Development of layered BNC composites for Food Packaging

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Abstract

The food industry is increasingly demanding advanced and sustainable packaging materials with improved physical, mechanical and barrier properties. The currently used materials are synthetic and non-degradable, which raises environmental concerns. Research efforts have been made in recent years towards the development of bio-based sustainable packaging materials. One of those is nanocellulose, which have a potential to be used as matrix, as nanofillers or as coatings for composites [1].

A promising material is bacterial nanocellulose (BNC), a biopolymer extruded by *Komagaebacter xylinus* as a 3D nanofibrillar network. BNC offers interesting properties such as high porosity, biocompatibility, non-toxicity and biodegradability [2]. From a food packaging perspective, BNC has a great potential due to the great mechanical performance. However, the high water affinity of BNC is ta major obstacle for food packaging applications [3]. Therefore, the first task was to develop a layered biodegradable composite based on a plasticized BNC (either with glycerol or polyethylene glycol) and poly (3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV), as an attempt to improve the water vapour permeability. The PHBV coating on plasticized BNC reduced significantly the water vapour permeability (from 0.990 to 0.032 $g.\mu m.m^{-2}.day^{-1}.Pa^{-1}$), increased the hydrophobicity (contact angle from 10-40° to 80-90°), but decreased the stiffness (from 3.1 GPa to 1.3 Gpa) of the BNC composite. The mechanical and barrier properties of the obtained layered composite were considered suitable for food packaging applications.

Although the results obtained being important for food packaging, its commercial use is still far off due to production costs and low production capacity, especially when compared to plant-based nanocellulose [1]. Nevertheless, BNC is a proven material to support substances that play an active/intelligent role in food packaging, with ability to carry and release active substances [4, 5]. Therefore, a functionalized BNC film was developed, by *in situ* incorporating zinc oxide nanoparticles (ZnONPs). The synthesis of ZnONPs was based on co-precipitation method, using zinc acetate and sodium hydroxide (NaOH) (added dropwise) as reactants. In order to prevent aggregation of ZnO NPs, polyvinyl alcohol (PVOH) was used as capping agent.

Overall, dropwise addition of NaOH in zinc acetate-PVOH (with immersed BNC), allowed the production of ZnONPs (≈144 nm), with low polydispersity index (≈0.139) and a homogeneous distribution of ZnONPs on the BNC. Concerning the antimicrobial activity, the minimum ZnO dosage for antimicrobial activity was 20%m_{ZnO}/m_{BNCZnO}, being effective on gram – bacteria (such *Escherichia Coli*) but only on some gram + bacteria (such *Staphylococcus Aureus*). The migration of ZnO onto food simulators are under testing.

References

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