EFFECT OF ALKALINE TREATMENT ON STUCTURE OF HEMP SEED HULLS AND THE BIODEGRADABILITY OF THERMOPLASTIC BIOCOMPOSITES

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Most conventional plastics originate from fossil resources and, if inadequately managed at the end of their life cycle, accumulate in the environment, contributing to greenhouse gas emissions and pollution [1,2]. Incorporating cellulose-based components, including modified cellulose and agricultural by-products such as hemp seed hulls, into biocomposite formulations not only reduces dependence on petroleum-based polymers but also supports circular-economy principles through the valorization of biomass residues.

The aim of this work is to evaluate the effect of alkaline treatment on the structure and biodegradability of biocomposites containing hemp seed hulls.

Biocomposites were obtained using hemp seed hulls (HH) as a filler in a cellulose diacetate matrix. The formation of biocomposites was carried out using a twin-screw extruder at a temperature range of 130-190 °C. To enhance interfacial adhesion between the filler and the polymer, the hulls were treated with alkali solutions at concentrations ranging from 4% to 16%. Alkaline treatment resulted in the removal of lignin, proteins and lipids from HH, thereby increasing their relative cellulose content. Hemicellulose content decreased most significantly, followed by a moderate reduction in lignin. During alkaline hydrolysis up to 29% of hemicellulose and 9% of lignin was removed without cellulose loss in HH biomass, demonstrating strong affinity between NaOH and amorphous cell wall components. However, even at higher NaOH concentrations, no evidence of cellulose mercerization was detected. XRD analysis confirmed the absence of the characteristic structural transition from cellulose I to cellulose II, indicating that alkaline treatment did not induce crystalline rearrangement in the hemp seed hulls. Instead, SEM analysis revealed pronounced surface degradation and increased roughness of the alkali treated hulls. The biocomposites with alkalized hemp hulls exhibited measurable biodegradation during the initial days of testing. Meanwhile, after 70 days approximately 29% biodegradation was reached under the applied conditions.

Obtained results show that that hemp seed hulls are suitable for the production of thermoplastic biocomposites. Alkaline treatment increases the surface roughness of the hulls, enhancing interfacial adhesion between the filler and the cellulose diacetate matrix. Moreover, biocomposites containing alkalized hulls exhibit improved biodegradability compared with untreated materials.

[1] "Plastics," Environment. https://environment.ec.europa.eu/topics/plastics/
[2] S. Nizamuddin and C. Chen, "Biobased, biodegradable and compostable plastics: chemical nature, biodegradation pathways and environmental strategy," Environmental Science and Pollution Research, vol. 31, no. 6, pp. 8387–8399, Jan. 2024, doi: 10.1007/s11356-023-31689-w.