Functionalization of agro-food waste fillers to develop antimicrobial green composites of interest in active food packaging

S. Torres-Giner [1], K.J. Figueroa-Lopez [1], B. Melendez-Rodriguez [1], L. Hilliou [2], A.A. Vicente [3], J.M. Lagaron [1]

[1] Novel Materials and Nanotechnology Group, IATA-CSIC, Paterna, Spain Tel.: (+34) 963 900 022. E-mail: storresginer@iata.csic.es [2] IPC/I3N, University of Minho, Guimarães, Portugal [3] CEB, University of Minho, Braga, Portugal

Introduction – The use of agro-food residues as fillers in polymer composites is gaining a significant attention due to their huge availability and low price, being also a highly sustainable strategy for waste valorization. The term "green composites" indicates that the material as a whole, i.e. both matrix and reinforcement, originates from renewable resources [1]. The use of cellulosic fillers also opens up novel opportunities for the development of antimicrobial materials by the adsorption of essential oils (EOs), i.e. aromatic and volatile oily liquids obtained from herbs and spices [2]. This process is based on the outstanding capacity of some cellulosic materials, such as porous particles and fibers, to retain polar components in their structure [3].

Experimental – Bacterial aliphatic polyhydroxyalkanoates (PHAs) were melt compounded with functionalized cellulose fibers at different weight ratios by twin-screw extrusion (TSE) and then shaped into sheets by compression molding. Functionalization of the cellulose fibers was previously attained by impregnation of different EO contents with an air spray gun and a rotating drum, as shown in **Figure 1**. The main physical properties and the antimicrobial properties were determined.

Figure 1. Functionalization of cellulose fibers by spray coating

Results and Discussion – The incorporation of EO-containing cellulose fibers into PHB and PHBV resulted in green composite sheets (see **Figure 2**) with similar thermal stability, slightly higher rigidity but lower ductility, and improved barrier performance than those of unfilled PHA [4]. It was also possible to successfully attain bacteriostatic effect against food-borne bacteria from relatively low contents of functionalized fibers. The enhanced active properties achieved were ascribed to the high capacity of the cellulosic fibers to entrap active substances, being able to resist typical processing conditions of thermoplastic materials in the packaging industry. The EO impregnated on the fibers was effectively released in a slow manner, remaining at effective concentrations on the green composite sheet surfaces for a period of at least 15 days.

I. **Conclusions –** The here-presented methodology allows to obtain of fully bio-based materials, in which a natural antimicrobial is incorporated into the structure of an agro-food waste filler. The functionalized filler also serves to improve the

Figure 2. Green composite sheets produced with low (left) and high (right) contents of functionalized cellulosic fibers.

physical performance of the biopolymer, potentially reducing the cost of the overall formulation. The resultant green composites, developed within the frame of EU H2020 project YPACK, add to actual strategies to pursue Circular Economy's approaches for the design of active packaging materials.

References

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