Eucalyptus residues biorefinery products: cellulose nanofibers, xylooligosaccharides, and high-purity lignin

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Abstract

Forest biomass is available in Uruguay due to the development of cellulose pulp industries and wood mechanical transformation (mainly sawmills), which generate a significant amount of wood residues (sawdust, pinchips, etc.). Their valorization through conversion into high-value products in a circular economy scheme allows the productive chain to be strengthened. For this, several pretreatment stages that allow the separation of its main components (cellulose, hemicelluloses and lignin) into separate fractions are required.

The aim of this work was to achieve an integral use of a forest residue through the production of multiple high value-added products to benefit from the different components and maximize their value, under a biorefinery concept. Eucalyptus pinchips, a residue from local pulp industries, were used as raw material and subjected to several physicochemical pretreatments to recover the different components. Autohydrolysis, which is considered an effective hydrothermal pretreatment and an interesting first step in a lignocellulosic biorefinery for hemicellulose solubilization and recovery, was first performed to recover the eucalyptus hemicellulosic fraction [1]. Autohydrolysis conditions (165°C, P-factor 400) were selected to maximize xylooligosaccharides (XOS) content in the liquid stream, which was then purified to evaluate XOS functionality as a promising source of prebiotics. Prebiotic potential of XOS and purified XOS were evaluated using *Lactobacillus* spp., *Bifidobacterium animalis* and *Escherichia coli,* testing its ability to grow on the different prebiotic media under anaerobic condition at 37°C and 150 rpm for 48 h. Secondly, NaOH pretreatment (155°C, 60 min, 15-18% NaOH) was performed on the spent solid (60% cellulose, 36% lignin) to extract the lignin and increase its enzymatic susceptibility [2]. Lignin separated in the alkaline liquor was recovered by acid precipitation (80°C, pH 7, 60 min), and its applicability in the formulation of wood adhesives was evaluated. The solid fraction resulted of high cellulose (88-94%) and low residual lignin (8-12%) contents, which was then subjected to enzyme-mediated mechanical treatment for CNF extraction. CNF was extracted from the solid fraction by pretreatment with a complex mixture of cellulases and xylanases (Cellic CTec3 and HTec at 6.0 FPU/$g_{cellulose}$, 50°C, 4% solids, 12-24 h) followed by ball milling (20 Hz, 80 g_{balls}/g_{solid}, 1% solids, 30 min) employing 0.5 and 3 mm ball sizes [3]. Liquid and solid fractions from the different stages were thoroughly characterized following standard protocols.

Results obtained in this work showed the potencial of this integrated and scalable process which involves the combination of physicochemical and biological pretreatments for an efficient fractionation and valorization of eucalyptus residues to produce prebiotic XOS, high-purity lignin, and a sustainable nanomaterial (CNF).

References

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