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Nanocellulose Reinforced Biocomposites Based on Wheat Plasticized Starch for Food Packaging

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Abstract : Starch is a promising polymer for producing biocomposite materials because it is renewable, completely biodegradable and easily available at a low cost. Thermoplastic starches (TPS) can be obtained after the disruption and plasticization of native starch with a plasticizer. In this work, the solvent casting method was used to obtain TPS films from wheat starch plasticized with glycerol and reinforced with nanocellulose (CNC). X-ray diffraction analysis was used to follow the evolution of the crystallinity. The native wheat starch granules have shown a profile corresponding to A-type crystal structures typical for cereal starches. When TPS films are analyzed a high amorphous halo centered on 19º is obtained, indicating the plasticization process is completed. SEM imaging was made in order to analyse the morphology. The image from the raw wheat starch granules shows a bimodal granule size distribution with some granules in large round disk-shape forms (A-type) and the others as smaller spherical particles (B-type). The image from the neat TPS surface shows a continuous surface. No starch aggregates or swollen granules can be seen so, the plasticization process is complete. In the surfaces of reinforced TPS films aggregates are seen as the CNC concentration in the matrix increases. The CNC influence on the mechanical properties of TPS films has been studied by dynamic mechanical analysis. A direct relation exists between the storage modulus values, E', and the CNC content in reinforced TPS films: higher is the content of nanocellulose in the composite, higher is the value of E'. This reinforcement effect can be explained by the appearance of a strong and crystalline nanoparticle-TPS interphase. Thermal stability of films was analysed by TGA. It has not observed any influence on the behaviour related to the thermal degradation of films with the incorporation of the CNC. Finally, the resistance to the water absorption films was analysed following the standard UNE-EN ISO 1998:483. The percentage of water absorbed by the samples at each time was calculated. The addition of 5 wt % of CNC to the TPS matrix leads to a significant improvement in the moisture resistance of the starch based material decreasing their diffusivity. It has been associated to the formation of a nanocrystal network that prevents swelling of the starch and therefore water absorption and to the high crystallinity of cellulose compared to starch. As a conclusion, the wheat film reinforced with 5 wt % of cellulose nanocrystals seems to be a good alternative for short-life applications into the packaging industry, because of its greatest rigidity, thermal stability and moisture sorption resistance.

Keywords : biocomposites, nanocellulose, starch, wheat
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