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Mechanocatalytic partial depolymerization of lignocellulosic feedstock towards oligomeric glycans

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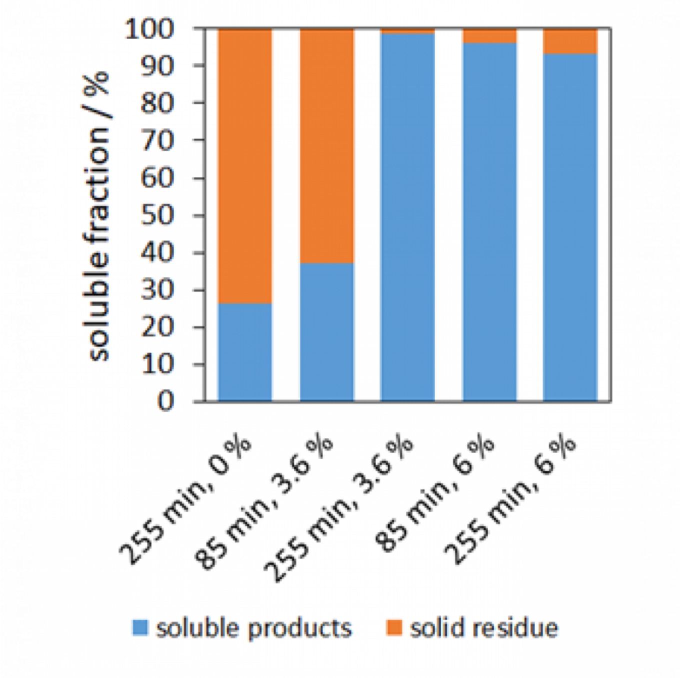
PURPOSE OF THE ABSTRACT

The depolymerization of lignocellulosic feedstock with a heterogeneous composition is a major challenge and usually leads to the formation of monosaccharides as main products. Our work aims to process such feedstock into oligomeric glycans as more valuable products compared to sugars, by using mechanocatalysis in a cost-efficient and resource-saving manner.

Mechanocatalysis is the combination of a chemical catalyst and mechanical forces that provide the input of energy for a reaction to take place. As a solvent-free approach and, in some cases, enabling activation only due to mechanical forces e.g. breaking the rigid structure of cellulose and lignocellulosic structures [1], renders this method highly attractive. In addition, the energy required for a reaction can be reduced by scale up [2]. Therefore, mechanocatalysis has great potential for the processing of lignocellulosic residues as reported previously [3, 4]. E.g., cellulose and lignocellulose in beechwood were processed successfully into oligomers by combining low acid amounts as hydrolysis catalyst and ball milling. In our work within the BMBF project GlyChem we investigate raw materials such as wheat straw, beet pulp, cocoa shells and apple pomace as residual natural raw materials. They are impregnated with sulphuric acid and ground in a planetary ball mill. XRD measurements confirmed the improved destruction of the microcrystalline cellulose and thus, improved accessibility for the catalyst. Reaction parameters were investigated and optimized towards a maximum amount of soluble species and a minimum of monosaccharides. E.g., for shredded wheat straw a solubility of over 90 % comprising a mixture of oligomeric glycans (glucans and xylans), as well as partially depolymerized lignin (Figure 1) was achieved. In case of the other biomasses, a lower fraction of soluble products was obtained. However, this could be increased by an additional pre treatment process followed by the same mechanocatalytic milling conditions. Furthermore, the soluble fraction was examined for its molecular weight distribution by GPC. Using cellulose as starting material, which only forms glucans, it was found that the preferred molecular weight fraction of 5 to 10 kDa required for the project is formed (Figure 2). Overall, in this work we demonstrate the versatility of mechanochemistry towards the production of value-added glycans as functional oligomers from lignocellulosic residues.

FIGURES



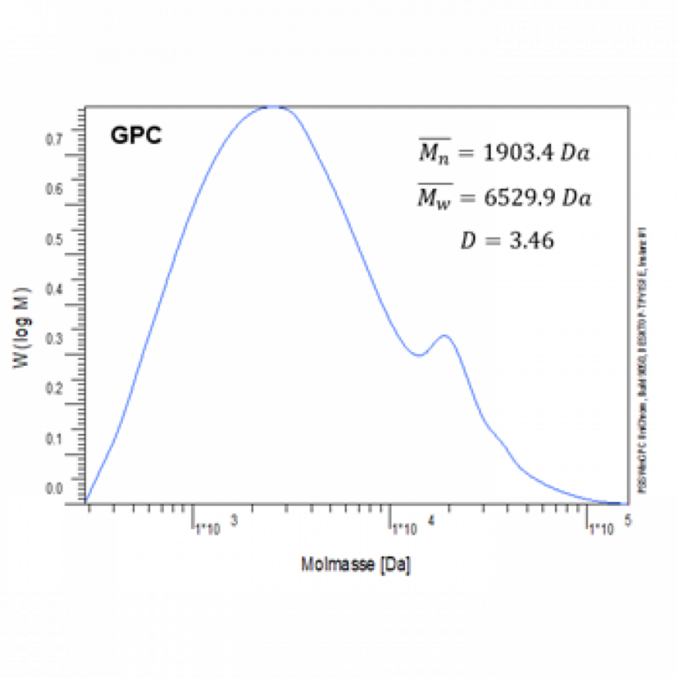


FIGURE 1

Fraction of soluble products after mechanocatalytic partial depolymerization with varying effectiv milling duration and acid loading.

FIGURE 2

Molecular weight distribution of the soluble product fraction after mechanocatalytic partial depolymerization of cellulose. Reaction conditions: 500 rpm, 86 min, 2.4 wt% sulfuric acid.

KEYWORDS

Glycans | Biomass | Lignocellulose

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