

Some properties of bio-based epoxy vitrimers with activated carbon derived from oil palm biomass; effects of curing ratio and filler content

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ABSTRACT

The increasing demand for recyclable, high-performance adhesives in engineered wood systems has led to growing interest in dynamic covalent resins. This study investigates a bio-based epoxy vitrimer reinforced with activated carbon derived from palm kernel shell (PKS), a lignocellulosic byproduct of the oil palm industry. The vitrimer matrix, formulated using Diglycidyl Ether of Bisphenol A (DGEBA) and a disulfide-based curing agent (2-aminophenyl disulfide), enables thermal reprocessability and self-healing via dynamic exchange reactions.

Formulations varied epoxy-to-curing agent ratios (1:1.4, 1:1.6, 1:1.8) and activated carbon loadings (0.5-1.5 wt%). Mechanical, thermal, and self-healing properties were evaluated using tensile testing, TGA, DMA, FESEM, and FTIR. The 1:1.6 ratio with 1.0 wt% filler demonstrated the highest mechanical and thermal performance, including dual glass transitions, enhanced crosslinking, and improved char residue. In contrast, the 1:1.8 formulation achieved the highest self-healing efficiency (74%), attributed to increased chain mobility. FTIR confirmed strong N-H and Si-O-Si bonding, while FESEM revealed microstructural recovery. However, excessive filler content (1.5 wt%) caused agglomeration and reduced performance.

These findings revealed that vitrimer performance can be tailored through formulation tuning, supporting the development of renewable, reprocessable adhesives for engineered wood composites. Future research will investigate adhesion to wood substrates, long-term durability, and catalyst-assisted healing to further enhance sustainability and functional performance.

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