yang tertinggi diperoleh daripada komposit serbuk kayu dirawat pada 180°C. Penambahan polietilena maleik anhidrida (MAPE) ke dalam komposit yang menggandungi polietilena membawa kepada peningkatan dalam sifat termal dan mekanikal pada tahap yang berbeza. Dalam komposit yang mengandungi serbuk kayu dirawat, penambahan 8% MAPE menghasilkan komposit dengan modulus dan kekuatan tegangan tertinggi manakala 6% MAPE mencatatkan modulus lenturan maksimum. Semua komposit menyerap lembapan pada tahap yang berbeza dan mengakibatkan kemerosotan sifat mekanikal. Komposit daripada serbuk kayu dirawat menunjukkan penyerapan air yang lebih rendah sehingga 90% dan tidak mempamerkan perubahan ketara atas sifat bahan. MAPE tidak menunjukkan kesan perubahan ketara ke atas penyerapan air bagi komposit serbuk kayu yang dirawat. Terhadap kesan penanaman di dalam tanah, komposit daripada kayu dirawat menunjukkan pertumbuhan kulat yang kurang pada permukaan dan ketahanan yang lebih baik terhadap penguraian. Sifat termal dan mekanikal merosot akibat pendedahan kepada persekitaran luar. Walau bagaimanapun, komposit daripada kayu dirawat menunjukkan ketahanan yang lebih kepada persekitaran luar. Kesimpulan dapat dibuat bahawa rawatan haba serbuk kayu meningkatkan keupayaan komposit untuk mengekalkan sifat-sifat mekanikal selepas pendedahan kepada persekitaran luar. Secara umum, sifat-sifat komposit tidak terjejas akibat pendedahan kepada persekitaran tertutup. Oleh itu, menggunakan produk ini sesuai digunakan dalam aplikasi domestik.

ABSTRACT

Red balau saw dust was heat-treated at 180°C and 200°C for one hour and compounded with low density polyethylene (LDPE) at 9, 20 and 37 wt%, then injection moulded. The composites specimens were exposed to different environments and characterised for the thermal, dynamic mechanical and mechanical properties. Thermogravimetric analysis revealed that heat treatment improved the thermal properties of the wood flour and its LDPE composites. Differential scanning calorimetric study showed that wood had no significant effect on the melting behaviour of the composites. However, the degree of crystallinity of composites containing untreated wood flour increased with increasing wood content, while the composites made from heat-treated wood flour, a decreasing trend was observed as the wood content increased. Dynamic mechanical analysis revealed that composites made from heat-treated wood flour exhibited higher storage and loss modulii than that of untreated wood. Lower tan delta values were observed in the heat-treated wood composites.

The tensile modulus of the heat-treated wood flour/LDPE composites increased by 400% while the untreated wood flour/LDPE composites increased by 309% over the neat LDPE. This is because of the improved wetting of the heat-treated wood particles by the matrix, leading to a better interfacial adhesion.

In addition, composites containing wood flour treated at 180°C showed higher tensile strength values than those made from untreated and 200°C treated wood flour. Furthermore, the flexural properties were found to increase with filler loading in the untreated wood composites, relative to those containing heat-treated wood flour. Peak load and critical stress intensity factor increased with wood content and treatment temperature. While the energy to failure and the critical strain energy release rate decreased with wood content, the values are highest in composites made from wood flour treated at 180°C. Incorporation of maleic anhydride grafted polyethylene (MAPE) into the composites led to improvements in the thermal and mechanical properties to various extents. In the composites containing untreated wood flour, incorporation of 8% MAPE provided the highest tensile strength and modulus, while 6% MAPE content recorded the maximum flexural modulus. All composites absorbed moisture to various extents with different levels of mechanical property deterioration. Composites made from heat-treated wood flour showed a reduction in water absorption up to 90% and offered better resistance to decline in properties. Heat-treated wood composites showed negligible effect of MAPE on the water absorption. For soil burial, composites made from heat-treated wood flour showed less fungal growth on the surface and better resistance to properties deterioration. Thermal and mechanical properties deteriorated with outdoor exposure. However, composites made from heat-treated wood flour showed better resistance to the elements of the outdoor environment than their untreated counterparts. It can be concluded that heat treatment of wood flour enhances the properties of wood thermoplastic composites with complementary ability to retain their mechanical properties following exposure to harsh outdoor environment. In general, the properties of the composites are not adversely affected on exposure to indoor environment. Therefore, using this product for domestic applications will be worthwhile.

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a/D	Notch-to-depth ratio
ASTM	American Society for Testing and Materials
ATR	Attenuated total reflectance
D_A	Apparent diffusion coefficient
DMA	Dynamic mechanical analysis
DSC	Differential scanning calorimetry
D_T	True diffusion coefficient
DTG	Derivative thermogravimetry
DT_p	Derivative peak temperature
E''	Loss modulus
E'	Storage modulus
FTIR	Fourier transform infrared
G_c	Critical strain energy release rate
GPa	Giga pascal
HDPE	High density polyethylene
ICTAC	International Confederation of Thermal Analysis and Calorimetry
ILSS	Interlamina shear stress
K_c	Critical stress intensity factor

Kg	Kilogram
LDPE	Low density polyethylene
M	Mass
MAPE	Maleic anhydride polyethylene
MFI	Melt flow index
MPa	Mega Pascal
P	Peak load
PE	Polyethylene
PMMA	Polymethylmethacrylate
PP	Polypropylene
PRF	Permanent reserved forest
PS	Polystyrene
PVC	Polyvinyl chloride
RM	Ringgit Malaysia
S/D	Span to depth ratio
SEM	Scanning electron microscopy
SEN	Single edge notch
$T_{\beta}^{E''}$	Temperature at maximum E″
$T_{50\%}$	Temperature at 50% degradation

$Tan\ \delta$	Tan delta
T_c	Crystallisation temperature
TGA	Thermogravimetric analysis
T_m	Melting temperature
T_{onset}	Onset temperature
T_p	Degradation peak temperature
UV	Ultra violet radiation
V	Volume
W	energy to failure
$W_{\sqrt{2}}$	Tan delta transition region width
wt%	Weight percent
WTC	Wood thermoplastic composites
X_c	Degree of crystallinity
ΔH_c	Enthalpy of crystallization
ΔH_m	Enthalpy of fusion
ρ	Density

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