Structure–property relationships in bionanocomposites for industrial applications

STRUCTURE–PROPERTY RELATIONSHIPS IN BIONANOCOMPOSITES FOR INDUSTRIAL APPLICATIONS

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Introduction

Bionanocomposites are an emerging class of nanostructured biomaterials, involving a bioderived polymer combined with organic or inorganic fillers, showing at least one nanometric dimension. These promising materials have potential industrial applications as an alternative to nanocomposites based on petrochemical thermoplastics, in attempting to solve the environmental concerns related to the intensive utilization of non-renewable resources.

Material and methods

Five different commercial biopolymers (i.e. blends of aliphatic and aromatic biodegradable co-polyesters with proprietary composition) were used as polymeric matrices. Two modified clays and a nanosized $CaCO_3$ were used as fillers. Bionanocomposites containing 5 wt.% of fillers were obtained through melt compounding, then subjected to a further processing step, aiming at evaluating their suitability for film blowing or pipe extrusion and finally characterized.

Results and discussion

The rheological characterization of all investigated bionanocomposites showed that, regardless of the biopolymeric matrix, the introduction of nanoclays significantly modified the material low-frequency rheological response, promoting a slowdown of the relaxation processes of the macromolecular chains due to the achievement of an intercalated morphology. Otherwise, bionanocomposites containing nanosized calcium carbonate exhibited a rheological behavior quite similar to that of the unfilled matrices, notwithstanding higher viscosity values. The analysis of the high-shear rheological response suggested a marginal effect of the nanofiller on the trends of the shear viscosity curves; similar results were obtained from the characterization of the material behavior under non-isothermal elongational flow, as the presence of the nanofillers did not remarkably affect the deformability of the biopolymers. The mechanical characterization highlighted an increase of the elastic modulus of the biopolymers, owing to the homogeneous dispersion of the nanofillers within the host matrices and the good extent of interfacial adhesion, notwithstanding a slight reduction of the materials ductility. Finally, the evaluation of the processing behavior of all the investigated materials allowed for identifying the most suitable systems for the production of blown films or irrigation pipes. Additionally, the mechanical characterization of the so-processed materials indicated that selected bionanocomposites show adequate performances, thus confirming their suitability for these specific industrial applications as an alternative to traditional thermoplastics.