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Steam explosion pretreatment of lignocellulosic biomass - Influence of the explosion pressure difference on the enzymatic digestibility of different biomass types

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PURPOSE OF THE ABSTRACT

Steam explosion pretreatment for the biochemical conversion of biomass is currently the most common pretreatment method in commercial biorefineries[1] and has been examined in many studies. The information available on the effect of the explosion itself on the biochemical conversion is however very limited and inconsistent. On the one hand, it has been stated that the explosion efficiently decreases biomass particle size and disrupts plant cells[2], resulting in an increased surface area and better accessibility of carbohydrates to enzymes[3,4].

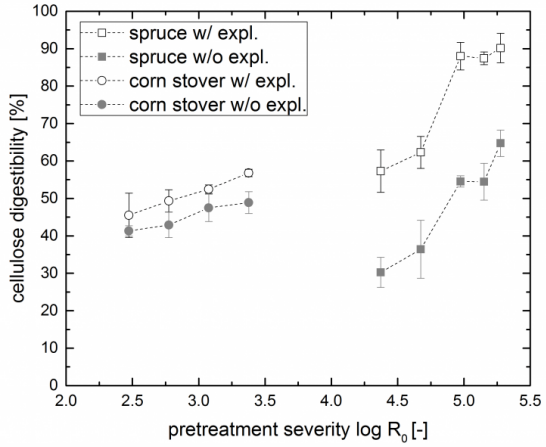
However, no direct proof for those conclusions has been presented in literature so far. In contrary on the other hand, it has been reported that the high level of digestibility provided by steam explosion is due to chemical autohydrolysis reactions and not due to the mechanical disruption during explosive decompression[5,6]. In order to close the knowledge gap of the explosion?s effect on enzymatic cellulose digestibility, we have carried out a systematic study on the basis of the steam explosion pretreatment of spruce wood chips and corn stover.

We could show for the first time that the explosion has a high influence on cellulose digestibility of spruce, improving it by up to 90% compared to a steam pretreatment without explosion[7](Fig 1). For spruce, the pretreatment severity and pressure difference of the explosion were identified to be essentially responsible for the explosion impact on enzymatic digestibility. Increasing the pressure difference of the explosion leads to more defibration, a smaller particle size and a better digestibility.

This was not the case for corn stover, where the explosion were decreasing the particle sizes only a little (Fig. 2) and due to that adding only 10-15% of digestibility (Fig 1.), independently of the pretreatment severity. Since total digestibility of corn stover cellulose can be easily reached at medium severities, the total severities for corn stover might be too low to observe a greater impact of the explosion.

The only influence of the explosion on digestibility for both biomasses was found to be the macroscopic particle size reduction. Steam explosion treatments with high severity and pressure difference of the explosion lead to a comparatively high cellulose digestibility of spruce, whereby the impact on corn stover was much lower (Fig 1.). This leads us to the assumption that the influence of the explosion is strongly dependant on the pretreated biomass type. The influence of crucial steam explosion pretreatment parameters (severity, pressure difference of the explosion) and its consequences for the biomass structure (particle size distribution, nanostructure) as well as for enzymatic hydrolysis have been studied. Current research focuses on studying the explosion effect on hardwood and acid impregnated spruce. Results from these studies will be presented.

FIGURES



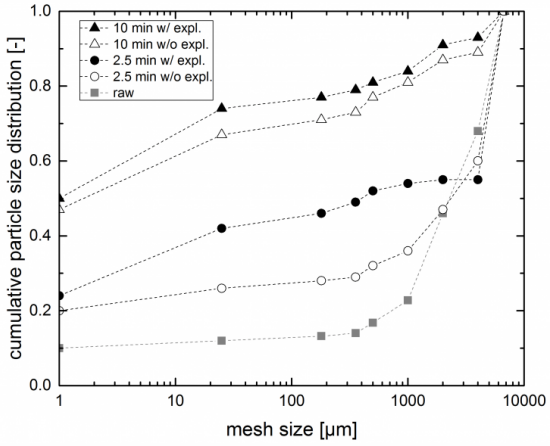


FIGURE 1

Enzymatic cellulose digestibility of pretreated corn stover and spruce

Cellulose conversion is expressed as % of pretreated biomass content. Pretreatment conditions spruce: T=235°C, t=2.5 - 20min, Delta p=30bar; Pretreatment conditions corn stover: T=170°C, t=2.5 - 20min, Delta p=7bar; hydrolysis conditions: 1 %w/w cellulose

FIGURE 2

Cumulative particle size distribution of raw and pretreated corn stover

Pretreatment conditions: T=201.4°C, t=2.5-10min, Delta p=15bar; hydrolysis conditions: 1 %w/w cellulose, 60 FPU g-1 cellulose

KEYWORDS

steam explosion pretreatment | lignocellulosic biomass | enzymatic digestibility | biorefinery

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