Chemical recycling of thermosetting epoxy composite from renewable resources manufactured by the Vacuum-Assisted Resin Infusion process (VARI)

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Thermosetting epoxy composites are well known in the literature for their high physical and chemical properties; however, due to the non-melting nature of the thermoset matrix, they are very difficult to recycle [1]. Different recycling methods have been explored, including mechanical, thermal, and chemical recycling methods, to find the most environmentally friendly and financially viable solution for waste management.

This research work focuses on the chemical recycling of a Carbon Fiber-Reinforced Composite (CFRC) manufactured through a Vacuum-Assisted Resin Infusion (VARI) process [2]. The composite is characterized by a high Young's modulus of approximately 7 GPa, consistent with materials used for structural applications. A mixture of green solvents is utilized in this study, specifically 14M acetic acid (95% v/v) and 9M hydrogen peroxide (5% v/v), aligning with the following study [3]. Three different experiments are conducted at three distinct temperatures, while maintaining a constant atmospheric pressure. The recovered fibers are designated as r-F70 (obtained at 70°C), r-F80 (obtained at 80°C), and r-F90 (obtained at 90°C). Spectroscopic investigations indicate that chemical bond cleavage occurred through the selective breaking of the C-N bonds within the cross-linked matrix structure, allowing for the recovery of both the reinforcing phase and the epoxy matrix in the form of oligomers or monomers of the epoxy matrix. The final depolymerization efficiency is evaluated by a new method through thermogravimetric analyses. It is observed that the depolymerization efficiency increased with the reaction temperature, reaching a maximum value of 81.3%. The same trend is observed from morphological analyses, electrical characterization, and atomic force microscopy.

These results demonstrate that it is possible to recycle carbon fiber composites for structural applications using green solvents at low temperatures and atmospheric pressure, thereby reducing the environmental impact and the cost associated with recycling processes.

Keywords: *chemical recycling, epoxy resin, CFRC*

References

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