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Modelling the Thermomechanical Behaviour of Thermoplastic Starch – Cellulose Fibres Composites

V. Randrembason, J.C. Bénézet, L. Ferry, M. Fouletier
Centre des Matériaux de Grande Diffusion, Ėcole des Mines d'Alès, 6 avenue de Clavières, 30319 Alès Cedex, France

Starch is a natural and renewable polymer suitable for designing new biodegradable industrial products. Plasticized starch exhibits flexibility properties and good mechanical strength but its development is limited by its moisture sensitivity. In order to decrease hydrophily and to enhance thermo-mechanical properties, wood cellulose fibres were incorporated in thermoplastic starch. Composites were produced by common processing techniques (extrusion and injection moulding). The aim of this work is to study relations between processing, microstructure and mechanical properties for these composites by coupling an experimental approach with mechanical modelling.

The static and dynamic mechanical behaviour of thermoplastic starch (TPS)-cellulose fibres composites, was examined as a function of fibre aspect ratio and volume fraction for two storage conditions (50%, 74% relative humidity). The results showed that the presence of fibres reduces material hydrophily however the influence of water on the mechanical behaviour remains strong. The presence of cellulose fibres may induce different phenomena, such as the formation of water clusters, the modification of starch retrogradation or plasticization, which counterbalance its intrinsic positive effect on water sensitivity. Halpin-Tsai equations have been used for predicting the viscoelastic properties of TPS-cellulose composites. Modeling succeeds in well describing experimental results obtained for samples stored at 50% RH, indicating that, in these storage conditions, the microstructure of starch matrix is not strongly affected by the presence of fibres. For samples stored at 74%RH, mismatches between experiments and modeling are observed. Attempts have been made to relate these discrepancies to characteristics of cellulose fibres (polydispersity, orientation, tortuosity, percolation) and to morphological changes induced by cellulose fibres (starch retrogradation, presence of porosity...).