P37: Optimization of bacterial nanocellulose fermentation using lignocellulosic residues and development of novel BNC-starch composites

Soares da Silva, F.A.G.[1,*]; Dourado, F.[1,2]; Ferreira, E.[1]; Poças, F.[3]; Gama, M.[1]
[1]CEB - Centre of Biological Engineering, University of Minho, Gualtar, Braga, Portugal;
[2]Satisfibre, S.A. Portugal
[3]CBQF - Centre of Biotechnology and Fine Chemistry – Associated Laboratory, Faculty of Biotechnology, Catholic University of Portugal, Rua Arquiteto Lobão Vital 172, 4200-374 Porto, Portugal *francisco.agss@gmail.com

Abstract

In papermaking industry, significant fraction of fibres that cannot be re-utilized are wasted, which raise economic and environmental concerns[1]. On the other hand, development of renewable polymeric materials became a priority for the sustainability of several industries. Bacterial nanocellulose (BNC), a biopolymer extruded by *Gluconacetobacter xylinus* as a 3D nanofibrillar network, provide interesting properties as high porosity, high water retention, biocompatibility, non-toxicity and biodegradability [2]. These properties have sustained promising applications in the biomedical field, papermaking, composites and foods. However, large-scale BNC production remains a challenge, due to ineffective fermentation systems and high operating costs [2-3]. Therefore, the production of BNC through lignocellulosic residues has been studied. Recycled-paper-sludge (RPS) composed of small fibres with 40% of carbohydrates were hydrolysed and used as a carbon source in culture media formulation. Then, a Response Surface Methodology (RSM) optimization with RPS was assessed in order to maximize BNC production, through static fermentation with *K. hansenii* ATCC 53582. Overall, the results suggest that RPS had potential to be an alternative carbon source for BNC production with a maximum BNC yield of 5 g/L.

BNC produced as described above was then used for the development of novel green thermoplastic nanocomposites, combined with starch. When mixed with water and glycerol (with heat and shear), starch undergoes spontaneous destructuring, forming thermoplastic starch (TPS). In particular to food packaging applications, BNC has remained unexploited in spite of being considered to have enormous potential [4-5]. In this work, two approaches for composite production were assessed. Firstly, BNC 3D membrane was filled with biodegradable bio-based thermoplastic starch (TPS), where the production was achieved in a two-step process: impregnation of TPS in the BNC membrane, followed by drying. Different thicknesses of BNC membrane were studied (1-5 mm) as two impregnation time (24h;72h). The second approach consisted on the use of glycerol-TPS as matrix, where different concentrations (0.05 -0.5% w/v) of cellulose (Plant (PC) and BNC) was added. TPS-BNC and TPS-PC films were prepared by solution casting method. All nanocomposites manufactured were then characterized in terms of mechanical properties, morphology and permeability to water vapor (WVT). Overall, enhanced mechanical and barrier properties were obtained with BNC-TPS composites. In comparison to TPS-BNC and TPS-PC films, higher young modulus and tensile strength was obtained with the BNC-TPS composites. Being longer and thinner, the BNC fibres offer greater mechanical resistance than the ordinary TPS-cellulose composites.

References:

[1] Gomes, D., L. Domingues and M. Gama (2016). "Valorizing recycled paper sludge by a bioethanol production process with cellulase recycling." Bioresour. Technol. 216: 637-644.

[2] Campano, C., Balea, A., Blanco, A., Negro, C., 2016. Enhancement of the fermentation process and properties of bacterial cellulose: a review. Cellulose. 23(1): 57-91.

[3] Rodrigues, A. C.; Fontão, A. I.; Coelho, A., Leal, M., da Silva, F. A. S., Wan, Y., Dourado, F., Gama, M., (2018). Response surface statistical optimization of bacterial nanocellulose fermentation in static culture using a low-cost medium. New Biotechnol., *49*, 19-27.

[4] Pelissari, F. M., Ferreira, D. C., Louzada, L. B., dos Santos, F., Corrêa, A. C., Moreira, F. K. V., & Mattoso, L. H. (2019). Starch-Based Edible Films and Coatings: An Eco-friendly Alternative for Food Packaging. In *Starches for Food Application* (pp. 359-420). Academic Press.

[5] Bharimalla, A. K., Deshmukh, S. P., Vigneshwaran, N., Patil, P. G., & Prasad, V. (2017). Nanocellulose-polymer composites for applications in food packaging: Current status, future prospects and challenges. *Polymer-Plastics Technology and Engineering*, *56*(8), 805-823.