An Acid Impregnated Steam Explosion Pretreatment Study For Elephant Grass Biomass

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INTRODUCTION

- Lignocellulosic biomass conversion to fuels and chemicals has attracted great interest
- Such conversion processes usually involve three main steps: Pretreatment, Hydrolysis and Fermentation
- Lignin is the main obstacle for utilization of biomass sugars. Pretreatment is the most important step for lignin removal and to promote an effective utilization of cellulose

MATERIAL: Elephant grass (*Pennisetum purpureum)*

- Fast growing and most common grass in Netherlands
- High productivity (45t dry matter/ha/year)
- Require few or no additional supplement/ water
- C4 plant more efficient in photosynthesis

Fig:1 Elephant grass

BENCH SCALE STEAM EXPLOSION PRETREATMENT

Effects of Steam explosion pretreatment:

- Structural change in biomass with sudden pressure change
- Effective Lignin removal
- Hemicallulose removal
- Low capital investment
- Low inhibitors production

Bench scale pretratment reactor:

- Bench scale reactor with 40 L capacity and 3 Kg of biomass loading
- Composed of three parts: Pressure Reactor, Cyclone and Collection Vessel

Fig:2 Bench scale pretreatment reactor

METHODS

- Central Composed design (CCD)
- Limits: Lower (-), Central point (0), Upper limit (+)
- Variables: Temperature (ºC), Acid concentartion (%) and Residence time (min)
- Pretreated biomass analyses: Lignin and ash contents according to NREL protocol; Cellulose content by the Upedegraff method

Experiment No.	H_2SO_4 Conc.	Time (mint.)	Temperature (ºC)
1	0.5	5	160
2	0.5	5	200
3	0.5	15	160
4	0.5	15	200
5	4.5	5	160
6	4.5	5	200
7	4.5	15	160
8	4.5	15	200
9	0.5	10	180
10	4.5	10	180
11	2.5	5	180
12	2.5	15	180
13	2.5	10	160
14	2.5	10	200
15 (C)	2.5	10	180
16 (C)	2.5	10	180
17 (C)	2.5	10	180

PRETREATMENT STEPS

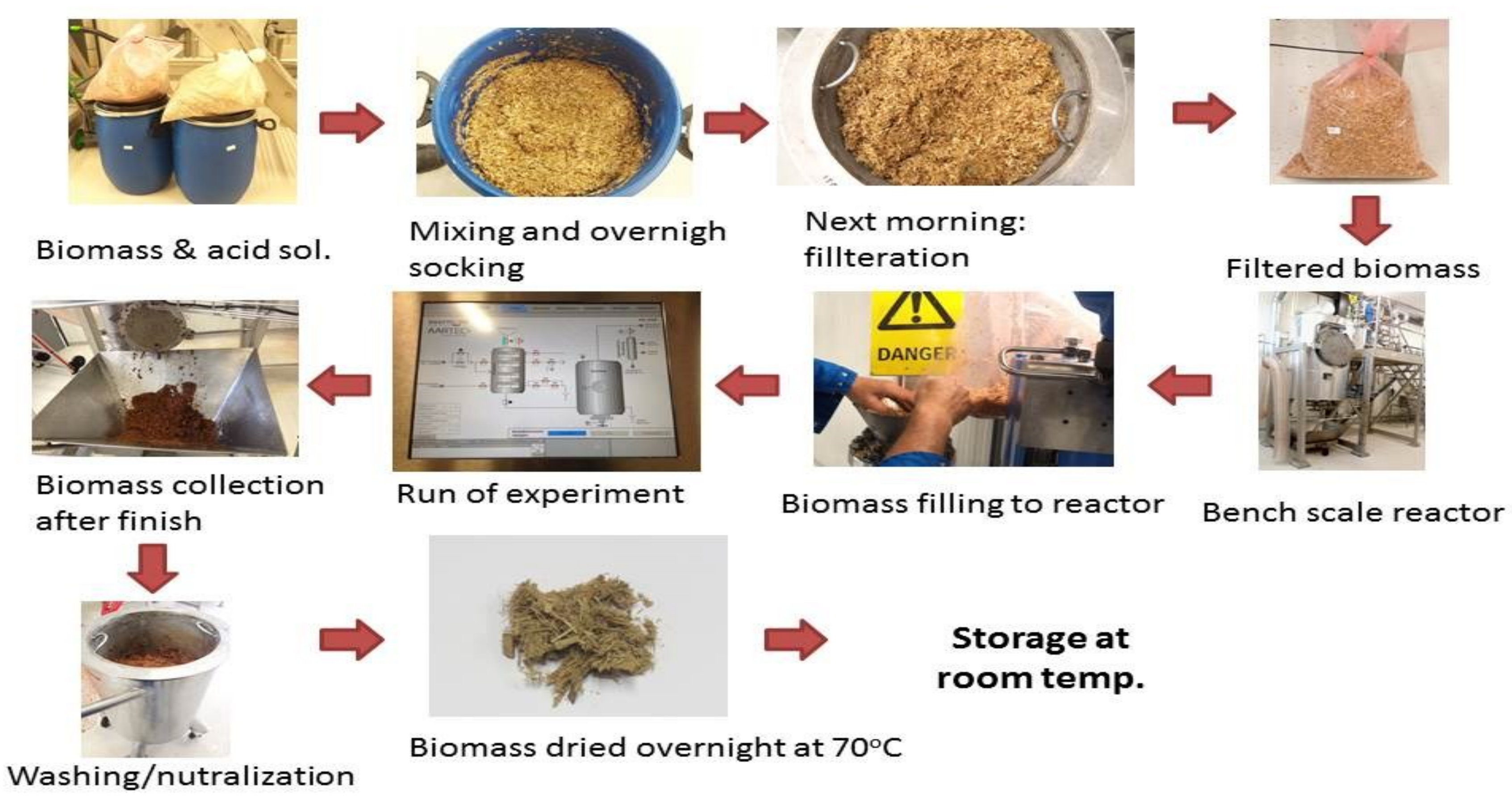

Fig:3 Biomass pretreatment in Bench scale reactor

RESULTS

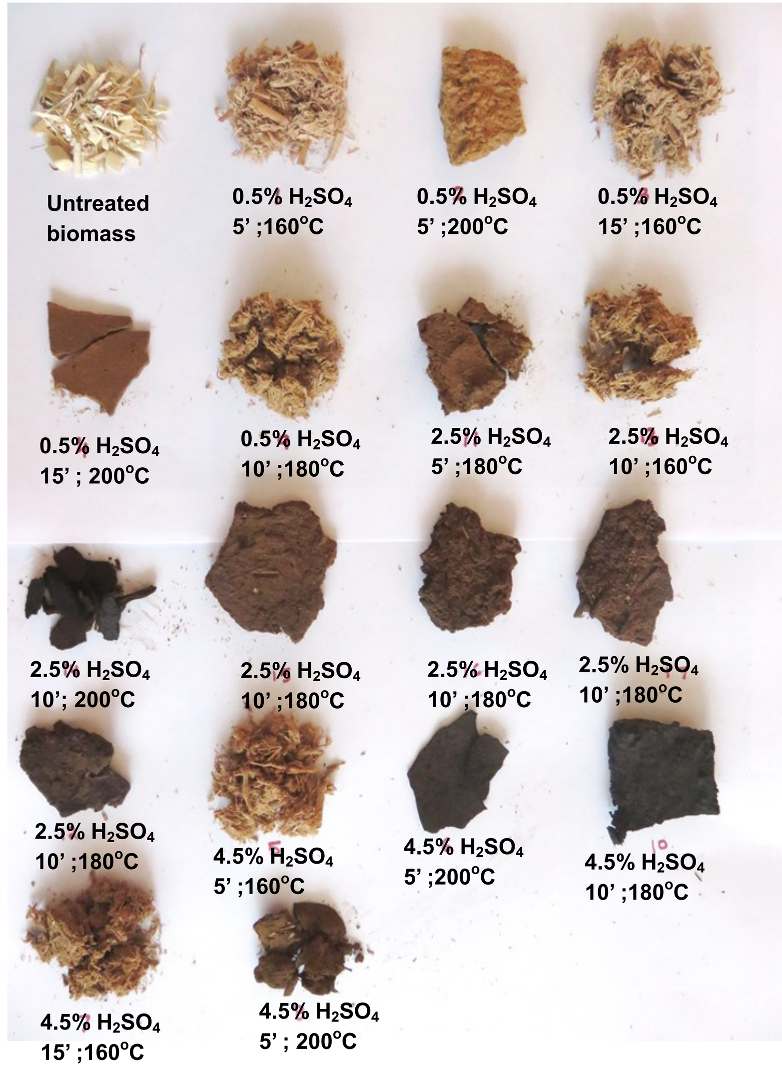

Fig:4 Pretreated Biomass at different conditions

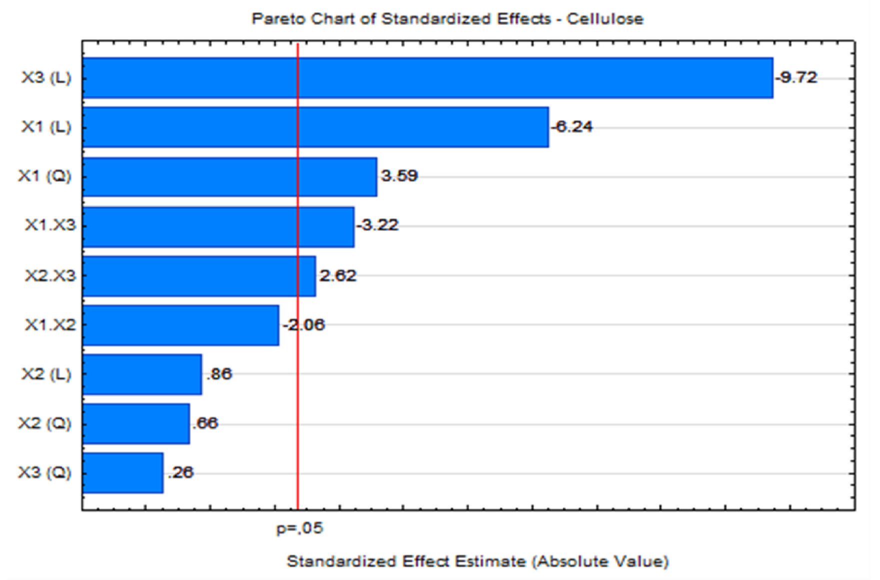

Fig:5 Effect of different parameters X1, X2 and X3 in Cellulose

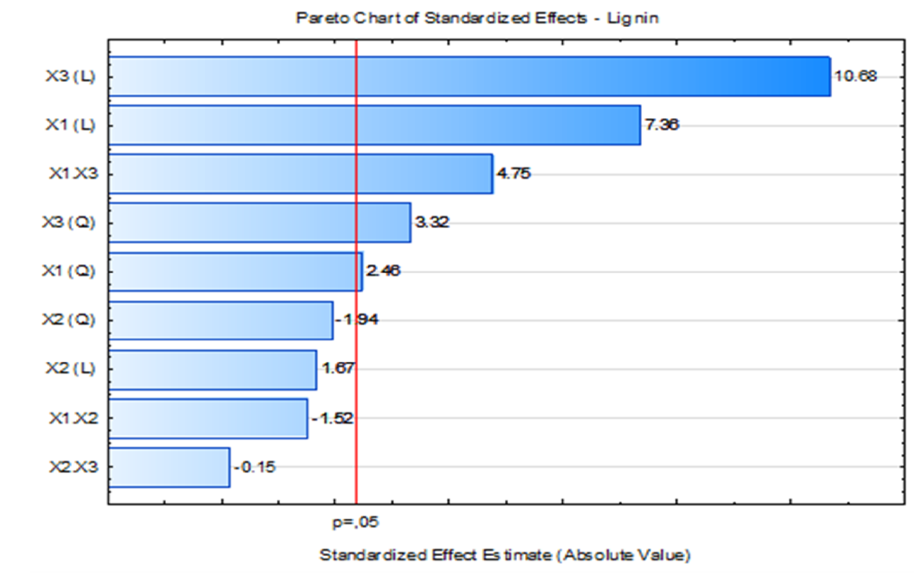

Fig:6 Effect of different parameters X1, X2 and X3 in Lignin

- Acid concentration and temperature were the variables with the highest effects on both responses: lignin and cellulose contents (Figs. 5 and 6- where X1: acid; X2: time; X3: temperature; L: Linear effects; Q: quadratic effects)
- When the temperature and acid concentration were decreased, the residual solid material contained less lignin and more cellulose content (Figs. 7 and 8). A region that optimize the results was identified in Fig 7.
- Time was not significant at 90% confidence level (p<0.1) for both responses
- An overlaying of both fitted surfaces (Figs. 7 and 8) was done in order to select a condition able to provide a residual solid biomass with maximum cellulose and minimum lignin content (Fig. 9)
- Acid concentration and temperature were kept as minimum as possible, reaction time fixed at 11.5 min (critical point to minimize the lignin content), cellulose as maximum as possible and lignin as minimum as possible
- A point was then selected attaining these criteria and corresponded to using acid at 0.5% and temperature at 161ºC, during 11.5 min
- Under these conditions it is possible to obtain a solid containing 51.9% cellulose and 33.7% lignin (w/w)

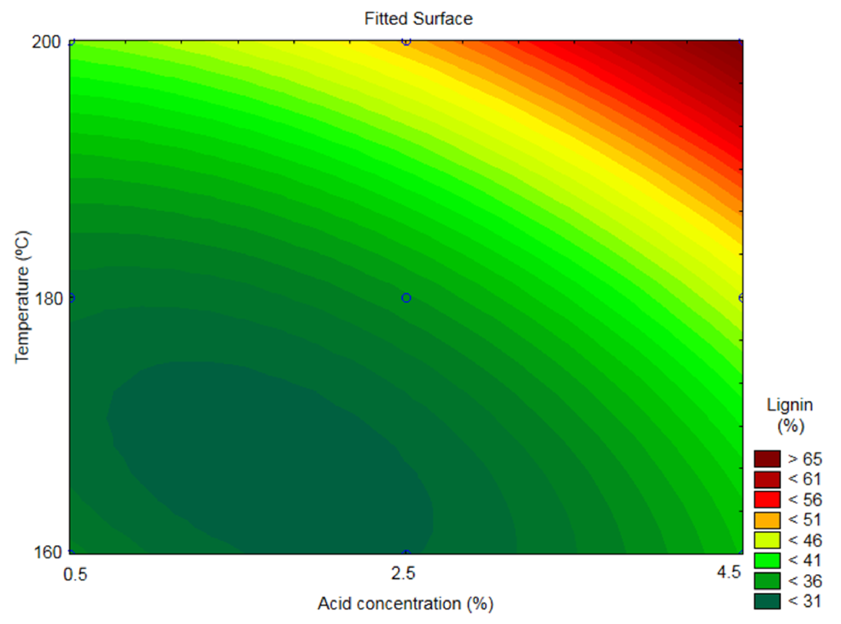

Fig:7 Fitted Surface for lignin response

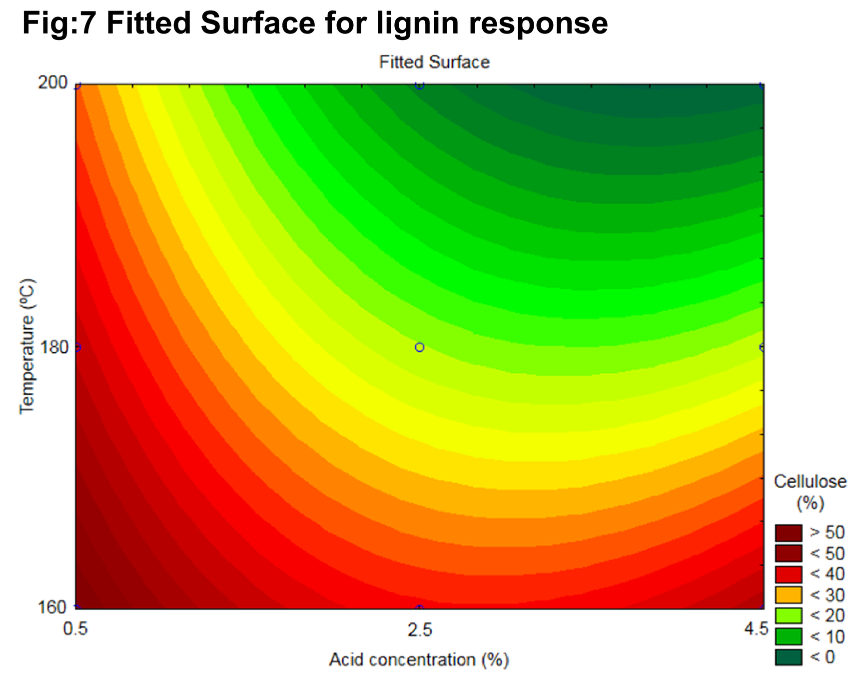

Fig:8 Fitted Surface for cellulose response

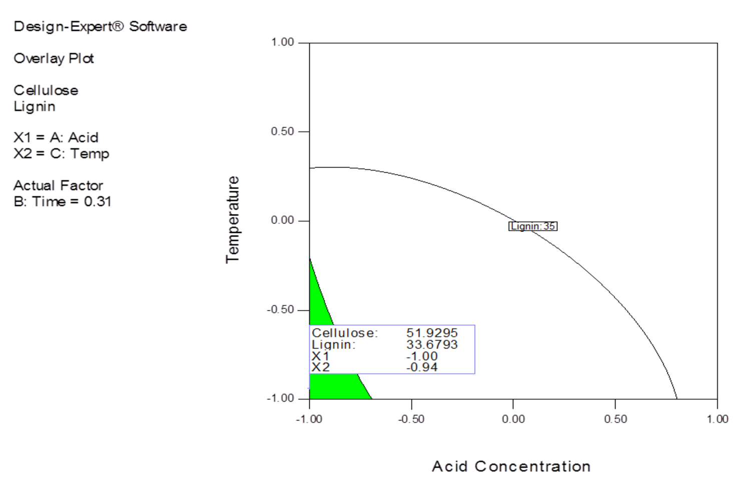

Fig:9 Overlaying plot for the fitted surfaces

CONCLUSIONS

- Elephant grass is a good candidate biomass for the production of fuels and chemicals
- An effective bench scale pretreatment process was performed and optimized
- Physical changes in biomass were observed after different pretreatment conditions
- An optimum pretreatment condition was selected, which promotes maximum removal of lignin and results in a solid with high cellulose content
- Acid: 0.5%; Time: 11.5 min; Temperature: 161 ºC. Under these conditions it is predicted to obtain a solid containing 51.9% cellulose and 33.7% lignin (w/w)

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