CHARACTERIZATION OF OIL PALM EMPTY FRUIT BUNCH MAT/WOVEN AND NON-WOVEN KENAF FIBER-REINFORCED EPOXY HYBRID BIOCOMPOSITES

By

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The demand for sustainable materials has increased, leading to a greater emphasis on using renewable and eco-friendly resources, such as natural fibers, as reinforcement in engineering composites. The primary objective of this study is to evaluate characterization of oil palm empty fruit bunch (EFB) mat/woven and non-woven kenaf fiber reinforced with epoxy polymers. The hybridization effect of oil palm EFB/kenaf fibers was studied at different weight ratios (30EFB:70K; 50EFB:50K; 70EFB:30K), while maintaining a total fiber loading of 50% by weight. The fibers in mat form were stacked alternately using a hand lay-up method and then subjected to hot pressing molding. Various physical, mechanical, thermal, and morphological properties were evaluated following American Society for Testing and Materials (ASTM) standards. Three stages of fabrication for the composites were prepared: single oil palm EFB composites and kenaf fiber (woven and non-woven) composites. Following by oil palm EFB mat/non-woven kenaf hybrid and oil palm EFB mat/woven kenaf hybrid composites. The finding demonstrated that non-woven kenaf composites exhibited slightly higher of tensile strength and modulus with values of 84.32 MPa,2782.5 MPa, respectively compared to woven kenaf composites with value of 65.9 MPa,2630.63 MPa, respectively. Positive hybrid effects were observed indicating good tensile strength and modulus in the 50EFB:50K hybrid composites for non-woven kenaf/oil palm EFB with value of 62.26 MPa, 3579.04 MPa, respectively. Meanwhile, the 30EFB:70K hybrid composites exhibited highest tensile strength and modulus with values of 55.72 MPa,2972.78 MPa, respectively. The flexural strength and modulus indicated 50EFB:50K hybrid composites given highest values (113.14 MPa, 7797.86 MPa respectively) for non-woven kenaf/oil palm hybrid composites while the 30EFB:70K hybrid composites showed highest values (115.8 MPa, 8724.7 MPa respectively) for woven kenaf/oil palm EFB hybrid composites. However, oil palm EFB composites exhibited higher impact strength due to high-speed impact loads and the chemical composition of oil palm EFB with a values of 8.5 J. Similarly, to

impact properties, oil palm EFB composites reported higher void content, water absorption, and thickness swelling attributed to their random orientation and wetting of the fibers. Kenaf fiber composites for both woven and non-woven exhibited excellent thermal properties thus improving hybridizing of oil palm EFB/woven and non-woven hybrid composites. Overall, the 50EFB:50K hybrid composites exhibited the best thermal stability, char residue, and decomposition temperature for both hybrid composites. This is attributed to the inclusion of fibers inhibiting segmental motion within the composite structure, thereby boosting the thermal stability of the hybrid composites. Further research and improvements can be applied to enhance the properties of oil palm EFB/kenaf fiber reinforced epoxy hybrid composites.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENCIRIAN BIOKOMPOSIT HIBRID EPOKSI DIPERKUKUH OLEH HAMPARAN SERAT TANDAN BUAH KOSONG KELAPA SAWIT/HAMPARAN TERANYAM DAN TIDAK TERANYAM SERAT KENAF

Oleh

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Disember 2023

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Institut : Perhutanan Tropika dan Produk Hutan

Permintaan untuk bahan lestari telah meningkat, yang membawa kepada penekanan yang lebih besar kepada penggunaan sumber yang boleh diperbaharui dan mesra alam, seperti serat semulajadi, sebagai bahan memperkukuh dalam kejuruteraan komposit. Objektif utama kajian ini ialah untuk menilai ciri-ciri biokomposit hibrid epoksi diperkukuh oleh hamparan serat tandan buah kosong kelapa sawit (EFB)/hamparan teranyam dan tidak teranyam serat kenaf. Kesan hibridisasi serat kelapa sawit EFB/kenaf telah dikaji pada nisbah berat yang berbeza (30EFB:70K; 50EFB:50K; 70EFB:30K), sambil mengekalkan muatan serat keseluruhan sebanyak 50% berdasarkan berat. Serat-serat dalam bentuk hamparan telah ditindan secara berselang-seli menggunakan kaedah menghampar menggunakan tangan dan kemudian dikenakan dengan tekanan acuan yang dipanaskan. Pelbagai sifat fizikal, mekanikal, termal dan morfologi dinilai mengikut piawaian ASTM. Tiga tahap pembuatan telah disediakan untuk komposit ini. Pertama, komposit dengan serat tunggal kelapa sawit EFB dan komposit dengan hamparan (teranyam dan tidak teranyam) serat tunggal kenaf. Kedua, hibridisasi hamparan kelapa sawit EFB/serat kenaf tidak teranyam. Terakhir ialah hibridisasi hamparan kelapa sawit EFB/serat kenaf teranyam. Hasil penemuan telah menunjukkan bahawa komposit dengan hamparan tidak teranyam serat kenaf mempunyai kekuatan tegangan dan modulus yang sedikit tinggi dengan nilai 84.32 MPa dan 2782.5 MPa berbanding komposit dengan hamparan teranyam serat kenaf dengan nilai 65.9 MPa dan 2630.63 MPa. Kesan hibridisasi yang positif dapat dilihat menunjukkan kekuatan tegangan dan modulus yang baik bagi komposit hibrid 50EFB:50K untuk kelapa sawit EFB/hamparan tidak teranyam kenaf dengan nilai 62.26 MPa dan 3579.04 MPa. Sementara itu, hibrid komposit 30EFB:70K menunjukkan kekuatan tegangan dan modulus yang tertinggi dengan nilai 55.72

MPa dan 2972.78 MPa kelapa sawit EFB/hamparan teranyam kenaf. Kekuatan lenturan dan modulus telah menunjukkan komposit hibrid 50EFB:50K memberi nilai tertinggi (113.14 MPa, 7797.86 MPa) mewakili hamparan tidak teranyam kenaf/kelapa sawit EFB, manakala komposit hibrid 30EFB:70K menunjukkan nilai tertinggi (115.8 MPa dan 8724.7 MPa) mewakili kelapa sawit EFB/hamparan teranyam kenaf. Walaubagaimanapun, komposit kelapa sawit EFB tunggal menunjukkan kekuatan hentaman yang lebih tinggi berdasarkan kesan daripada beban berkelajuan tinggi dan komposisi kimia untuk kelapa sawit EFB dengan nilai 8.5 J. Dengan cara yang sama, komposit kelapa sawit EFB tunggal dilaporkan kandungan liang, serapan air dan ketebalan pembengkakan yang lebih tinggi kesan daripada orientasi rawak dan kebasahan serat. Komposit serat kenaf bagi kedua-dua hamparan teranyam dan tidak teranyam menunjukkan sifat termal yang amat baik justeru menambah baik hibridisasi komposit kelapa sawit EFB/hamparan teranyam dan tidak teranyam serat kenaf. Secara keseluruhannya, hibrid komposit 50EFB:50K menunjukkan stabiliti termal, sisa hangusan dan suhu penguraian yang terbaik untuk kedua-dua komposit hibrid kelapa sawit EFB/hamparan teranyam serat kenaf dan kelapa sawit EFB/hamparan tidak teranyam serat kenaf. Ini adalah kesan daripada rangkuman serat yang menduduki gerakan segmental di dalam struktur komposit, justeru menggalakkan kestabilan termal komposit hibrid tersebut. Penyelidikan dan penambah baikan lanjutan boleh diaplikasikan untuk menambahbaik komposit hibrid kelapa sawit EFB/serat kenaf.

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