Non-thermal plasma and lignocelullose susbstrates in biorefinery processes

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Introduction

Lignocelullosic substrates are abundant and available in almost all parts of the world. However, we are still lacking efficient ways to valorise it due to recalcitrant nature of lignocelullose and presence of lignin which prevents enzymatic hydrolisis of cellulose. The compact nature of lignocellulose biomass prevents its wider application in biorefineries. Effective way to separate lignin from cellulose or to make cellulose more accessible to enzymes remains challenge. Among lignocellulose biomass, agricultural by-products like corn stalks or husks are considered more convenient as substrates as they contain less lignin then wood biomass and therefore can be more easily degraded. However, acid or alkaline hydrolysis are the most common approach in pretreatment of lignocellulose substrates, but they are not selective, lead to loss of significant amount of sugars and cause generation of inhibitory substances in hydrolysate. Additionally, acid and alkaline pretreatments are performed at elevated temperatures and have significant environmental impact.

Non-thermal or cold plasma treatment has been previously applied to increase roughness of surfaces for biomedical (Dalei *et al.*, 2019) and other application, inactivation of microorganisms on surfaces or in liquids (Djukić-Vuković *et al*., 2017) and for decolourisation of wastewater (Mitrović *et al*., 2020). Non-thermal plasma treatment of lignocelullose substrates has been performed mainly on pulverised biomass in plasma reactors (Mooktzeng & Zulkifli, 2018). This approach does not provide data on changes non-thermal plasma treatment introduces in anatomically and chemically different components of lignocelullosic biomass. We proposed experimental setup where plasma needle will be used for treatment of thin corn stalk slides to access effects on different components of corn stalk.

Material and Methods

Thin corn stalk slides were anatomically analysed after non-thermal plasma treatment under different conditions including different water content, distance between plasma needle and sample, treatment time and feed gas rate. Plasma needle setup was used with Argon as feed gas (Zaplotnik et al. 2015). These results were coupled with FTIR spectra of corn stalk slides. After the selected treatments, non-thermal biomass were subjected to enzymatic hydrolysis and concentration of reducing sugars was compared with untreated controls.

Results and Discussion

Non-thermal plasma treatment *per se* resulted in higher concentration of reducing sugars in water media used during treatment in comparison to untreated controls. The effects were pronounced after additional step of enzymatic hydrolysis. The parenchymal cells were significantly more damaged than piths by treatment, but increase in roughness was obtained in all parts of the biomass slides exposed to plasma treatment. The changes in morphology and chemical composition induced by non-thermal plasma probably suggest that higher exposure to enzymes is the reason for improved effectiveness of enzymatic hydrolysis. Degradation of both complex natural biopolymers, cellulose and lignin by non-thermal plasma can be a promising approach for development of new strategies in valorization of lignocellulose biomass and should be studied in more details.

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