Pretreatment of Switchgrass by Steam Explosion in a Semi Continuous pre-pilot plant

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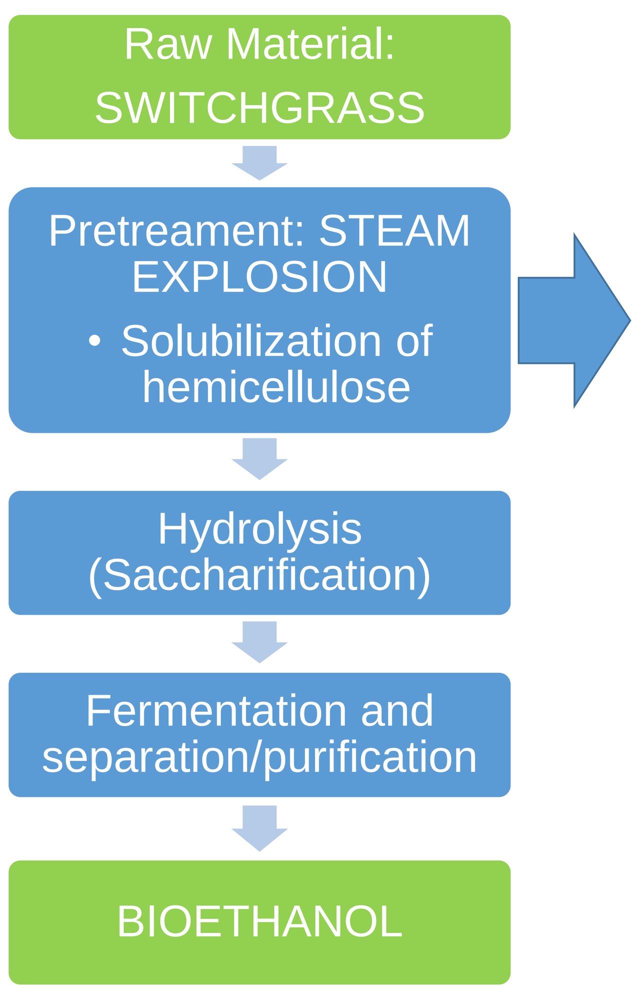
Introduction

Switchgrass (*Panicum virgatum*) is a perennial warm season grass highly valued as an energy crop resource for the production of bioethanol due to its high carbohydrate content, fast growth, and ability to grow in lands that cannot support crop or food production.

BIOETHANOL production process:



The recalcitrance of the lignocellulosic material can be overcome by applying steam **at high pressure and temperature** during a certain amount of **time**, and then suddenly releasing the pressure. This opens the fibers solubilizing the hemicellulose and making the cellulose fibers more accessible to the enzymes in the following step of saccharification.

Problem: Steam explosion has been demonstrated to be an efficient technology for biomass pretreatment. However, the efficiency and the selectivity of this process is highly dependent on the feedstock and conditions applied, being the temperature and residence time the two main parameters affecting the results. Therefore, **the aim of the present study** was to evaluate the impact of the temperature and residence time on the pretreatment of switchgrass by steam explosion in a semi-continuous pre-pilot plant able to generate between 3 and 7 kg of pretreated solid material.

Experimental

Raw material:

Switchgrass harvested in Uruguay, dried and milled to approx. 1 cm size

Moisture content: 30% humidity

Experimental design:

Temperature: 170, 185 and 200 ºC

Residence time: 5, 10 and 15 min

Combined through a 2^2 central composite design (11 assays)

Temperature and residence time were combined through the factor of Severity (R_0), which was calculated by the equation:

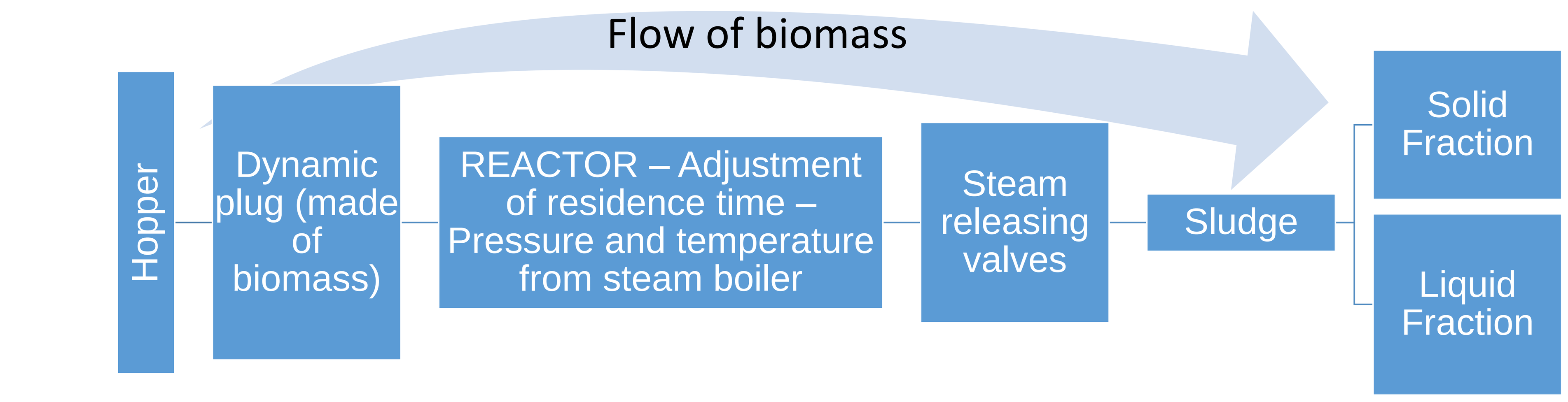
$R_0 = t \times e^{[(Tr-100)/14,75]}$, where Tr is the reaction temperature in ºC and t is the residence time in minutes.

Analyses:

- Characterization of exploded switchgrass (Solid Fraction) according to NREL standard protocol for lignin, cellulose, and hemicellulose
- TLC follow up of the Liquid Fraction relative to xylose content and presence of degradation products

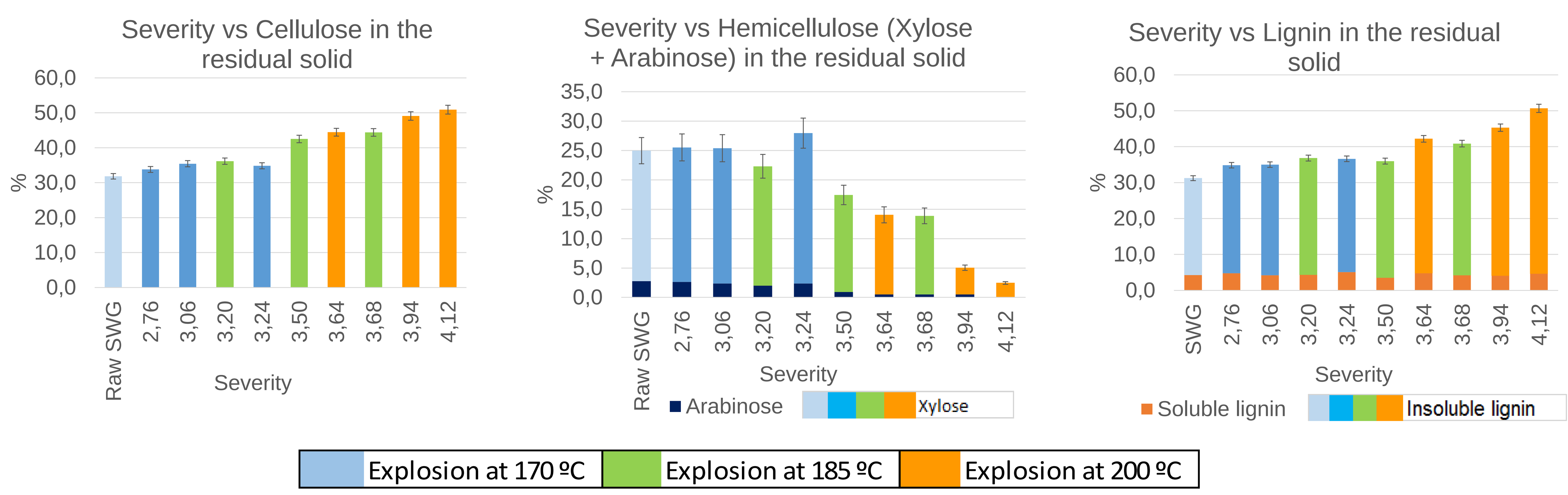
Experimental (cont.)

Steam Explosion Equipment



Results

Solid fraction composition

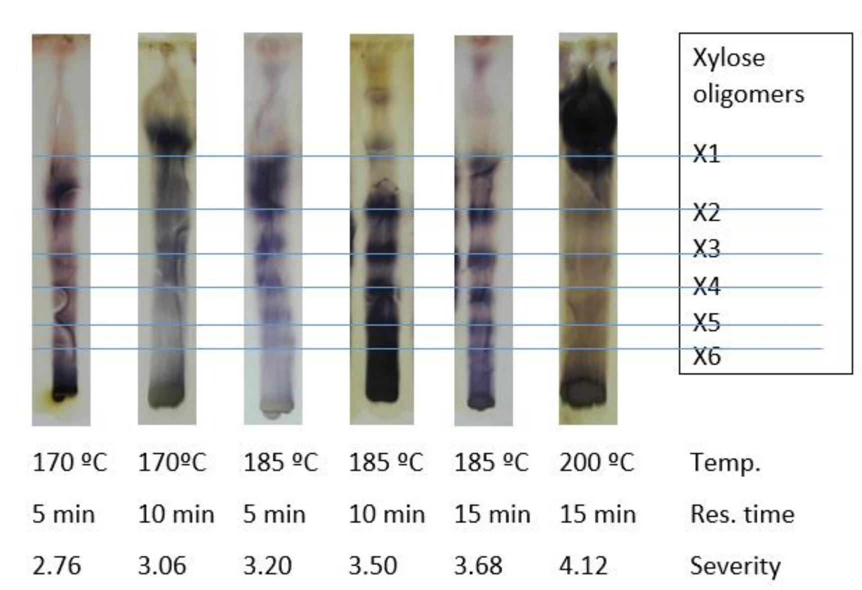


- Steam explosion at 170 ºC had little effect in the composition of the residual exploded solid material. However, increasing the severity factor favored the hemicellulose removal from the feedstock, while increased the amount of cellulose and lignin in the residual solid material. On the other hand, there was no clear correlation between the amount of soluble lignin and the severity factor employed, suggesting that the mildest conditions were already enough to recover this fraction from the feedstock.
- Temperature had a more significant effect than the residence time to overcome the recalcitrance of feedstock.

Liquid Fraction composition

The differences among the conditions, specially for the three temperatures used, were evident:

- At 170 ºC – only few hemicellulose solubilized
- At 185 ºC - more hemicellulose solubilized with the identification of several xylose oligomers
- At 200 ºC – almost no oligomers in the Liquid Fraction, and more noticeable presence of inhibitors such as Furfural and HMF as can be seen in the TLCs observed with UV light



Conclusions

At this moment, statistical tools are being used to optimize the conditions able to result in maximum hemicellulose solubilization in the liquor (with minimal generation of inhibitory compounds) and maximum amount of cellulose in the residual solid material. The obtained results, already in a pre-pilot scale, are very promising and contribute to the development of an ethanol biorefinery using switchgrass as a feedstock.