A green approach to produce cellulose nanofibers and biobutanol from eucalyptus cellulose pulp via the biochemical pathway

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Aim and approach used

The production of nanocellulose via the biochemical pathway using hydrolytic enzymes allows the production of sugars that can be converted in biofuels by microbial fermentation, such as biobutanol. Therefore, the recovery of a fermentable sugar stream during nanocellulose production results critical. In the present study, the integrated production of cellulose nanofibers and biobutanol was investigated using eucalyptus cellulose pulp as feedstock employing enzymatic pretreatment, fermentation, and ball milling pretreatment (Figure 1).

Scientific innovation and relevance

The integrated production of biofuels and value-added products from the different components in lignocellulosic biomass has emerged as a goal for lignocellulosic biorefineries to achieve economic self-sustainability. Cellulose nanofibers (CNF) are a renewable nanobiomaterial with potential applications in material science and biomedical engineering. CNFs are typically produced by mechanical pretreatment of delignified cellulosic biomass. Ball milling pretreatment represents an attractive mechanical method for CNFs production due to its main advantages such as simplicity, environmentally friendly, and high efficiency. However, the high energy consumption associated to the mechanical process can be reduced by incorporating another chemical or enzymatic treatment. Even though several chemical treatments have been successful, enzymatic treatment represents an environmentally clean alternative due to high enzyme specificity and less harmful reaction conditions. Moreover, high solid loading enzymatic treatment is attractive since it allows to obtain a high concentration of sugars, thus reducing capital investments and operation costs.

Biobutanol has received considerable attention as a biofuel because it is more compatible with combustion engines than ethanol. Also, it has been recognized as a chemical and solvent used in various chemical industries. Nowadays, biofuel production strategies are centered on the fermentation of C5 and C6 sugars that are liberated from the carbohydrate components of the lignocellulosic biomass. To achieve economic feasibility of cellulosic biobutanol production, an integrated coproduction strategy should be developed in accordance with the biorefinery concept.

Preliminary results and conclusions

The effect of solids loading (4-16%) on glucose and xylose release as well as cellulose and xylan conversions was investigated during enzymatic pretreatment. Glucose concentrations from 17 to 40 g/L and xylose concentrations from 5 g/L to 12 g/L were obtained after 8 h using commercial cellulase and xylanase cocktails. The sugars released in the liquid fraction were used for the production of butanol by two *Clostridium* strains: ABE (acetone-butanol-ethanol) producer *C. beijerinckii* DSM 6422 and IBE (isopropanol-butanol-ethanol) producer *C. beijerinckii* DSM 6423. Both native strains presented a remarkable ability to ferment the sugars derived from enzymatic pretreatment of eucalyptus cellulose pulp, producing butanol and total solvents concentration of 4-8 g/L and 7-12 g/L, respectively. The residual solids were subjected to ball milling pretreatment to produce CNF (Figure 2). Physicochemical characterization of CNFs is being performed to determine the nanobiomaterial characteristics for further potential applications. The findings in this study indicate the viability of obtaining cellulose nanofibers and butanol using the biochemical pathway, which potentially contributes to the future implementation of forest biorefineries.