(43)

Developing Eco-Friendly ABS Composites with Naphthoylated Microcrystalline Cellulose: Advancing Green Materials for Industrial Applications

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Abstract

Microcrystalline cellulose (MCC), a sustainable and renewable material, holds significant potential for advancing green technologies in environmental engineering. This research focuses on improving the mechanical properties of acrylonitrile butadiene styrene (ABS) polymer through the development of ABS-MCC composites, which can offer more eco-friendly alternatives for industrial applications. To overcome MCC's inherent hydrophilicity and enhance its compatibility with the hydrophobic ABS matrix, MCC was functionalized via naphthoylation, using aqueous 7% NaOH and 12% urea to facilitate the reaction. Results of Fourier-transform infrared spectroscopy (FTIR) and UV-visible spectrophotometry indicate naphthoyl group functionalization, with key FTIR bands at 1,669 cm^{-1} (carbonyl stretching) and 1,568 cm^{-1} (naphthalene C-H axial deformation). Contact angle measurements further confirm a reduction in hydrophilicity due to the naphthoyl group functionalization. The modified MCC was incorporated into ABS using melt blending, followed by compression molding to create composite sheets. Samples with varying modified-MCC loadings (1%, 3%, and 5%) were prepared to evaluate their mechanical performance. Shore D hardness tests showed a significant improvement in hardness compared to both pure ABS and non-functionalized MCC composites. The 5% functionalized MCC composite exhibited the highest hardness, attributed to enhanced interfacial adhesion between MCC and ABS, driven by π-π stacking interactions between the naphthoyl groups of modified-MCC and the styrene units in ABS. This research demonstrates that functionalized MCC can significantly enhance the performance of ABS composites, presenting a sustainable alternative for sectors such as automotive and construction. From an environmental engineering perspective, these composites reduce reliance on non-renewable resources, support the development of green materials, and have the potential to minimize the environmental impact of industrial manufacturing processes. Future work will explore additional mechanical properties, environmental impact assessments, and scalability for broader industrial adoption.

Keywords: *Microcrystalline cellulose, Acrylonitrile butadiene styrene, Sustainable materials, Polymer composites, Environmental engineering*