Autothermal Performic Acid pretreatment for the Rapid Fractionation of Biomass

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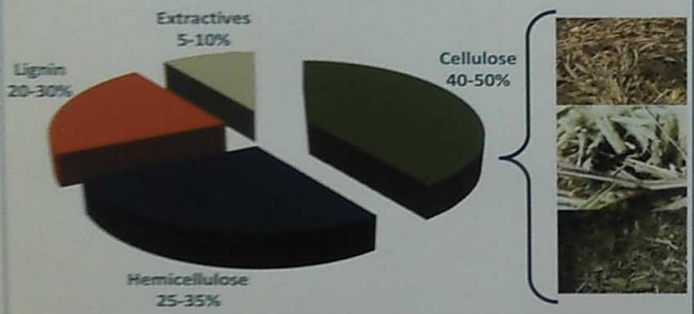
Introduction

Lignocellulosic biomass, such as energy crops and agricultural residues, has been identified as a promising feedstock for the production of platform chemicals as they do not compete with food and represent an efficient renewable source of energy and materials. Cellulose (40-50%), hemicellulose (25-35%), lignin (20-30%), and with lesser amounts of ash and extractives are the major components of lignocellulosic materials. Pre-treatment processes, such grinding, milling, and mild acid hydrolysis are essential to overcome the recalcitrance of biomass. A desirable pre-treatment would set free cellulose, the most abundant component, allowing it to be transformed into platform chemicals and biofuels.

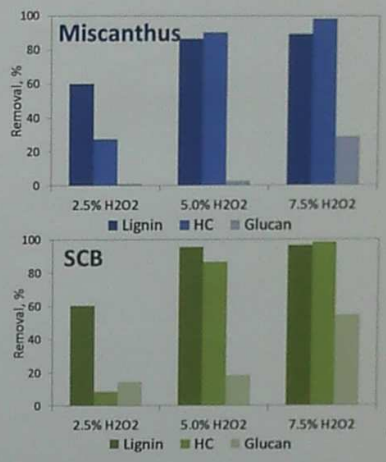


General composition of lignocellulosic biomass. Cellulose is composed mainly of glucose, while hemicellulose of pentoses and some hexoses. They represent a potential source for the production of furan-derivatives for the fuel industry.

Autothermal pretreatment

We present a novel oxidative treatment that fractionates efficiently the biomass components. This process is based on the decomposition of hydrogen peroxide (2-7 wt%) in formic acid and water. While the oxidative action of the peroxide attacks the lignin and separates it from the lignocellulosic network, the formic acid acts as both a solvent for the lignin and a catalyst for the hydrolysis of the hemicellulose.
The temperature is increased (100-200°C), speeding up significantly the time required for the fractionation of the lignocellulosic material (up to 10 min) and reducing the consumption of energy in typical biomass pretreatment operations.

This treatment yields a cellulosic pulp that can be readily transformed in chemolytic and enzymatic processes. Hemicellulose and lignin are readily removed and can be recovered from the solvent for further processing in yields higher than 90%. In experimental work carried out in a batch reactor with mixtures of up to 3 kg of material (10% of solid loading), the full fractionation has been obtained after just 6 min: When traditional chemical pretreatment processes can take hours.



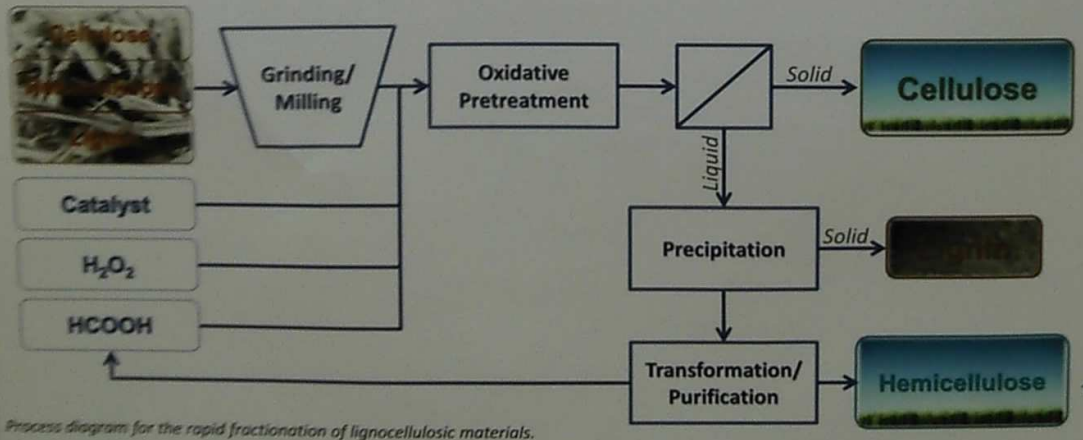
Yield of lignin, hemicellulose (HC) and glucan removal at different hydrogen peroxide concentrations.

Miscanthus x giganteus and Sugarcane Bagasse (SCB) has been treated at different H_2O_2 compositions: Reaction time is reduced up to 15 times by changing from 2.5 to 7.5% H_2O_2. Less than 15 min is required for the fractionation when 5.0% H_2O_2 is used. The two main variables that were found to influence both the extent of the fractionation and the time were the hydrogen peroxide concentration and the solid loading (ratio biomass to solvent).

Miscanthus x giganteus and the isolated fractions from the pretreatment process.

Rapid fractionation of biomass as a continuous process and future research

The relatively short residence time required for the decomposition of the hydrogen peroxide under the conditions studied, as well as the heat generated, are features for a versatile semi-continuous process that can transformed a wide range of lignocellulosic materials. Potentially, these advantages offer a more feasible route to sustainable and economical biorefinery processes. Experimental work is being carried out to study the fundamentals of the fractionation of representative lignocellulosic materials. This will allow for the optimization of the recovery of all biomass components and further scaling-up.



Process diagram for the rapid fractionation of lignocellulosic materials.

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