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Hygrothermal aging in biocomposites: Mechanisms, influencing factors, moisture diffusion models, and impact on material properties

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Abstract

Natural fiber–reinforced polymer composites (NFPCs) are a sustainable and eco-friendly alternative to synthetic fibers for various applications. However, they are susceptible to hygrothermal aging due to hygroscopic natural fibers, which leads to expedited degradation and early failure of biocomposites when exposed to high humidity and temperature. This chapter reviews the factors inducing hygrothermal aging of the biocomposite, detailing the mechanisms and investigating the effect of various factors with a particular emphasis on moisture ingress, temperature, solubility, type of fiber, and polymer matrix in relation to the mechanical behavior and morphology of NFPCs. It also examines the impact of hygrothermal aging on the mechanical characteristics of biocomposites, including the degradation of these qualities under various applications. The chapter also reviews the challenges of predicting the long-term performance of biocomposites while accounting for the hydrothermal effect. The methodologies employed to prevent hygrothermal aging, such as polymer coating, chemical treatment, and fiber hybridization, are discussed. Resultantly, the fiber-hybridizing method has been recognized as an optimization strategy for NFPCs in structural and semistructural applications, demonstrating effective hygrothermal aging resistance. This approach provides avenues for property improvement and economical strategies to alleviate the drawbacks of NFRCs. The chapter concludes by highlighting the opportunities for future research in this field, which will contribute to the advancement of sustainable materials.