148ª DEFESA DE TESE EM ENGENHARIA INDUSTRIAL

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA INDUSTRIAL - PEI

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Título: DEVELOPMENT OF SUSTAINABLE HYBRID POLY (BUTYLENE SUCCINATE) ECO-COMPOSITE FOR AGRICULTURAL PACKAGING APPLICATIONS.

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Resumo:

The growing concern over plastic pollution, particularly from non-biodegradable packaging materials used in agriculture, has driven the search for sustainable alternatives. Poly(butylene succinate) (PBS) is a promising aliphatic polyester due to its biodegradability, biocompatibility, and compatibility with conventional processing techniques. However, its high cost still limits its use in low-value applications such as seedling trays and agricultural packaging. In this context, the present study aimed to develop cost-effective, high-performance PBS-based hybrid eco-composites reinforced with Canabrava natural fiber (Gynerium sagittatum), kraft lignin, and sepiolite or montmorillonite clay. The goal was to reduce the overall cost, enhance functional properties, and provide an environmentally responsible alternative material to conventional non-biodegradable thermoplastics. Canabrava fiber, an underutilized lignocellulosic residue from Brazilian handicraft production, was used as sustainable reinforcement and processed by simple mechanical methods without chemical treatments. Lignin, a byproduct of the pulp and paper industry, was incorporated to improve termal stability, melt flow, and biodegradability control. Sepiolite, a natural fibrous clay with high surface area, was added to improve thermal and mechanical performance. Epoxidized soybean oil (ESO) was also evaluated as a compatibilizer and plasticizer to mitigate the brittleness typically observed in fiber-reinforced biopolymers. The research was conducted in two experimental phases. In the first, PBS/Cana composites containing lignin and clays (sepiolite or montmorillonite) were formulated and characterized through mechanical, thermal, and structural analyses (FTIR, XRD, SEM). In the second phase, a design of experiments (DOE) approach was applied to optimize formulations by evaluating the individual and synergistic effects of lignin, sepiolite, and ESO on properties such as melt flow rate, stiffness, toughness, and soil biodegradability. The results showed that Canabrava fiber significantly increased PBS stiffness and yield strength, while lignin improved melt flow and thermal stability. Sepiolite enhanced dispersion and interfacial interaction with the polymer matrix, resulting in improved mechanical performance. Although epoxidized soybean oil (ESB) was primarily incorporated to enhance fiber-polymer compatibility and secondarily to improve ductility, its contribution to increased ductility was not significant, attributed to its limited solubility in PBS. Optimized formulations showed a good balance between mechanical performance, biodegradation behavior, and cost. The developed composites exhibited competitive technical properties compared to fossil-based polyolefins, while offering a fully biodegradable and renewable alternative. This work advances eco-composite technology by integrating low-cost biomass residues and natural additives into biopolymers, aligning with circular economy principles and sustainable development goals. The properties achieved by the bio composite are comparable to those of polyolefin resins, making it a promising candidate for applications in agriculture, for example.

Palavras-chave: Poly(butylene succinate); Eco-composites; Canabrava fiber; Sepiolite; Lignin; Epoxidized soybean oil.