Single Step Organosolv Oxidative Pretreatment of Lignocelullosic Biomass for Valorisation to High Added Value Chemicals and Food Additives

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Introduction

Lignocellulosic biomass is an attractive source of fermentable carbohydrates and aromatic compounds, found in the form of cellulose/hemicellulose and lignin respectively, which can be converted to a variety of bioactive compounds, such as omega-3 fatty acids, as well as lactic acid, anhydrosugars and phenol oligomers that can be used as starting materials for a wide range of products. Key to successful valorization of biomass is its fractionation towards its 3 main components, cellulose, hemicellulose and lignin. Lignin is a crucial factor limiting the biotransformation of biomass by acting as a physical barrier between enzymes and holocellulose and by inhibiting fermentation processes. A new pretreatment method, organosolv oxidation, has been developed combining the advantages of wet oxidation such as relatively low temperatures and low yield of degradation products with high lignin removal. In this work, several different process parameters were investigated in an effort to optimize the fractionation process.

Experimental

Fractionation runs took place in a Hastelloy C-276 Parr reactor with a volume of 975 ml. The ratio of biomass to liquid solvents was 1/10. The reaction temperatures were 150 and 175 ^{o}C and reaction time was 1 or 2 hours. Enzymatic digestibility of the pulps took place by subjecting them to hydrolysis with Cellic® CTec2 and the hydrolysates were used for the production of fatty acids and lactic acid by a promising dinoflagellate microalga and one lactic acid bacterium, respectively.

Results and Discussion

Mixtures of water with different organic solvents such as Acetone, Ethanol, Propanol and Methyl- Isobutyl- Ketone (MIBK) were used. Phosphoric acid and/or gas O_2 were used as catalysts to enhance the cleaving of lignin ether bonds and increase the delignification degree (DD). Composition of the resulting pulps, along with constituents recoveries are presented in figure 1.

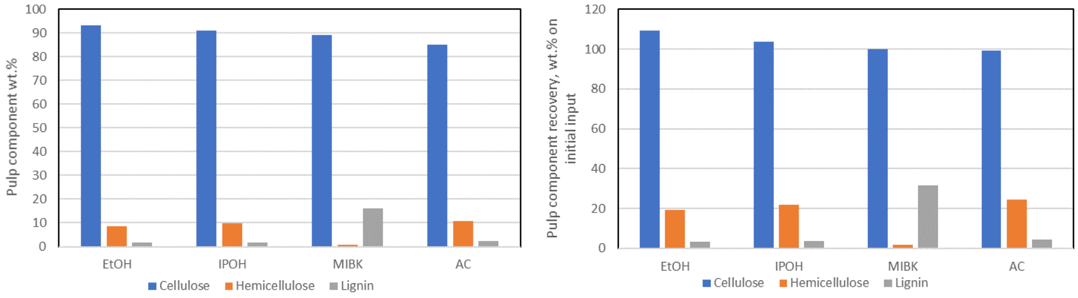

Figure 1. Pulp composition and constituents recoveries in pulp at 175 ^oC, 2 hrs reaction time, liquid to solid ratio=10.

Water miscible organic solvents were extremely efficient in removing lignin. DD exceeded 95% and cellulose content of the resulting pulps was >90%. MIBK was less efficient in removing lignin (DD=70%) due to its water immiscibility however, it was easily phase-separated from the aqueous fraction along with the dissolved lignin simplifying the one-step fractionation process. O_2 gas enhanced cleaving of the ether bonds of lignin and increased the DD. It successfully replaced homogeneous H_2SO_4 acid catalysis that requires corrosive-resistant reactors and produces acidic wastes and degradation products with inhibitory effects on downstream biological conversions. Moreover, a milder, less corrosive alternative, H_3PO_4, was found to significantly enhance the DD. Lower temperature delignification was also possible at 150 ^oC, when combining acidic catalysis with O_2 oxidation. More than 90% of lignin was removed, while ~100% of the biomass cellulose was recovered in the pulp.

The pulp hydrolysates supported the growth of microorganisms for the production of lactic acid and omega-3 fatty acids without the need for detoxification. Algae growth was found to be affected by the hemicellulose content, while reduction of lignin content was proved beneficial for the lactic acid production.