UTILIZATION OF OPEFB FIBER AND FLY ASH FROM COAL POWER PLANT REINFORCED RECYCLE POLYPROPYLENE FOR ENHANCEMENT IN FLAMMABILITY AND THERMAL PROPERTIES OF COMPOSITE PRODUCTION

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ABSTRAK

Pada masa kini, bidang komposit plastik yang diperkuat dengan gentian semula jadi telah berkembang pesat kerana kesedaran terhadap alam sekitar dan kos ekonomi yang rendah dengan kelebihan lain seperti ketumpatan rendah dan sifat mekanik yang agak tinggi. Namun, salah satu kelemahan utama sistem ini adalah kelemahan mereka terhadap kebakaran. Oleh itu, penyelidikan ini bertujuan untuk membentuk komposit yang memberi penekanan dalam prestasi termal dengan menggabungkan pelbagai jenis sisa sebagai sumber bahan mentah yang boleh dikitar semula untuk penghasilan komposit. Gabungan abu terbang (FA) dari sisa industri sebagai bahan kalis api berasaskan silika dan tandan buah kosong kelapa sawit (OPEFB), sisa pepejal perbandaran yang diperkuat serat, kitar semula polypropylene (RPP) dengan Maleated Polypropylene (MAPP) sebagai penstabil telah dijalankan. Kajian ini akan melibatkan beberapa peringkat iaitu yang pertama adalah pra-rawatan serat alkali. Proses ini melibatkan tiga larutan alkali berbeza Sodium Hydroxide (NaOH), Potassium Hydroxide (KOH) and Aluminium Hydroxide ($Al(OH)_3$) dengan kepekatan 15% (w / v) pada 130 ° C dan selama 40 minit dimana nisbah serat kepada larutan ialah pada 1:10. Kesan terhadap fisiko-kimia dan struktur pra rawatan serat OPEFB telah dikaji secara terperinci melalui beberapa analisis iaitu Fourier Transform Infrared (FTIR), Scanning Electron Microscopy (SEM), and X-ray Diffraction (XRD). Larutan KOH telah dipilih sebagai rawatan terbaik sebelum proses seterusnya iaitu pengkompaunan dengan pelbagai formulasi OPEFB,RPP, FA dan MAPP diikuti dengan proses pengacuan menggunakan mesin penekan bagi menyediakan sampel. Proses ini termasuk dalam fasa kedua. Fasa terakhir melibatkan prestasi pembakaran melalui analisis Limiting Oxygen Index (LOI) dan Underwriters Laboratory 94 (UL94). Berdasarkan hasil yang diperoleh, penyingkiran komponen yang tidak diingini seperti lignin, pektin dan hemiselulosa yang juga bertanggungjawab terhadap sifat degradasi api dapat dilihat dengan jelas di puncak sekitar 1729.74 cm^{-1} untuk analisis FTIR untuk pra-rawatan menggunakan NaOH dan KOH. Disokong oleh pembelahan hemiselulosa dan lignin dalam analisis SEM yang menyebabkan serat lebih berpori dapat diperhatikan secara signifikan berbanding dengan rawatan oleh larutan $Al(OH)_3$ dan serat yang tidak dirawat. Sementara itu, analisis XRD menunjukkan bahawa rawatan KOH menunjukkan indeks kristalinitas tertinggi sebanyak 60.8% namun hanya sedikit berbeza dengan larutan NaOH iaitu 60.5%. Untuk fasa kedua, sebanyak enam sampel telah dihasilkan melalui formulasi yang berbeza diikuti dengan proses pencirian melalui beberapa analisis seperti mechanical testing, SEM, Differential Scanning Calorimeter (DSC) dan Thermogravimetric Analysis (TGA). Telah diperhatikan bahawa dalam semua penambahan FA ke dalam formulasi serat RPP dan OPEFB, terdapat pola penurunan yang signifikan dan serupa dalam variasi kekuatan tegangan (pengurangan sebanyak 4% sehingga 50%) dan juga pemanjangan putus dengan peningkatan kandungan FA seperti yang disokong dalam analisis SEM . Walau bagaimanapun, untuk ujian TGA, penurunan berat sampel paling rendah sebanyak 33% berlaku pada sampel campuran RPP / EFB dengan kandungan FA terbesar iaitu sebanyak 75%. Dengan ketebalan spesimen ujian 3-13mm, UL94 menunjukkan sampel dengan kandungan FA tertinggi memberikan kadar pembakaran 19 (mm / min) yang dianggap sebagai bahan HB yang mana boleh "memadam sendiri" walaupun LOI menggambrkan bahan itu seperti mudah terbakar. Secara keseluruhan, kajian ini menunjukkan bahawa betapa pentingnya KOH pre rawatan kepada OPEFB fiber dan formulasi dengan penglibatan konsentrasi FA sebanyak 75% dapat digunakan sebagai bahan dalam meningkatkan prestasi termal dalam produksi komposit RPP / OPEFB.

ABSTRACT

Nowadays, the field of natural fibers-reinforced plastic composites has rapidly evolving because of environmental awareness and low economic cost with other advantages like low density and relatively high mechanical properties. However one of the major weaknesses of this system is its vulnerability to fire. Hence, this research aims to formulate a bio-composite that emphasises thermal and flammability performance by combining various waste streams as a source of recyclable raw material for fiber composite production. Combination of fly ash (FA) from industrial waste as silica-based flame retardant and biomass oil palm empty fruit bunch (OPEFB) fiber reinforced municipal solid waste, recycle polypropylene (RPP) with Maleinated polypropylene (MAPP) as stabilizer have been conducted. This study involved several phases; the first one is the alkaline pre-treatment of fiber to improve the interfacial adhesion of fiber with polymer matrix due to the loss of hydroxyl group. This process involved three different alkali solution; Sodium Hydroxide (NaOH), Potassium Hydroxide (KOH) and Aluminium Hydroxide ($Al(OH)_3$) with 15% (w/v) concentration at 130°C and for 40 minutes where fibre to solution ratio at 1:10. Their physico-chemical and structural behaviour were studied in detail by several analyses; Fourier Transform Infrared (FTIR), Scanning Electron Microscopy (SEM), and X-ray Diffraction (XRD). The best-treated fibers from the KOH treatment have been chosen then compounding by different formulation of OPEFB fiber, RPP, FA and MAPP have been done followed by molding process with hot press machine to prepare the samples. This process has represented as the second phase. The last phase involved the flammability performance through Limiting Oxygen Index (LOI) and Underwriters Laboratory 94 (UL94) analysis. Based on the result gained in the first phase, the removal of unwanted component such as lignin, pectin and hemicellulose that also responsible for flame degradation properties can be seen clearly at the peak around 1729.74 cm^{-1} for FTIR analysis for NaOH and KOH pretreatment. Supported by the split of hemicellulose and lignin in SEM analysis that cause the fiber to more porous can be observed significantly compared to the treatment by $Al(OH)_3$ solution and raw OPEFB fiber. Meanwhile, XRD analysis revealed that KOH treatment shows the highest crystallinity index by 60.8% yet only slightly different from NaOH treatment, 60.5%. In the second phase, six samples have been prepared with different formulations along with the characterization process by several analysis like mechanical testing, SEM, Differential Scanning Calorimeter (DSC) and Thermogravimetric Analysis (TGA). It was observed that in all addition of FA into the formulation of RPP and OPEFB fiber, there were significant lowering and quite a similar pattern in the variation of tensile strength (reduction from 4% to 50%) and Elongation at the break with the increase in fly ash content as this result was supported in SEM imaging where there were lots of pulled out shape can be seen. However, as for TGA testing, the lowest weight loss by 33% goes to the sample of the mixture RPP/EFB with the most significant FA loading, which is by 75%. The last phase involved the test specimen thickness of 3-13mm, standard for the safety of flammability of plastic material (UL94) described the sample with highest FA content (75%) gave the burning rate of 19 (mm/min), which showed as H-B (slow burning) rated materials that considered as "self-extinguishing" even though the LOI resulted in the material as combustible. Overall, this study showed that the significant of alkaline pre-treatment by KOH on the OPEFB fiber and the best formulation with the involvement of 75% FA concentration can be used as eco-friendly material to enhance thermal performance in RPP/OPEFB composite production.

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LIST OF SYMBOLS

θ	Theta
°C	Celsius
°F	Fahrenheit
I_{002}	Maximum intensity
I_{am}	Intensity of the amorphous diffraction
Wt.%	Weight percentage

LIST OF ABBREVIATIONS

Al	Aluminium
$Al(OH)_3$	Aluminium hydroxide
Al_2O_3	Aluminium oxide
ASTM	American Society for Testing and Materials
Ar	Arsenic
BR	Burn rate
Ca	Calcium
CaO	Calcium oxide
Cd	Cadmium
CO_2	Carbon dioxide
Cr	Chromium
DSC	Differential scanning calorimeter
EFB	Empty fruit bunch
FA	Fly ash
Fe	Ferum
Fe_2O_3	Ferric oxide
FTIR	Fourier transform infrared
Hg	Mercury
K	Potassium
KOH	Potassium hydroxide
LOI	Limiting oxygen index
MAH	Maleic anhydride
MAPP	Maleic anhydride-g-polypropylene
Mg	Magnesium
MgO	Magnesium oxide
Na	Sodium
Na_2SiO_3	Sodium silica oxide
NaOH	Sodium hydroxide
Ni	Nickel
OPEFB	Oil palm empty fruit bunch
Pb	Lead

PFA	Pulverised fly ash
PP	Polypropylene
RH	Relative humidity
RPP	Recycle polypropylene
S	Sulphur
Se	Selenium
SEM	Scanning electron microscopy
Si	Silica
SiO_2	Silica oxide
SIRIM	Standard and Industrial Research Institute of Malaysia
SO_3	Sulphate oxide
TGA	Thermogravimetric analysis
UL94	Standard for safety of flammability of plastic materials (Underwriters Laboratories 94)
XRD	X-ray diffraction
Zn	Zinc

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