OUTLINES
Tuesday 23rd June

FILLAUDEAU Luc
Overview of HTMS aims and context *~15'*
Description of LISBP *~ 15'*

LINDLEY Nicholas (LISBP head) *~ 30'*
Presentation and visit of LISBP

Lunch time (CEMES)

GOMA Gérard (LISBP) *~ 90'*
Biomass and bio-economy: the international context

PHAM Tuan Anh & CAO Bach Xuan (SBFT) ***~ 60'***
Pretreatment of lignocellulosic biomass: Steam explosion (rubber wood) and Organosolv (bagasse)

LISBP
LABORATOIRE D'INGÉNIERIE DES SYSTÈMES BIOLOGIQUES ET DES PROCÉDÉS
INRA SCIENCE & IMPACT
cnrs
INSA TOULOUSE
Université de Toulouse

BIO-Asie

HTMS BIOASIE PROJECT

BIOPROCESS INTENSIFICATION

CHALLENGES RELATED TO TRANSFER LIMITATION

1ST WORKSHOP AT LISBP (TOULOUSE, FR), 23-26TH JUNE 2015

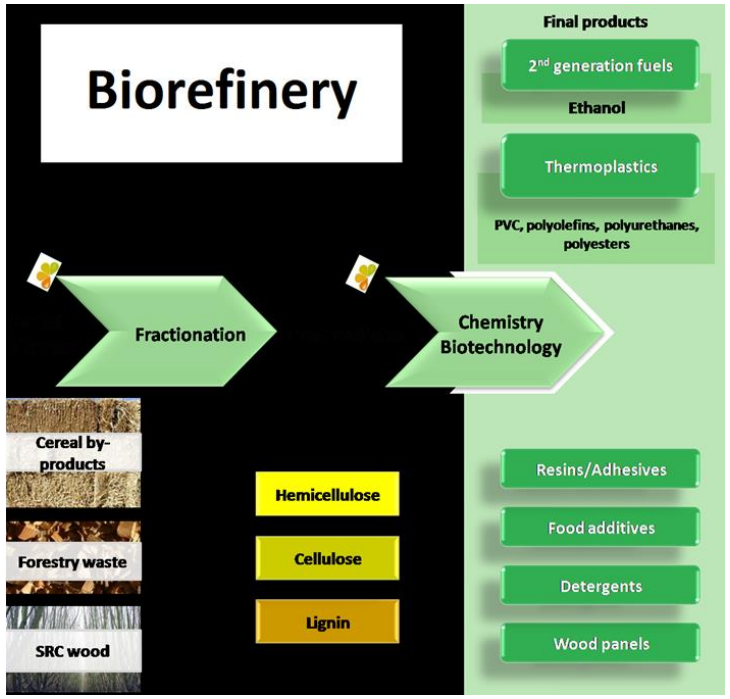
Pretreatment of lignocellulose biomass in term of glucose release

PHAM Tuan Anh
TO Kim Anh
LE Tuan
CAO Xuan Bach

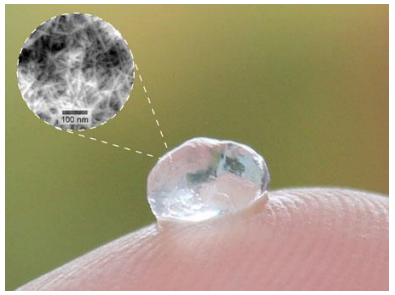
Sugarcane bagasse

Rubber wood

Cassava bagasse

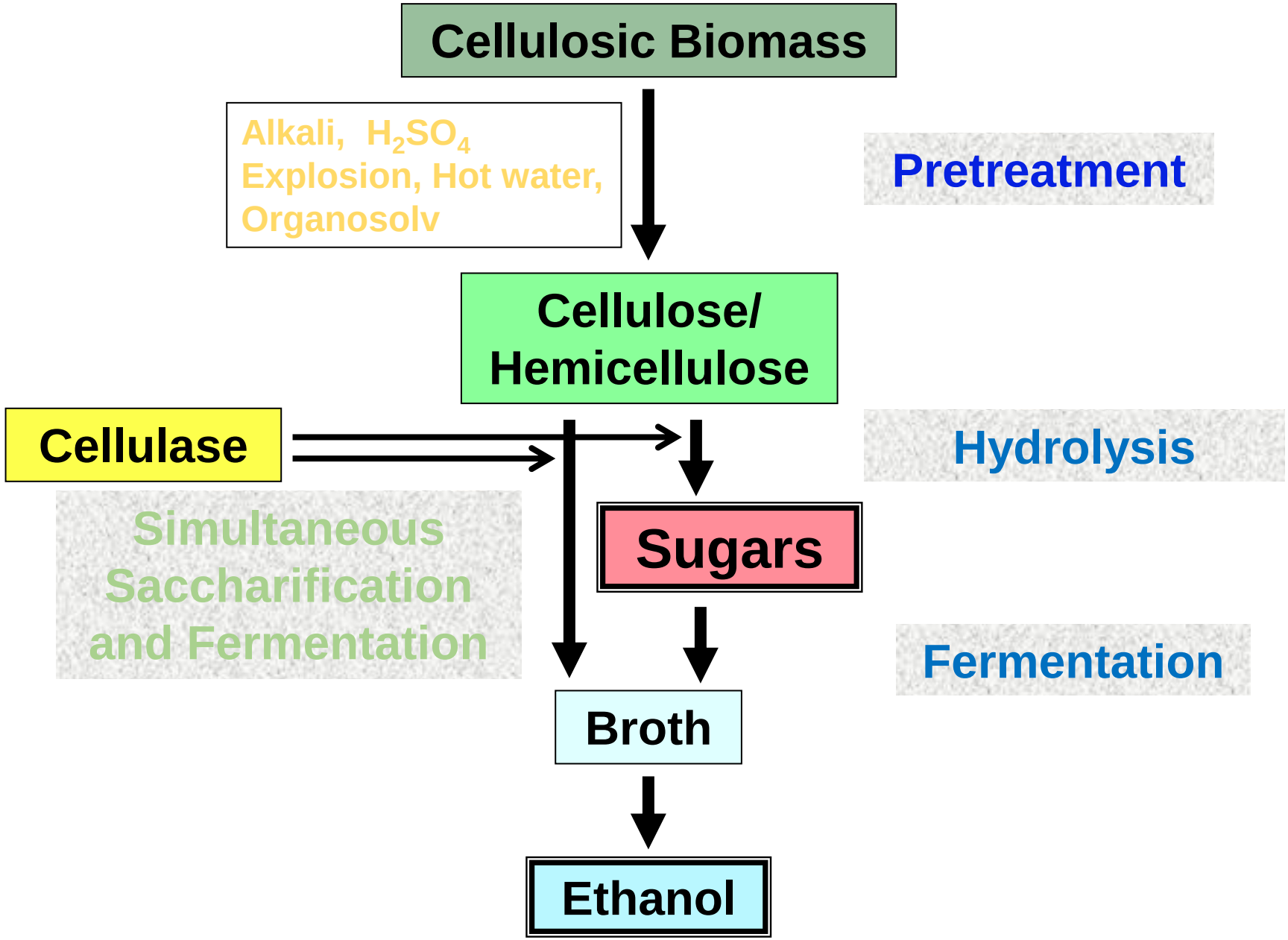


Bioethanol



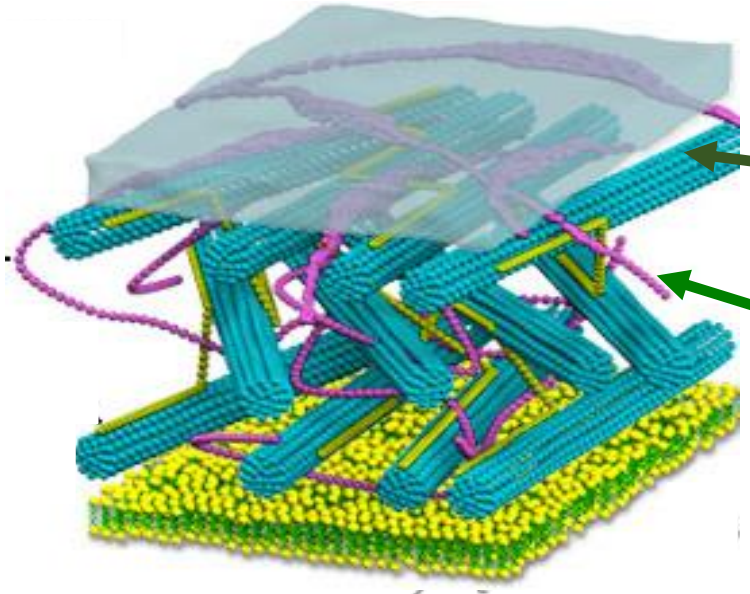
Nanocrystalline cellulose

Bioethanol Production Process from Cellulosic Biomass



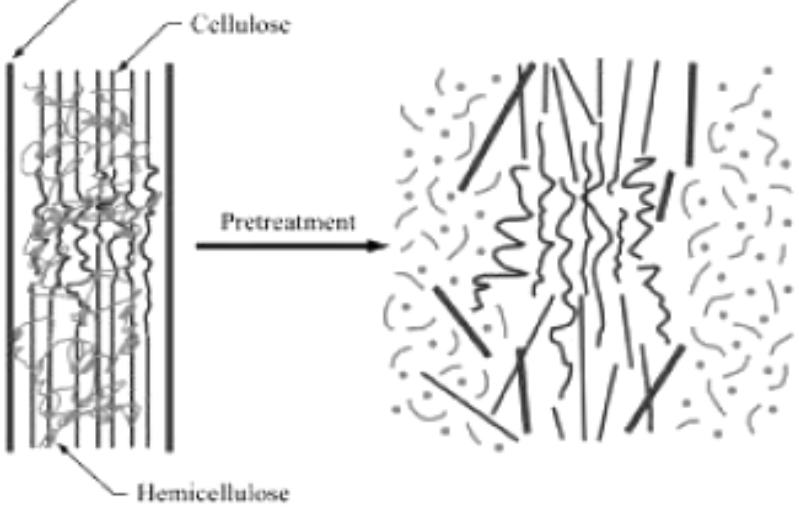
GOALS

- ✓ Maximizes lignin removal.
- ✓ Reduce cellulose crystallity.
- ✓ Limit formation of inhibitors
- ✓ Increase matrix porosity..
- ✓ Minimizes cost.



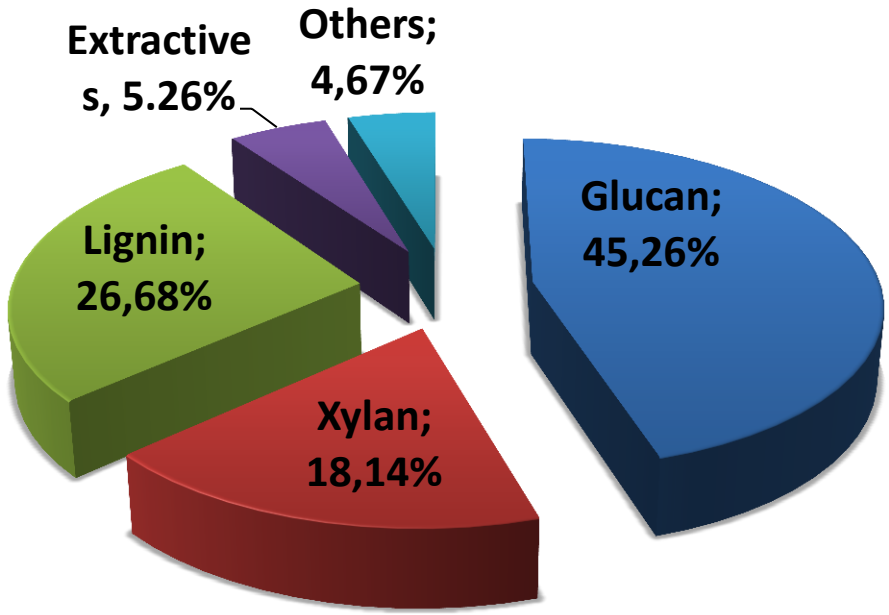
METHODS (at HUST-SBFT)

- ➢ Alkaline (NaOH)
- ➢ Dilute acid (H_2SO_4)
- ➢ Hot water
- ➢ Solvent: Formic acid
- ➢ Bio-pretreatment
- ➢ Steam explosion (Nagaoka University of Tech)



Pretreatment effect
(Hsu *et al.* 1980)

In 2012: 20 million tons Sugarcane

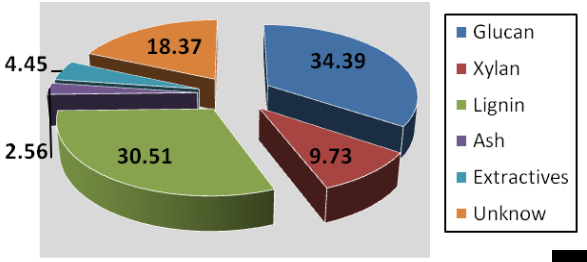


Bagasse

- Rich in glucan
- Lower lignin ratio

In 2012: 6.7 million tons Sugarcane bagasse ~ 1.17 million tons Bioethanol

Fractionation Process



ORGANOSOLV pretreatment

Biomass → Fractionation → Separation

Separation → Solid (cellulose) → Wash → Cellulose → C6 sugar

Separation → Liquid (Organosol+ lignin+ sugar syrup) → Distillation

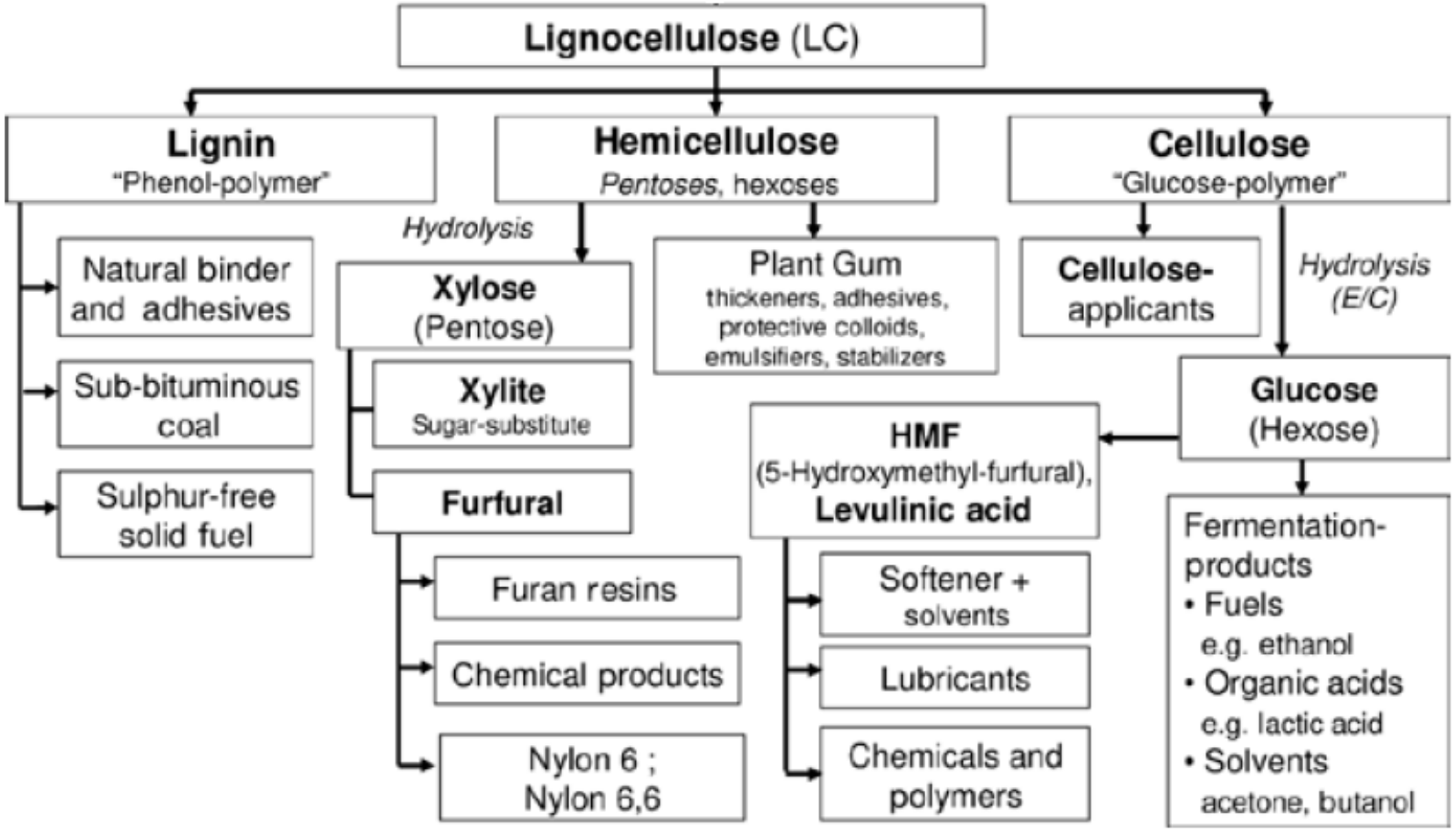
Distillation → Re-use → Fractionation

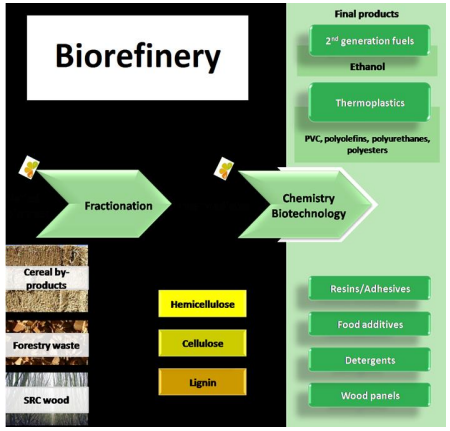
Liquid (Organosol+ lignin+ sugar syrup) + Water → Separation

Separation → Lignin

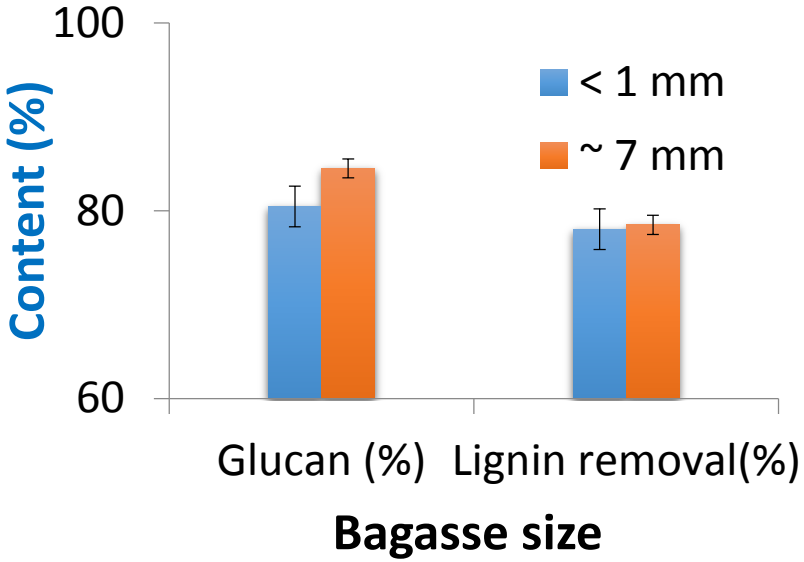
Separation → Sugar soluble

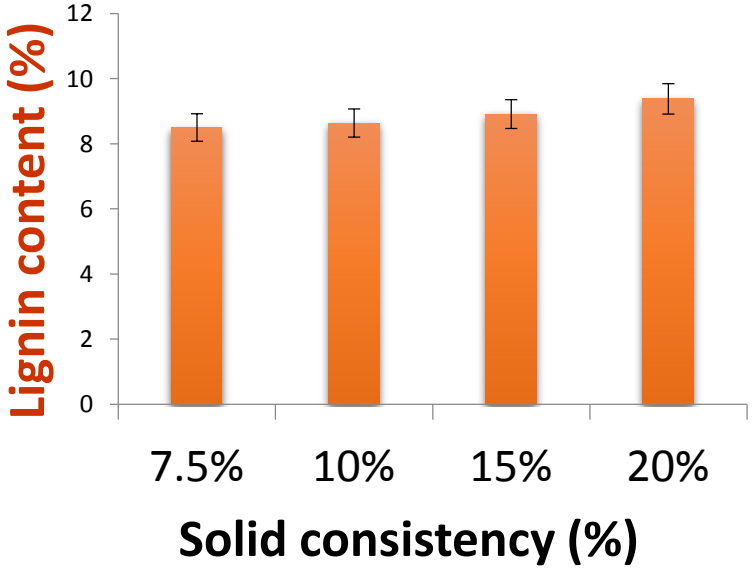
Eco-friendly process





- All fractions could be used in different applications
- Use the standard fermentation process



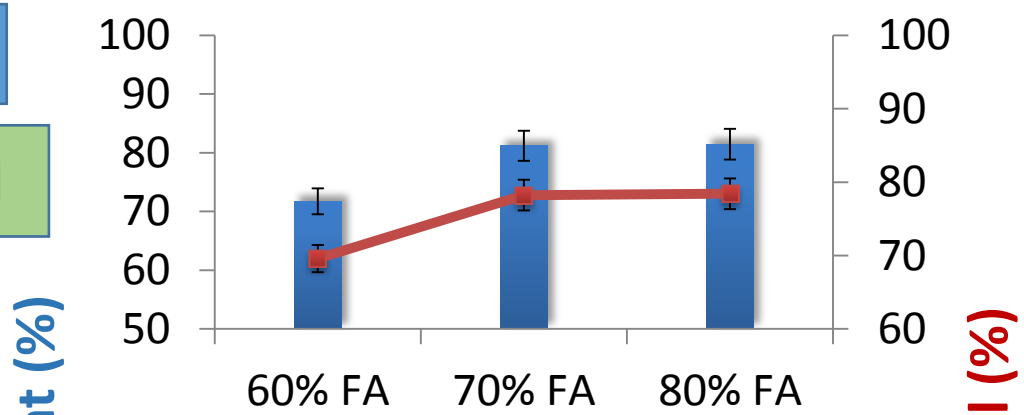


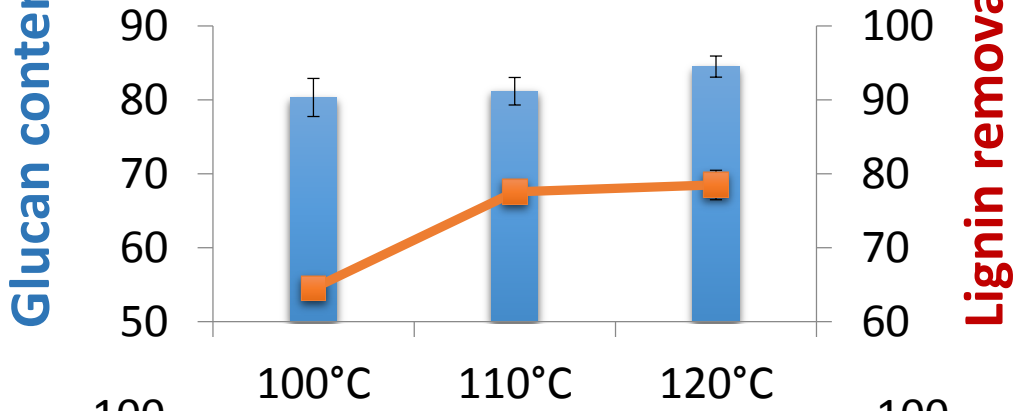
Fractionation Process

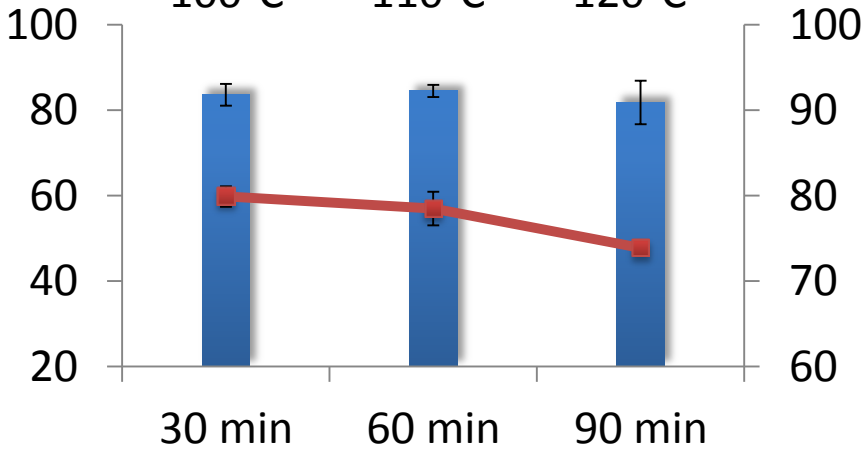
Sugarcane bagasse

Formic acid

- Residues composition
- Delignification

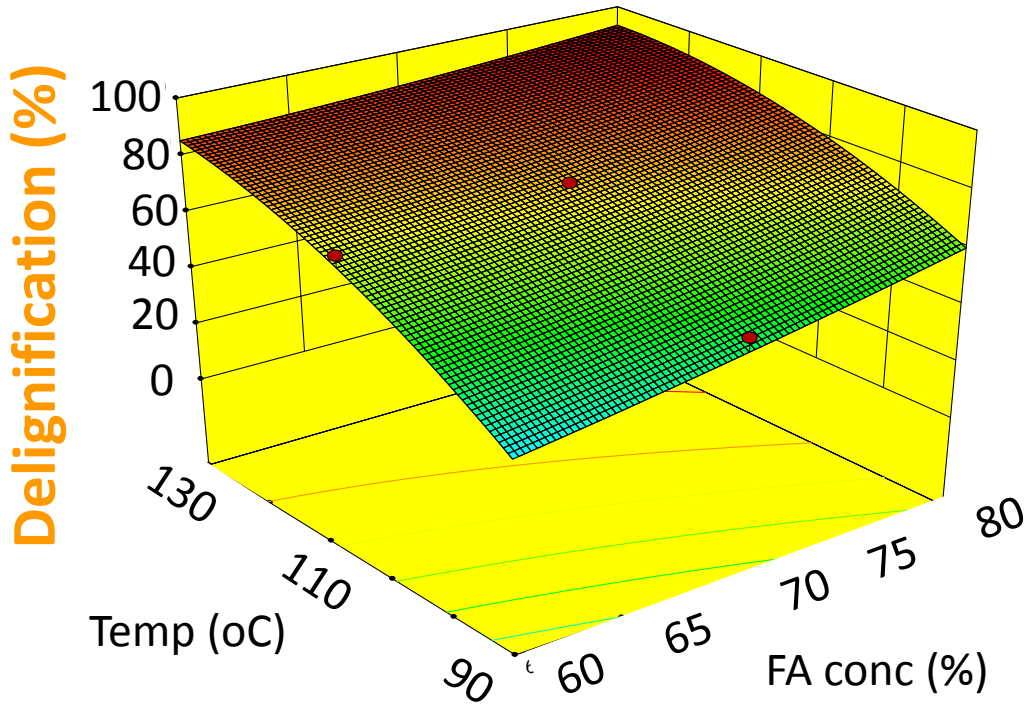


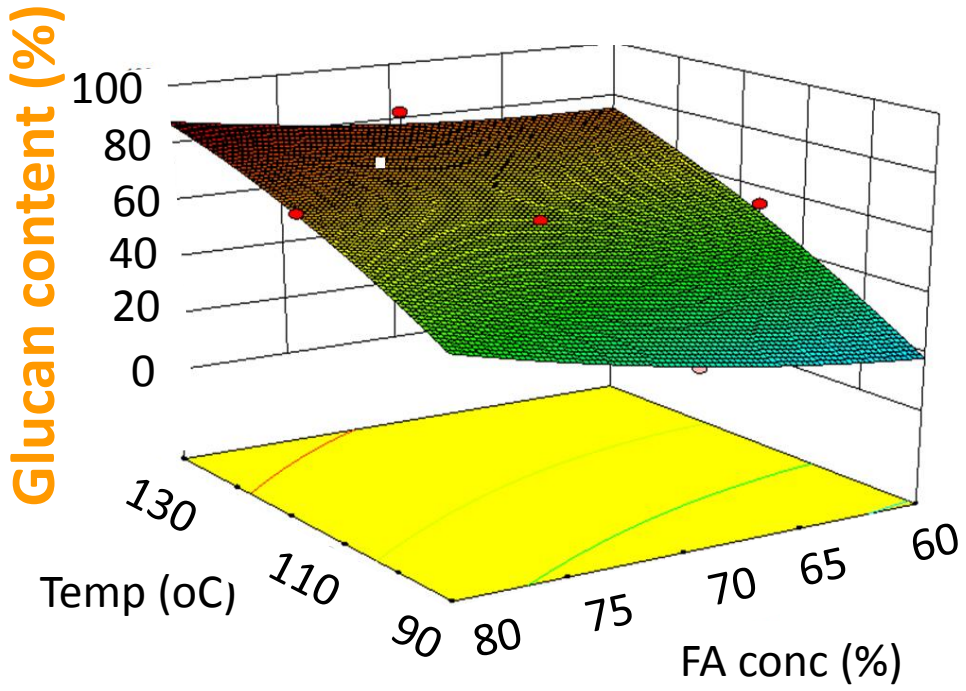




Optimization of fractionated process using response surface

Response surface using quadratic model (A: FA concentration, B: temp, C: time)	R^2
Delignification [%]=75.28 + 8.42*A + 20.96*B + 5.48*C - 4.59*A*B – 3.95*B*C – 7.87*B^2 – 5.96*C^2	0.9877
Glucan [%] =78.85 + 12.43*A + 4.98*B + 2.87 C - 1.92*A*B - 4.5*C^2	0.9887





Temperature, form... concentration Increase, increase the delignification and glucan content

> 90 % delignification

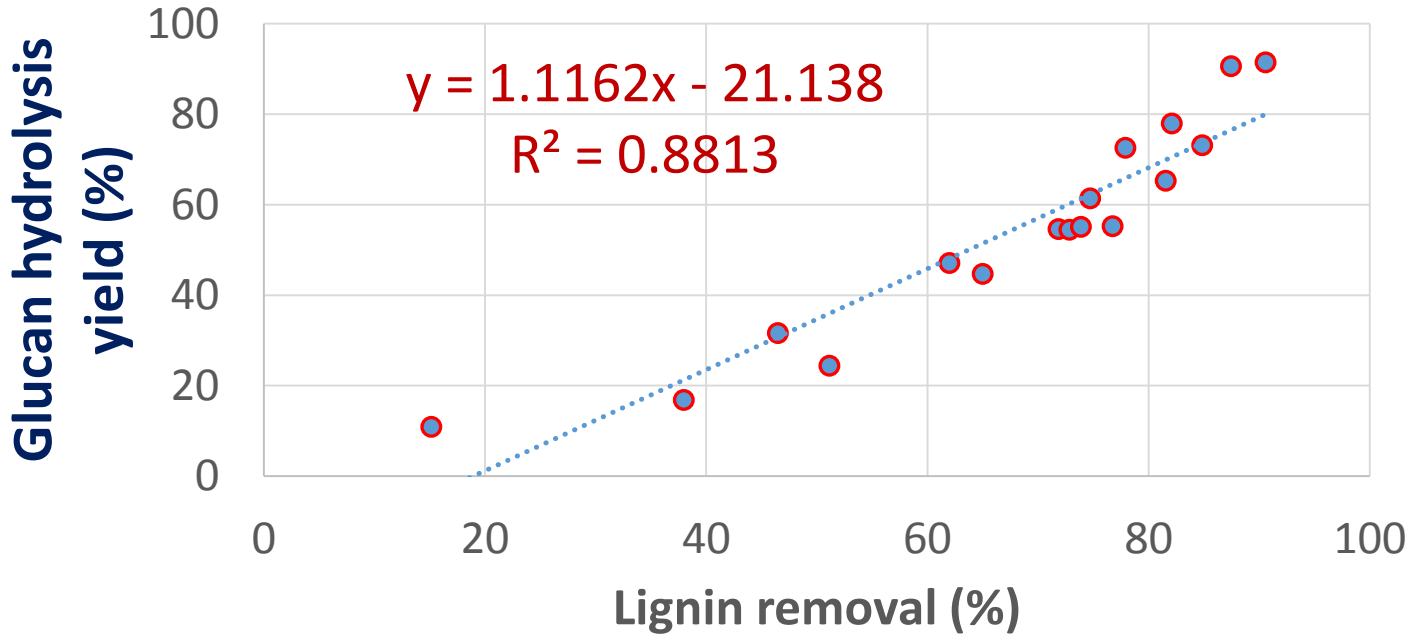
high glucan content (>92 %)

Relationship between lignin removal and hydrolysis yield

Fractionation

↓

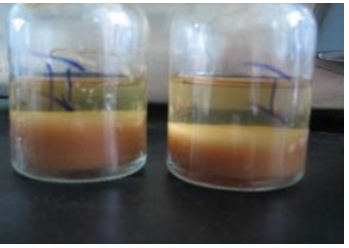
Hydrolysis



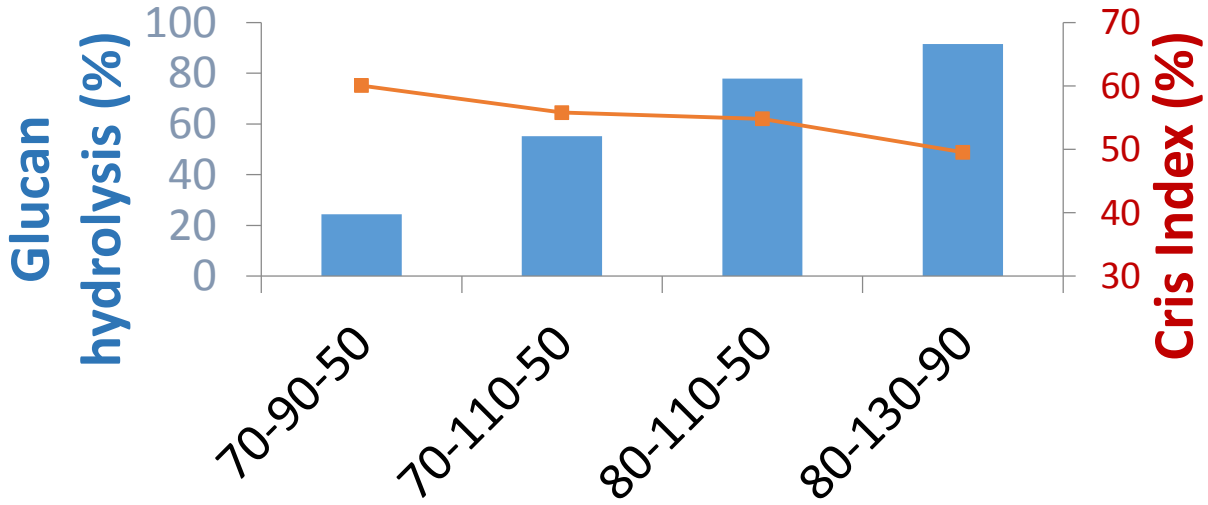
linear correlation delignification ~ glucan hydrolysis yield

72h, 50 °C, 150 rpm, 60 FPU/g dm using NS2192

At beginning…

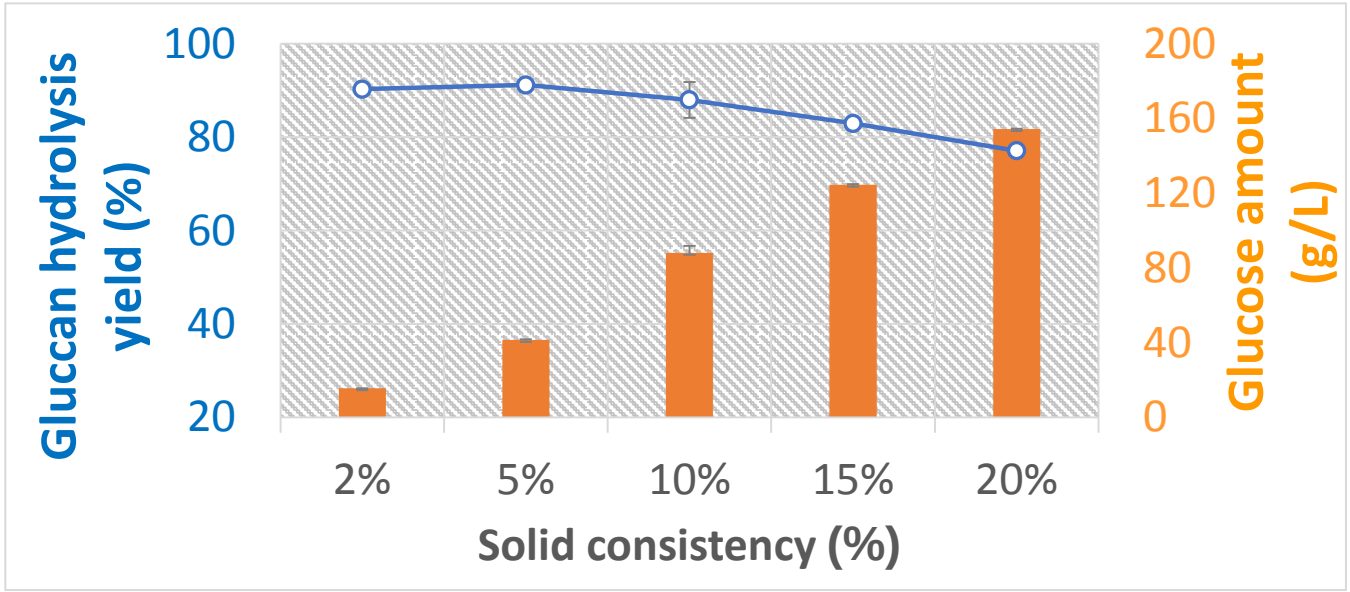


And after 72h



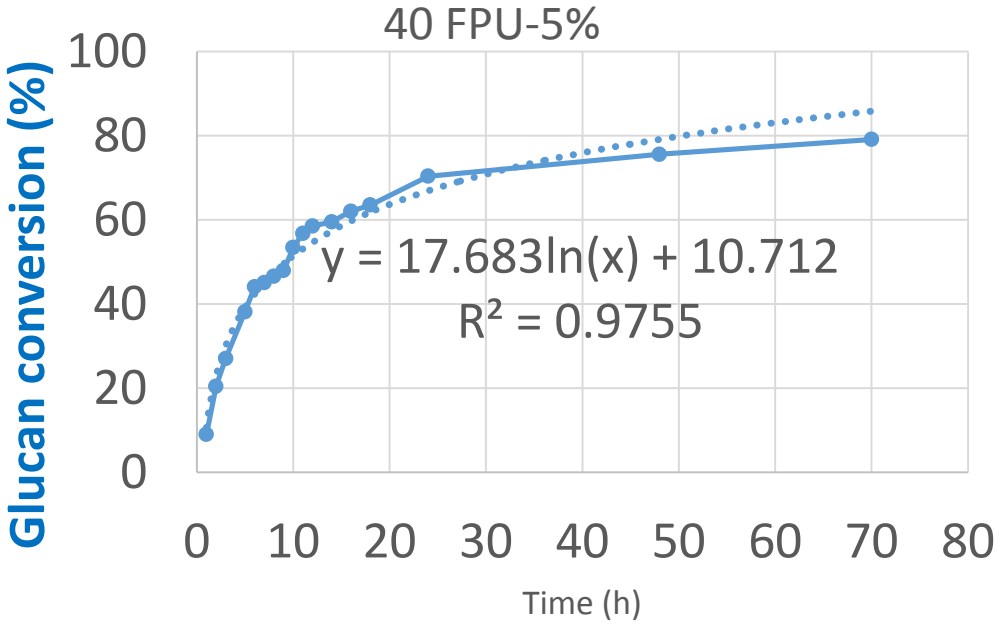
cellulose crystallinity affected on the hydrolysis yield

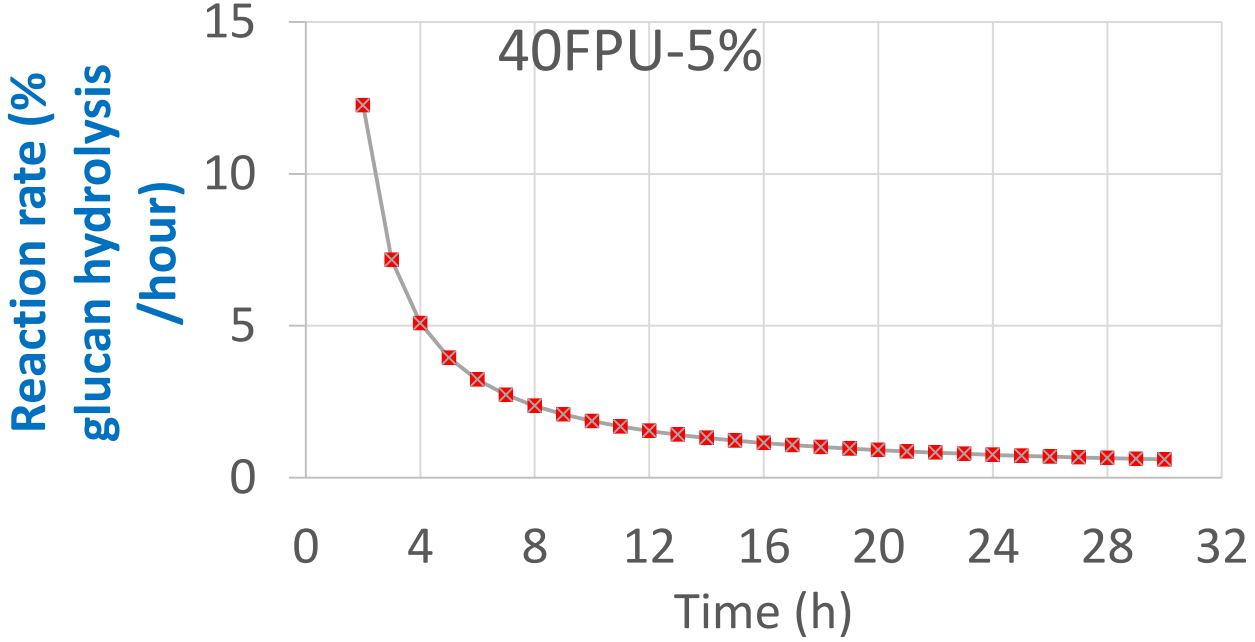
Hydrolysis of fractionated Sugarcane Bagasse



Residue is easy to hydrolysis

hydrolysis up to 20% with the hydrolysis yield with more 80% glucan hydrolysis and 160 g glucose /mL



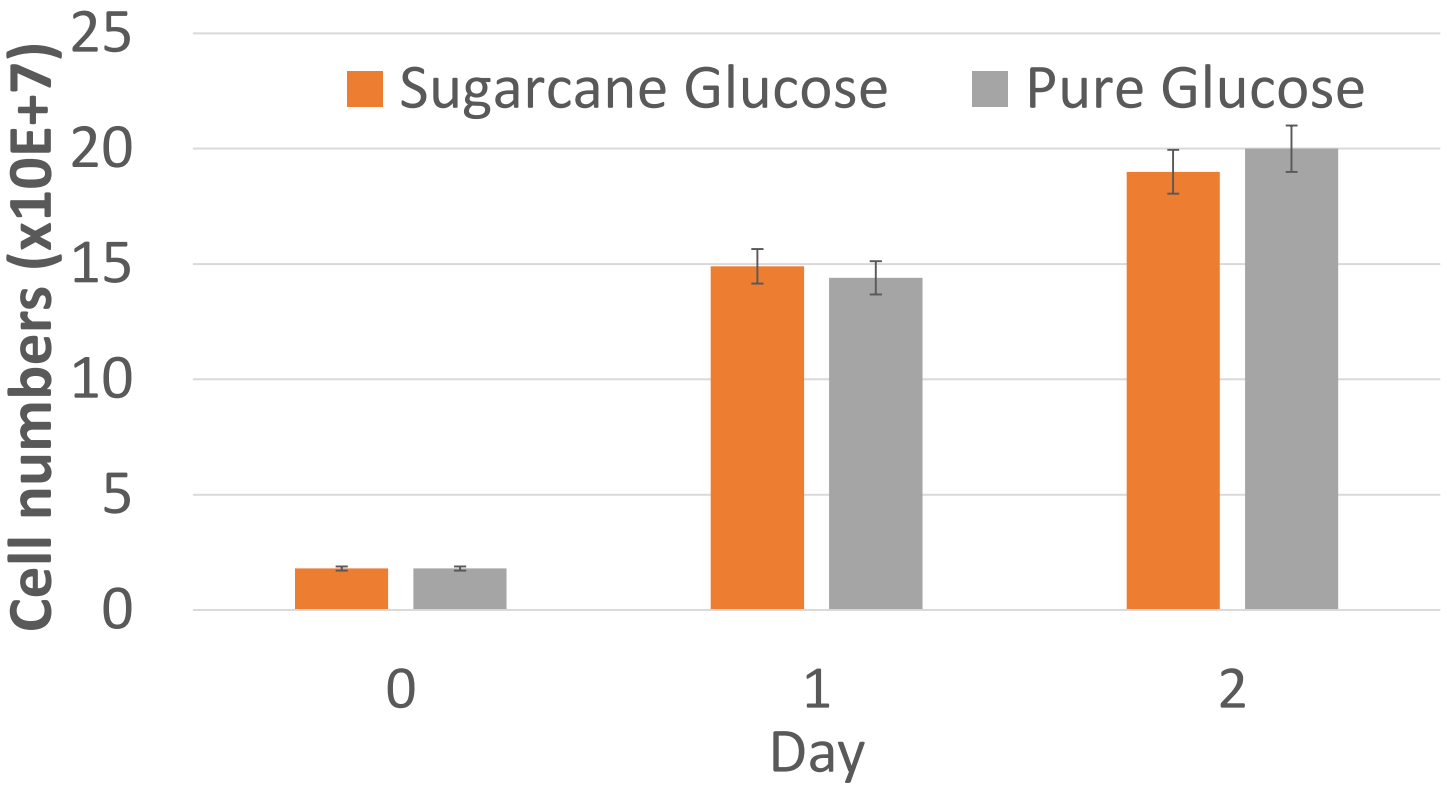


Ethanol Red ® (*Saccharomyces cerevisiae*) used the SB glucose

Ethanol Red 110 g/L Glucose + Ure…..

30oC, 100 rpm

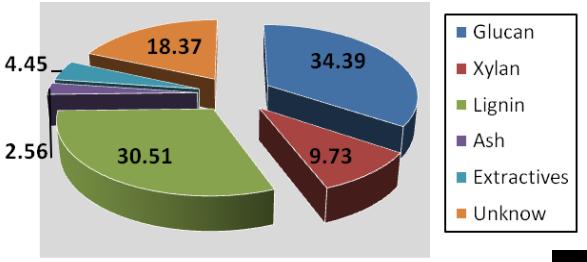
Cell number



Non-significant difference

Non product toxic was produced

Fractionation Process



ORGANOSOLV pretreatment

Biomass → Fractionation → Separation

Separation → Solid (cellulose) → Wash → Cellulose → C6 sugar

Separation → Liquid (Organosol+ lignin+ sugar syrup) → Distillation

Distillation → Re-use → Fractionation

Liquid (Organosol+ lignin+ sugar syrup) + Water → Separation

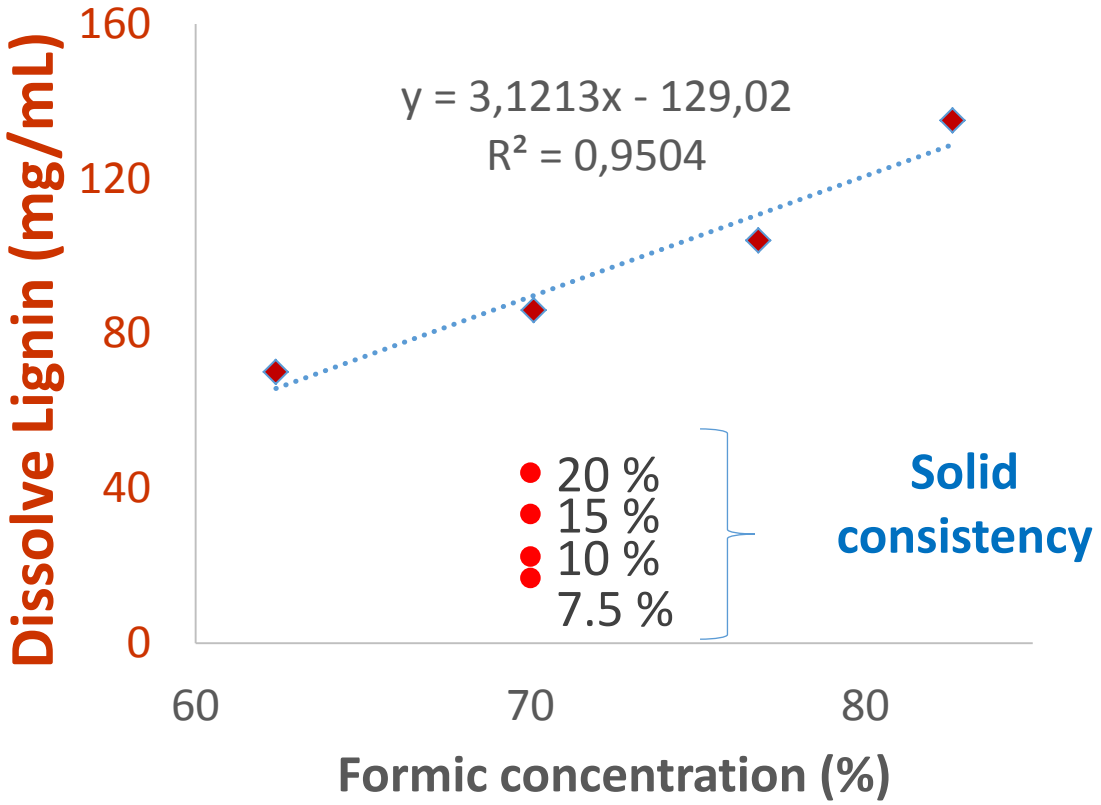
Separation → Lignin

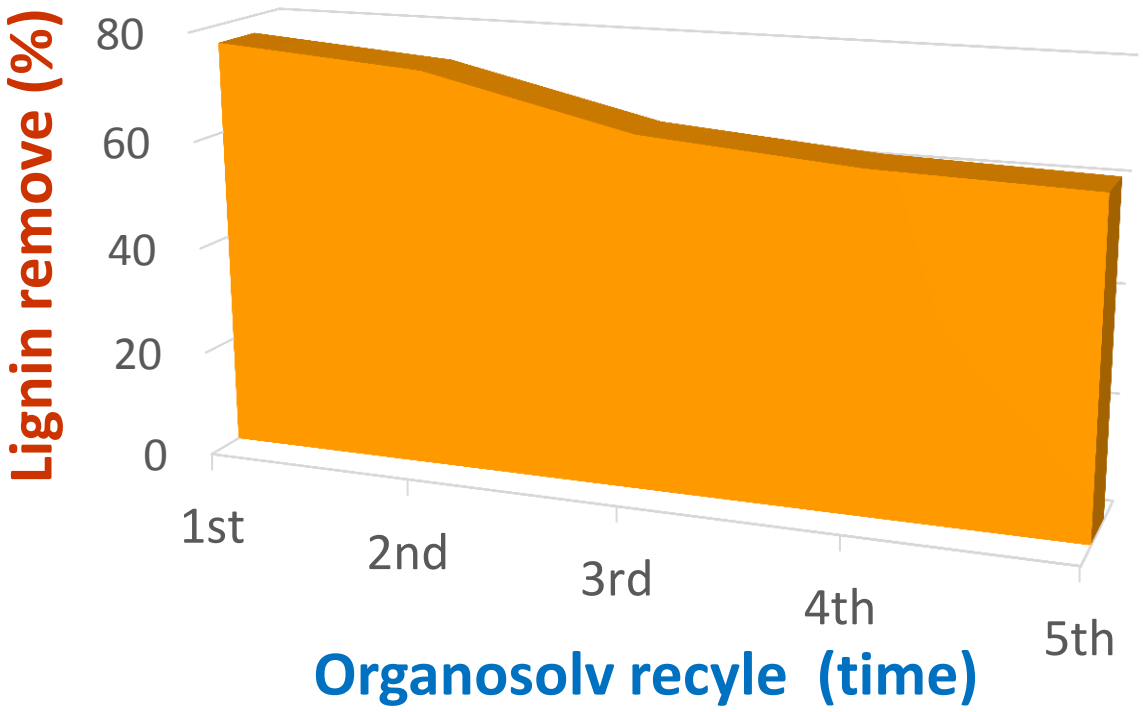
Separation → Sugar soluble

Eco-friendly process

Recycle of organosolv

Lignin Solubility in Formic acid





dissolve lignin in fraction process was not saturated

Directly reused solvent

Fractionation Process

Eco-friendly process

> 90 % delignification

high glucan content (>92 %)

More delignification -> more glucan conversion

Non yeast inhibitor

…continuous : development enzymatic secretome - > hydrolysis cellulose fractionation

Hanoi University of Sience and Technology

Nagaoka University of Technology

ESCANBER

ESCANBER

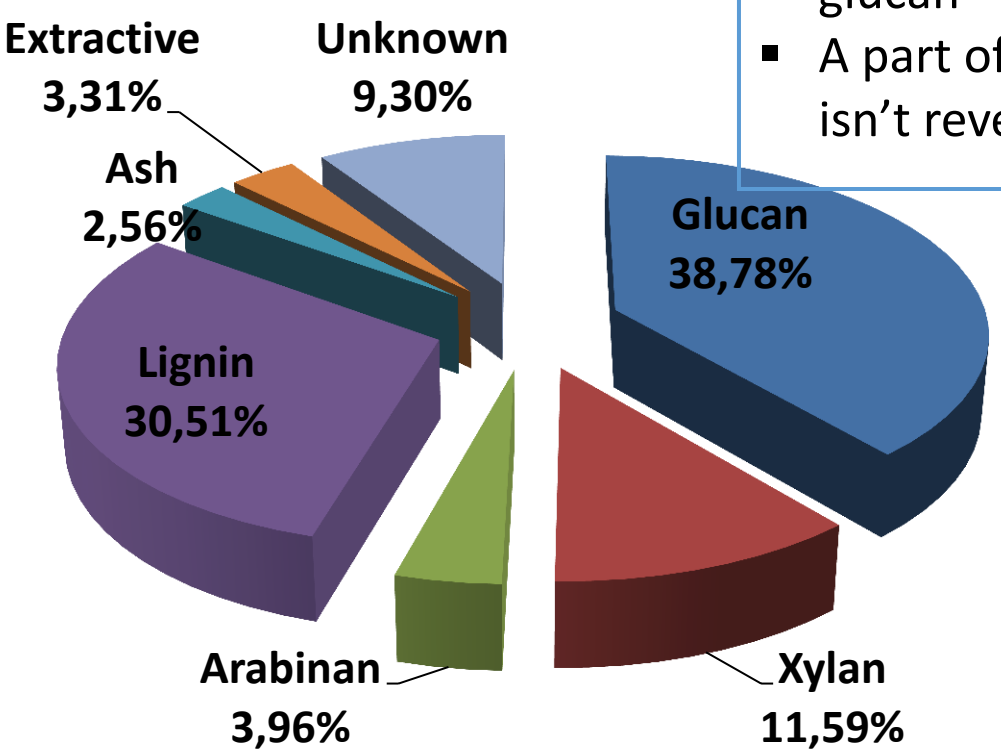
ESTABLISHMENT OF CARBON-CYCLE-SYSTEM WITH NATURAL RUBBER

- Research Group 1 (Development of a novel evaluation method of natural rubber)
- Research Group 2 (Development of high-performance rubber)
- Research Group 3 (Development of highly functional polymer)
- **Research Group 4 (Development of technology to produce bio-fuel from rubber waste woods)**
- Research Group 5 (Development of advanced treatment technology of rubber industrial wastewater)

Establishment of pretreatment method of rubber waste woods

Decision of a suitable decomposition micro-organism and enzyme

Rubber wood



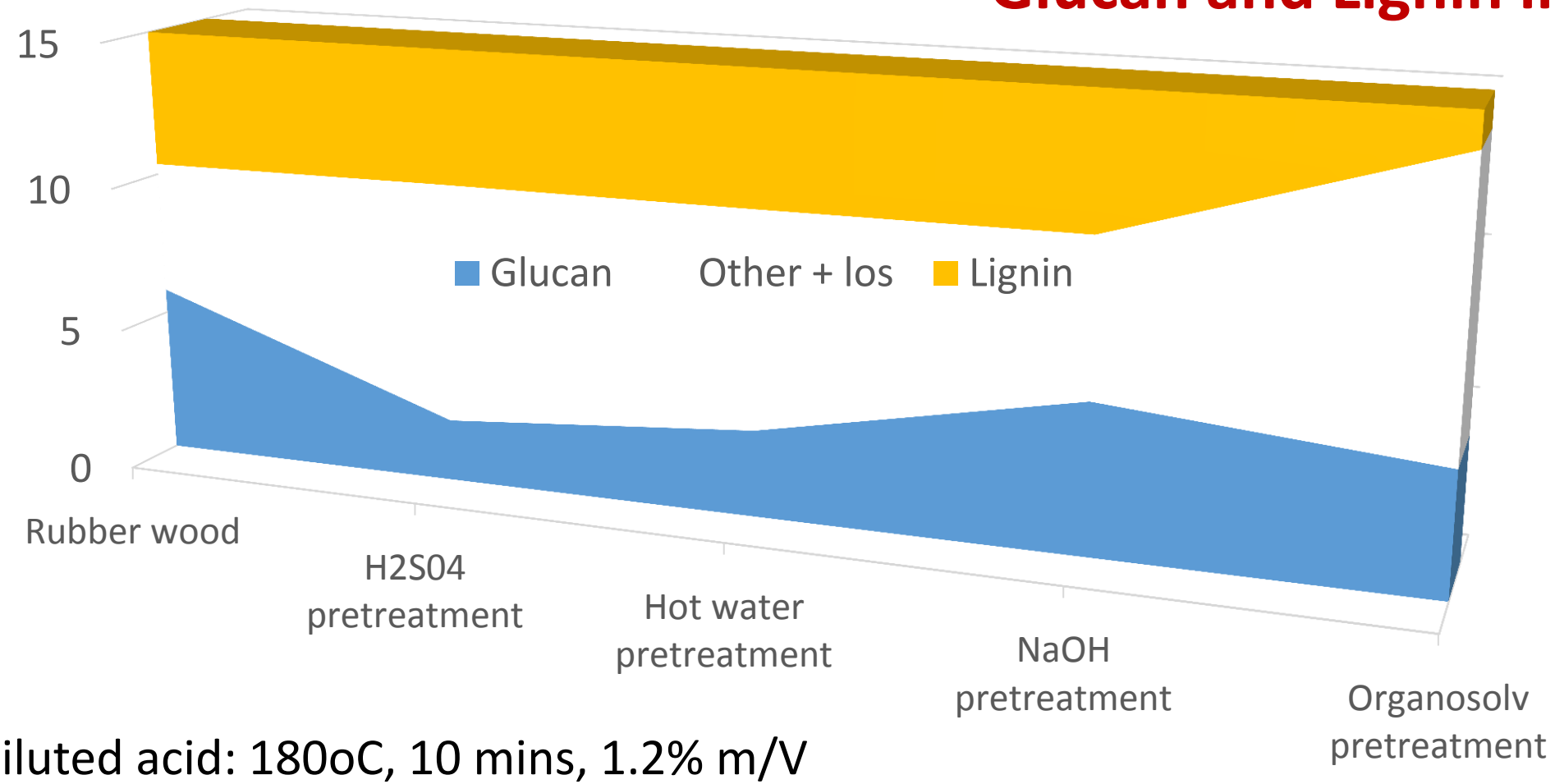
- High lignin content
- Average percentage of glucan
- A part of composition isn't revealed.

METHODS (at HUST)

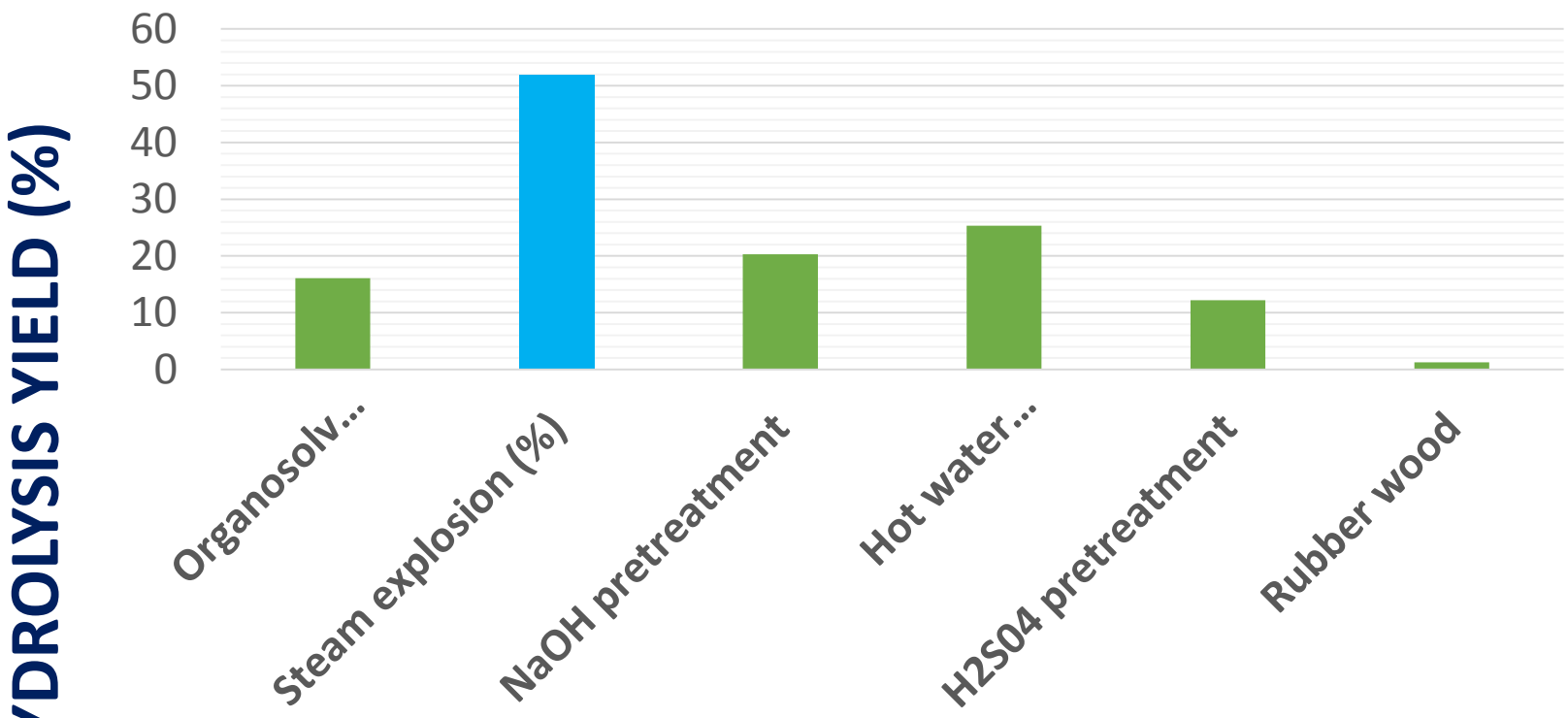
- Alkaline (NaOH)
- Dilute acid (H_2SO_4)
- Hot water
- Solvent: Formic acid
- Bio-pretreatment: *Phomopsis*
- Steam explosion (at Nagaoka University)

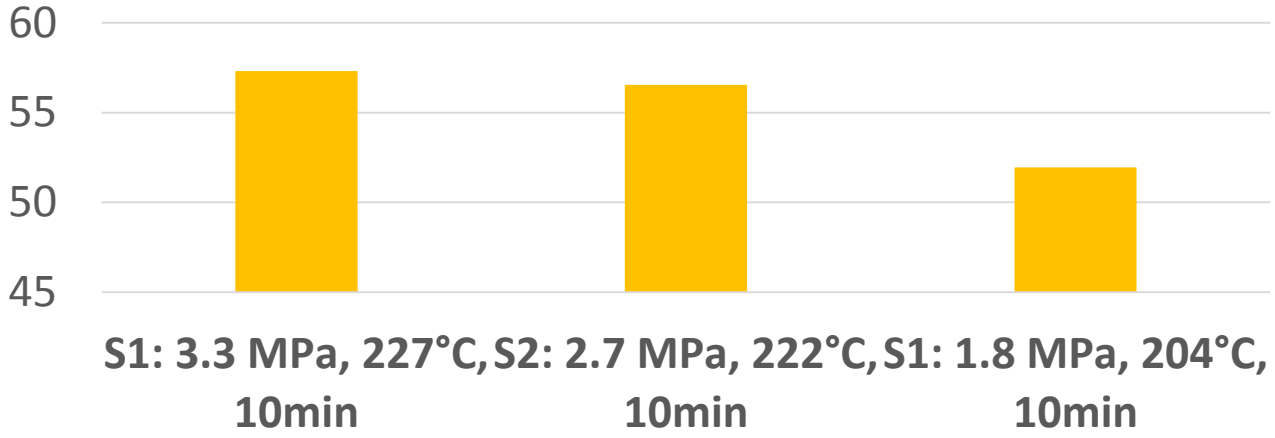
Rubber wood pretreatment

Glucan and Lignin in Residues



- Diluted acid: 180oC, 10 mins, 1.2% m/V
- Hot water: 195oC, 30 mins
- Alkaline: 190oC, 30 mins, 1.5% m/V
- Organosolv: 121oC, 60 mins 70% m/m



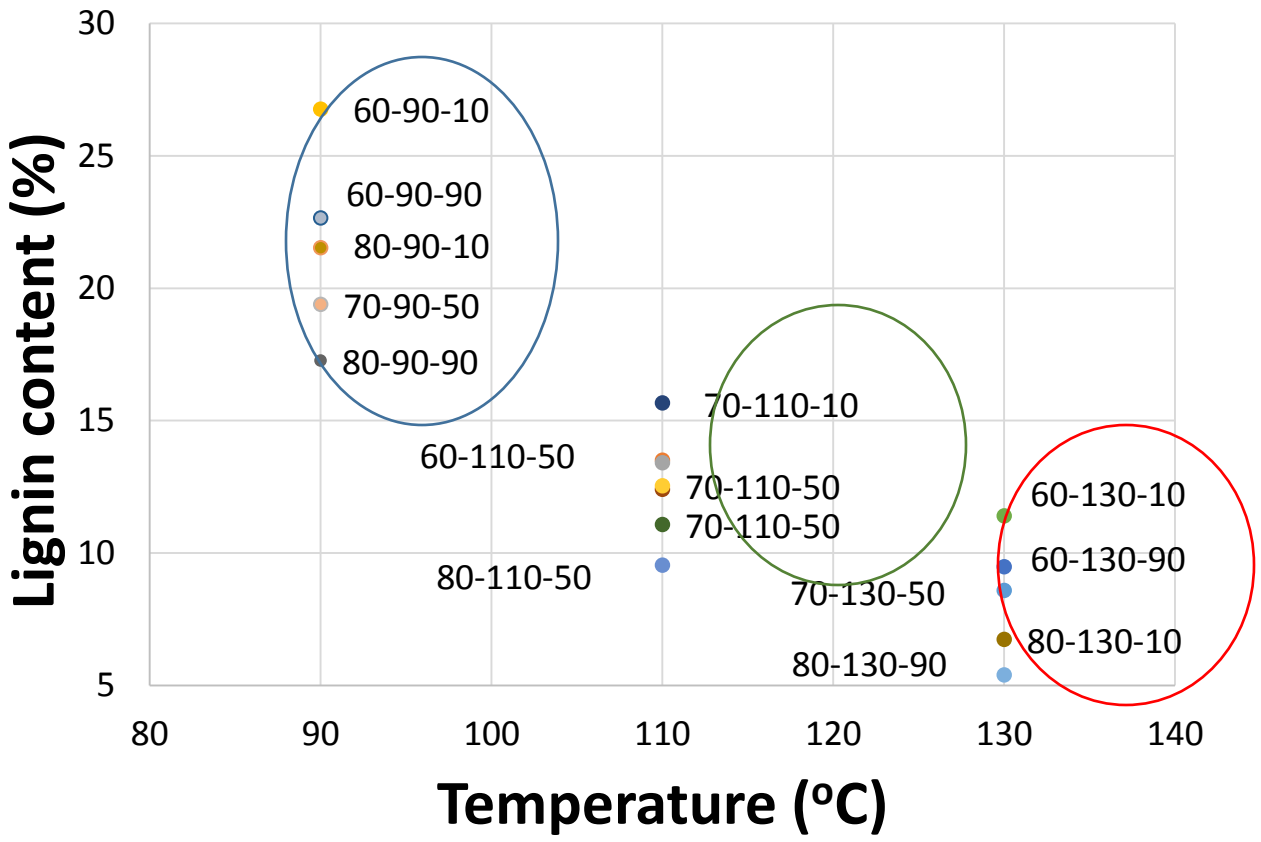


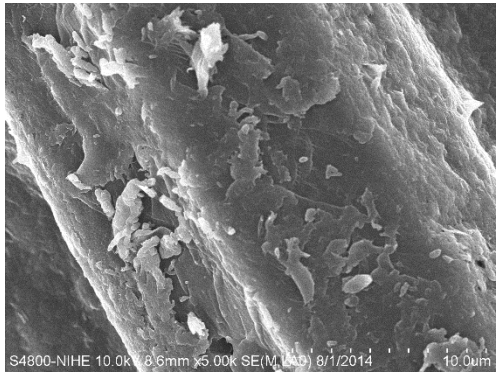
Steam explosion was better pretreatment for rubber wood

Thank you for your attention

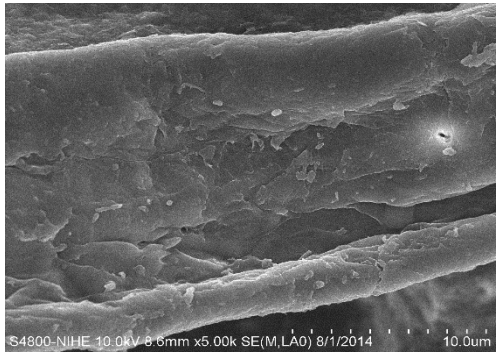
…and Welcome

Role of temperature on fractionated process





70-90-50

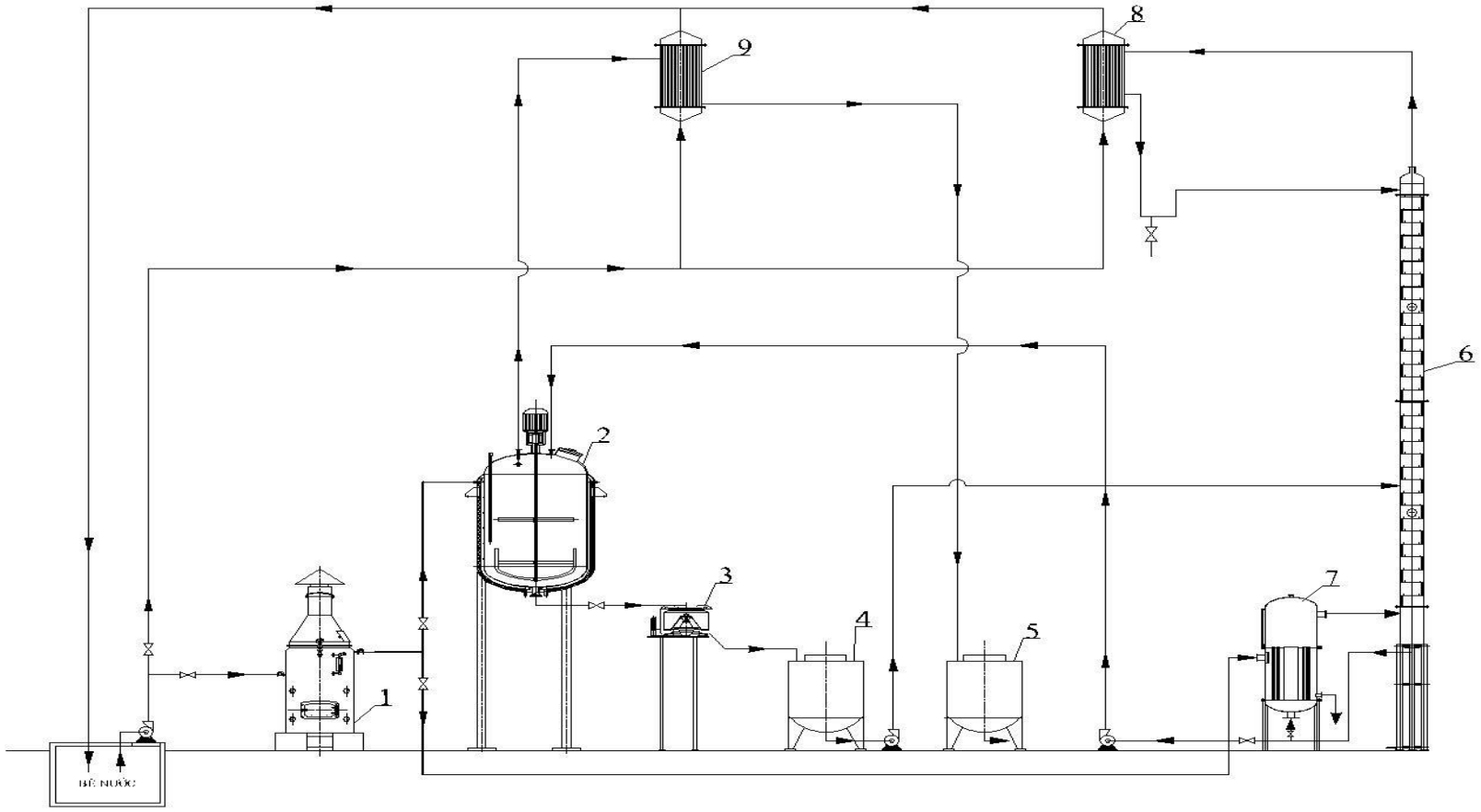


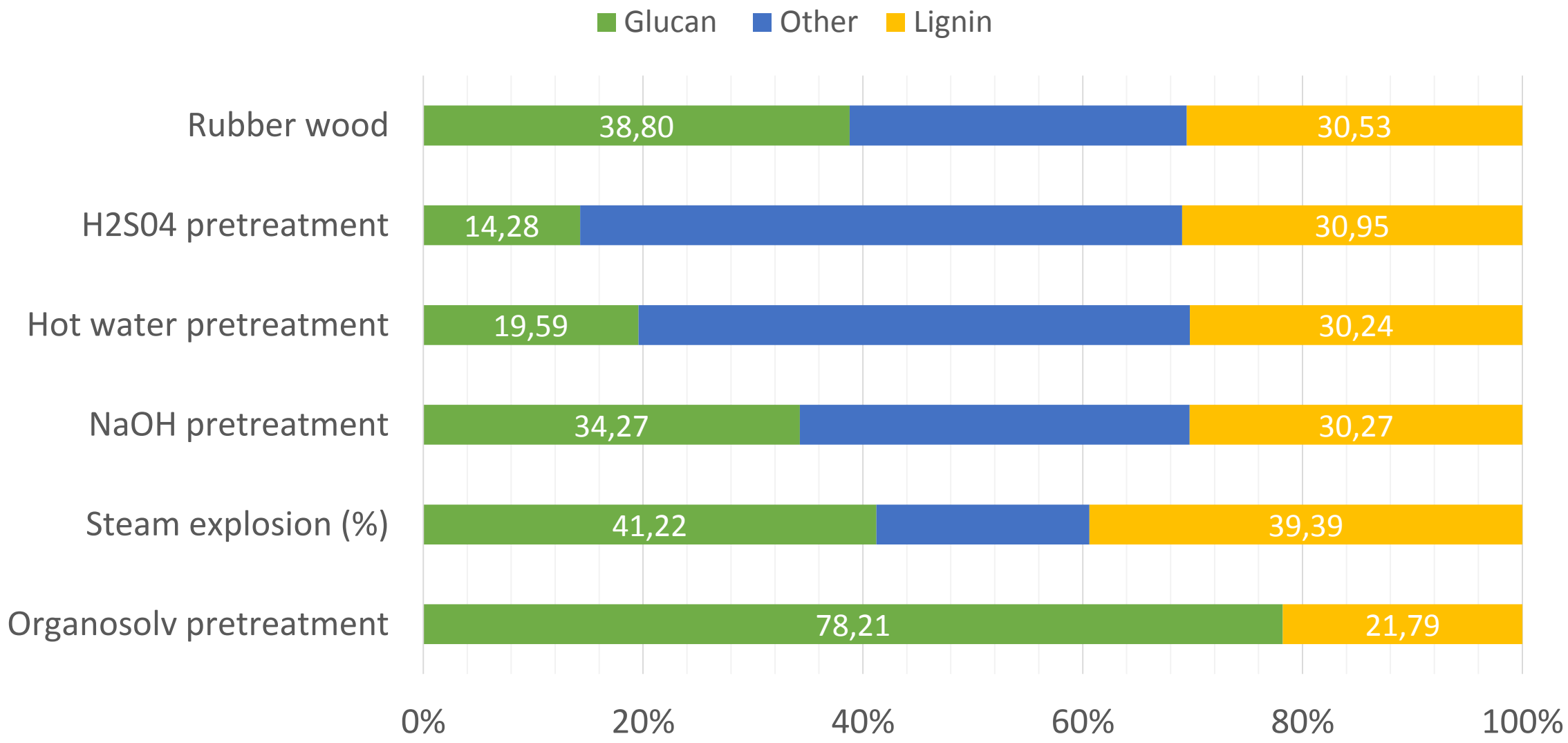
70-110-50

Residues could be divided on three groups : high lignin , middle lignin and low lignin content corresponding of the fractionated temperature 90, 110 and 130 ^{0C}

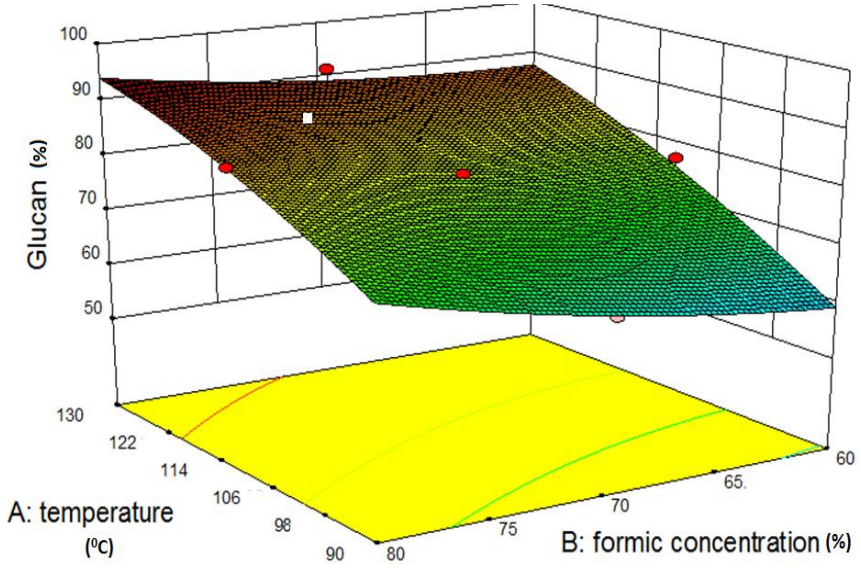
Fractionation and formic acid recovery pilot

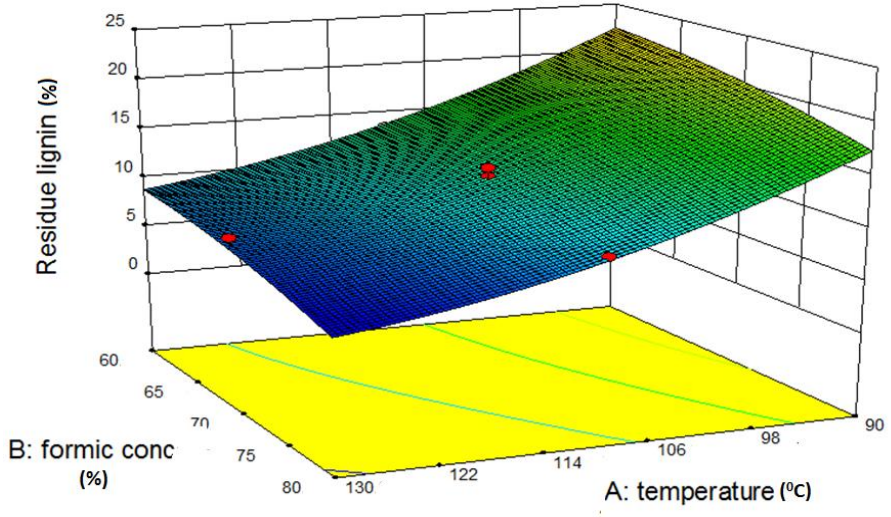
1: Steam generator




Glucan
Other
Lignin
Rubber wood
38,80
30,53
H2S04 pretreatment
14,28
30,95
Hot water pretreatment
19,59
30,24
NaOH pretreatment
34,27
30,27
Steam explosion (%)
41,22
39,39
Organosolv pretreatment
78,21
21,79
0%
20%
40%
60%
80%
100%

Optimization of fractionated process using response surface





Response surface using quadratic model	R^2	Ajust R^2
Lignin [%] =12.14 – 6.6*A – 2.33*B -1.49*C + 1.52*A^2 + 1.57*C^2	0.9877	0.9718
Glucan [%] =78.85 + 12.43*A + 4.98*B + 2.87 C - 1.92*A*B - 4.5*C^2	0.9887	0.9743
Hydrolys yield [%] = 55.28 + 26.22* A + 11.86*B + 3.17*C – 3.48*A*C – 9.4*A^2 + 8.1*B^2	0.9906	0.9786