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Valorisation of Hazelnut Shell Powder (HSP) in the production of biobased and recyclable composites.

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Introduction

Biocomposites based on natural fibers waste and biopolymers are currently explored because of their renewability, biodegradability and the accordance with the circular economy principles. Among the sources derived from agro-food waste, hazelnut shells can be of considerable interest because of their wide availability. This waste is composed of 90% of a lignocellulosic fraction with crude fiber accounting for over 85%. Considering the high amount of lignin and a predominantly fibrous structure, the hazelnut shell is considered a highly stiff material. Thus, it can be considered suitable as mechanical reinforcement for the production of biocomposites. Additionally, the recyclability of these biocomposites can be enhanced thanks to the possible addition of biobased processing aids, as they can enable a fine tuning of melt viscosity.

In the present work, biocomposites having a poly(lactic acid) (PLA) based matrix were produced by extrusion, considering different HSPs concentrations with the aim to obtain final biocomposites with a high filler quantity, acceptable mechanical properties and good melt fluidity. Moreover, methodologies to contrast the reduction of molecular weight through the use of biobased chain extenders were also investigated. Biobased chain extenders, consisting of epoxidized soy bean oil (ESO) and dicarboxylic acids from agro-food waste were used in a PLA/poly(butylene succinate-*co*-adipate) (PLA/PBSA) binary blend matrix reinforced with HSP.

Experimental

Biocomposites were prepared by miniextrusion (Haake Minilab II) in a first step using HSP with two different granulometries (HM210 > HM200), then they were scaled-up by semi-industrial twin screw extrusion (Comac EBC 25HT (L/D = 44)). The materials were injection moulded (Megatech H10/18) and characterized in terms of tensile properties (MTS Criterion model 43), Charpy impact properties (CEAST 9050), thermal characterization by DSC (Q200-TA DSC) and melt flow rate (CEAST Melt Flow Tester M20).

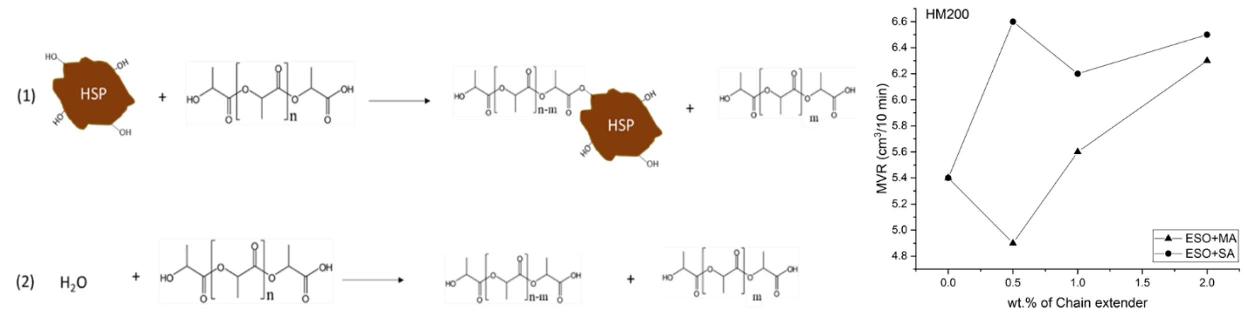

Figure 1. (a) Main reactions occurring during the preparation of PLA/HSP biocomposites, Reaction 1 involves a HSP solid particle; (b) Melt Volume Rate as a function of biobased chain extenders (ESO+MA and ESO+SA) percentage in PLA/PBSA based composite reinforced with HSP (HM200 type).

Results and Discussion

For the preparation of biocomposites two different HSPs of different sizes were added (20, 30 and 40 wt.%). For the best composition, the scale-up in a semi-industrial extruder was then explored. Thanks to the activation of the extruder venting system, the residual moisture was efficiently removed, guaranteeing to the final composites improved mechanical and melt fluidity properties, when compared to the lab-scaled composites. The addition of biobased chain extenders resulted only in a slight change of the biocomposites properties. A modest increase in melt viscosity, but only for the HSP with the lower dimension (so the higher surface area) was evidenced. Thus, the slight chain scission of polyesters, not significantly affecting the final properties (Figure 1b) of these biocomposites, is the most relevant effect that was revealed in this complex reactive system, thus suggesting the good recyclability of the Biocomposites containing HSP.

Conclusions

The possibility to process at the semi-industrial scale PLA-based composites containing hazelnut shell powder (HSP) was successfully investigated. The composition including 30 wt.% of HSP was selected for the successive scale-up in a semi-industrial extruder and the scaled-up composites showed improved mechanical properties. Thus it was possible to achieve an optimized balance between improvement of mechanical properties and the valorisation of a significantly high HSP content.

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Biography

Maria-Beatrice Coltelli is an Associate Professor of Materials Science and Technology of the Department of Civil and Industrial Engineering of the University of Pisa, referent person for UNIPI for the Biobased Industry Consortium. Her researches are mainly focused on polymer science. She is author/co-author of more than 115 papers published on international journals, co-authors of books and of three patents.