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Ionic liquids and enzymes for co-valorization of polysaccharidic and lignin fractions from Miscanthus x giganteus

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PURPOSE OF THE ABSTRACT

Over the last few decades, efforts to orientate the global production of fuels, materials and chemicals towards renewable carbon feedstocks have accelerated. A large portion of these efforts have focused on the valorization of the most abundant renewable carbon sources, the lignocellulosic biomass (LCB), mainly composed of two polysaccharides (cellulose and hemicellulose) and polyphenolic polymer, namely lignin [1]. In a perspective of biorefinery profitability, the field of lignin fractioning has attracted significant interest since lignin is the most abundant renewable aromatic polymer and it holds enormous potential as a renewable feed-stock for upgrading to high-value products including chemicals, adhesives, carbon fibers, bioplastics and biomaterials [2-4]. However, to date, this polymer is largely undervalued and its applications are still limited to low value-added products or burned. The structural variability of lignin due to different sources and isolation processes also affects the physical and chemical properties of this polymer [4-6]. In this this context, this work proposes an eco-friendly strategy to isolate in mild conditions and preserve as far as possible structural properties for further transformations of lignin polymer from Miscanthus x giganteus (Figure 1). First, a pretreatment step with the ionic liquid (IL) 1-ethyl-3-methylimidazolium acetate ([Emim][OAc]) under mild extraction conditions was performed [7, 8], generating a disorganized biomass less recalcitrant to the action of (hemi-)cellulolytic enzymes. Indeed, chemical composition after pretreatment is similar to the one of raw Miscanthus x giganteus. Then, the hydrolysis of the polysaccharidic fractions of the pretreated biomass was catalyzed by the enzymatic cocktail Cellic® CTec2 [9], obtaining a liquid C5 and C6 sugar-enriched fraction (Yield of glucose of 86% and yield of xylose of 89%) and a first solid lignin-enriched fraction exhibiting 48 g of lignin.100g-1 DW. This latter was then submitted to an additional enzymatic hydrolysis in similar conditions isolating a second solid lignin-enriched fraction with 55 g of lignin.100 g-1 DW. Structural properties of the solid fractions recovered along the strategy were characterized by FTIR and NMR. The morphology and textural properties were also studied by Scanning Electron Microscopy (SEM). The lignin-enriched fractions were then subjected to a Laccase Mediator System-catalyzed oxidative depolymerization in aqueous buffer and in the presence of recycled [Emim][OAc] as co-solvent. The produced phenolic mono/oligomers were identified by LC-MS-MS. This reported strategy was demonstrated as a promising sustainable route for producing both sugar-enriched fractions and phenolic chemical intermediates of interest from a dedicated crop.

FIGURES

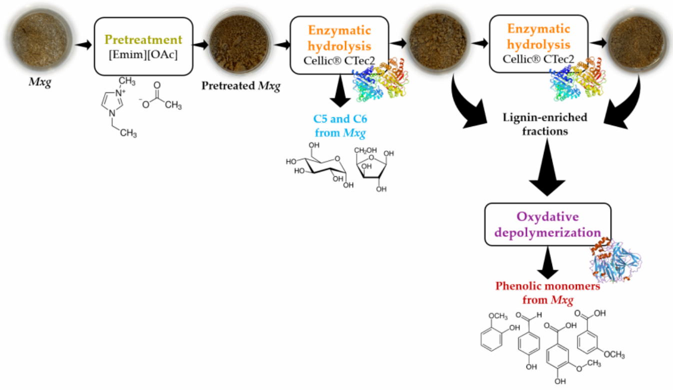

FIGURE 1

A sequential strategy of pretreatment and enzymatic transformation of lignin from Miscanthus x giganteus (Mxg).

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FIGURE 2

KEYWORDS

lignocellulosic biomass | fractioning | hydrolases | oxydo-reductases

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