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Comprehensive Utilization of Woody Biomass components

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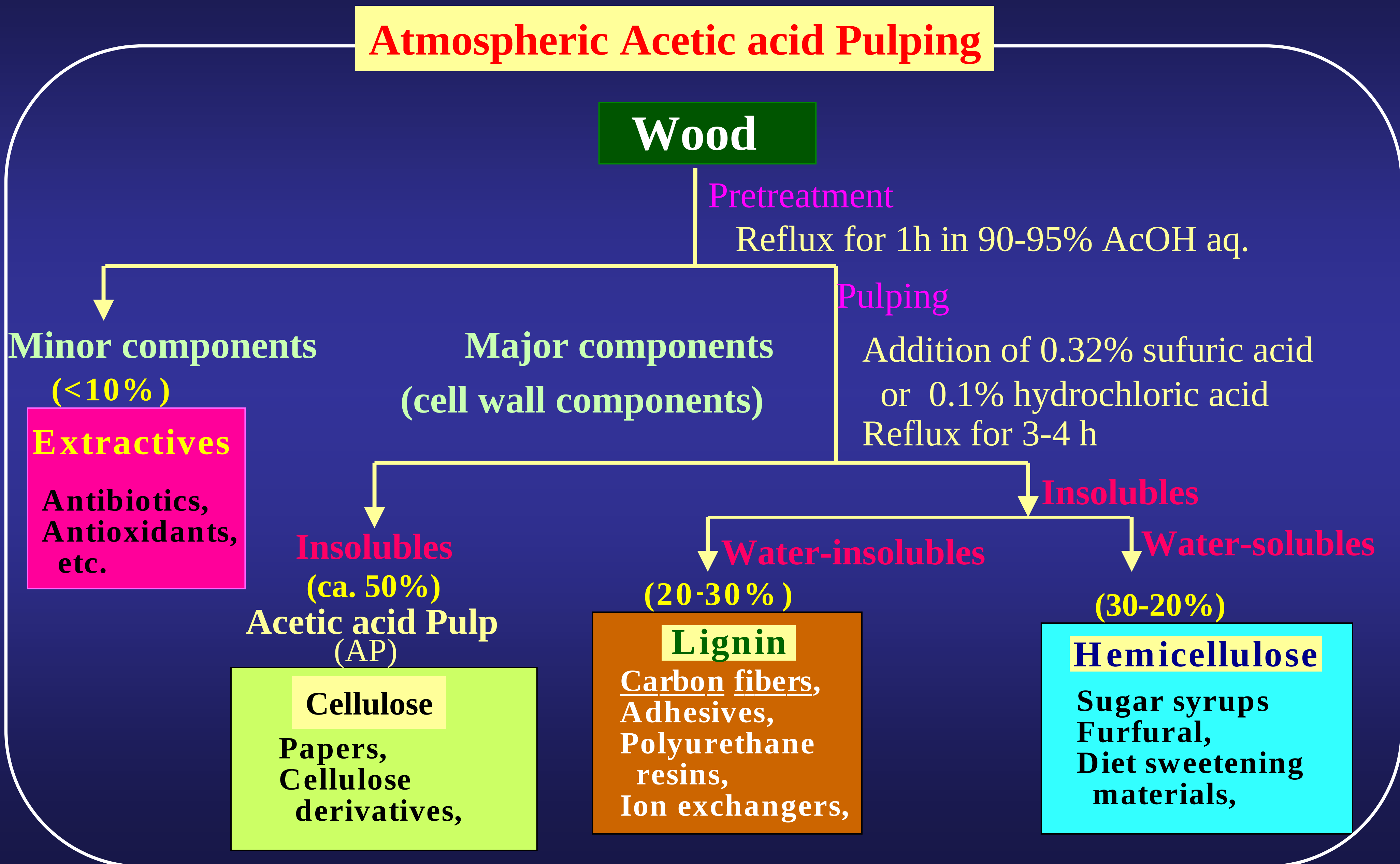
Woody biomass is

- **the most abundant natural resource on the earth.**
- **carbon neutral.**
- **comprised of hydrophilic polysaccharides,**
  cellulose and
  hemicellulose (glucomannan, glucuronoxylan, and arabinogalactan).
  and hydrophobic lignin (polyphenylpropanoid).

↓

An alternative resource to fossil resources

Objectives: Comprehensive utilization of woody biomass



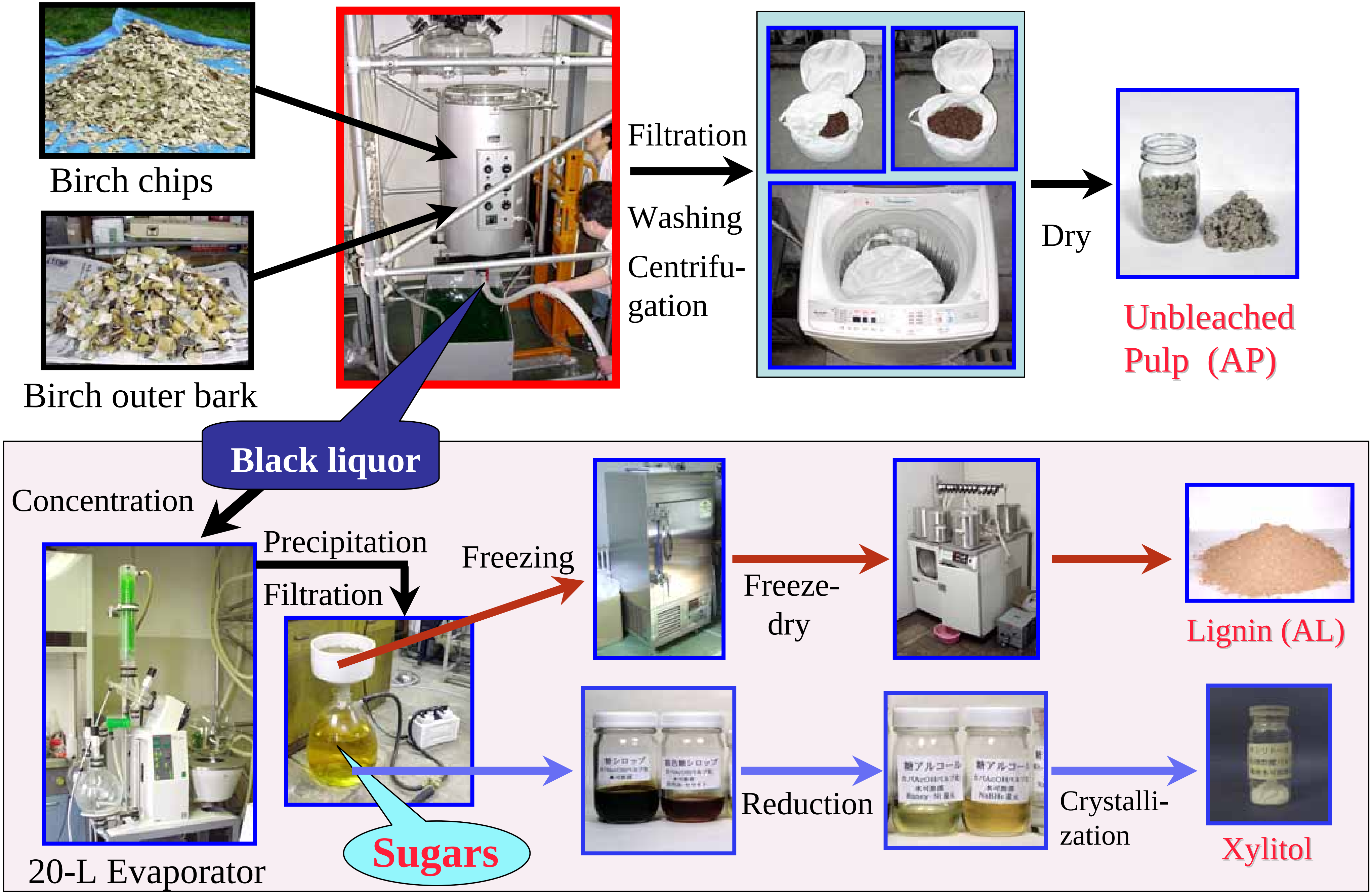


Fig. Separation scheme of woody biomass (birch) using a large reactor

Table Material balance on the atmospheric acetic acid pulping.

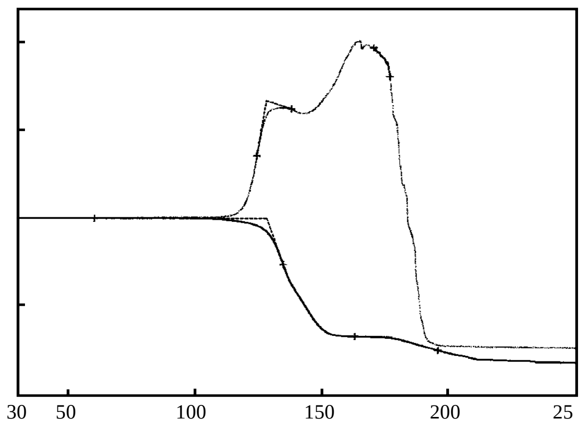
Species	Cooking conditions		Material balance (% on chips)			
	AcOH	Catalyst	Pulp (KL)	Reject	Lignin	WS
Birch	90%	0.32-SA	51.8 (5.3)	0.1	22.2	30.2
	95%	0.1-HCl	51.9 (4.7)	0.0	19.0	27.1
	90%[1)]	0.32-SA	46.3 (5.6)	0.8	24.9	27.7
Beech	90%	0.32-SA	47.5 (7.2)	0.4		
Poplar	90%	0.32-SA	49.9 (3.5)	0.0	22.9	22.3
Todo-fir	95%	0.1-HCl	51.7 (7.3)	0.2	24.5	25.9

SA, sulfuric acid; Pulp, screened pulp; KL, Klason lignin (% on pulp).

1) The pulping was performed in a 100-L reactor (Chips, o.d. 9 kg; Liquor, about 60 kg)

Lignin utilization I.

-Finding fusibility and Preparation of carbon fibers -


30
50
100
150
200
25

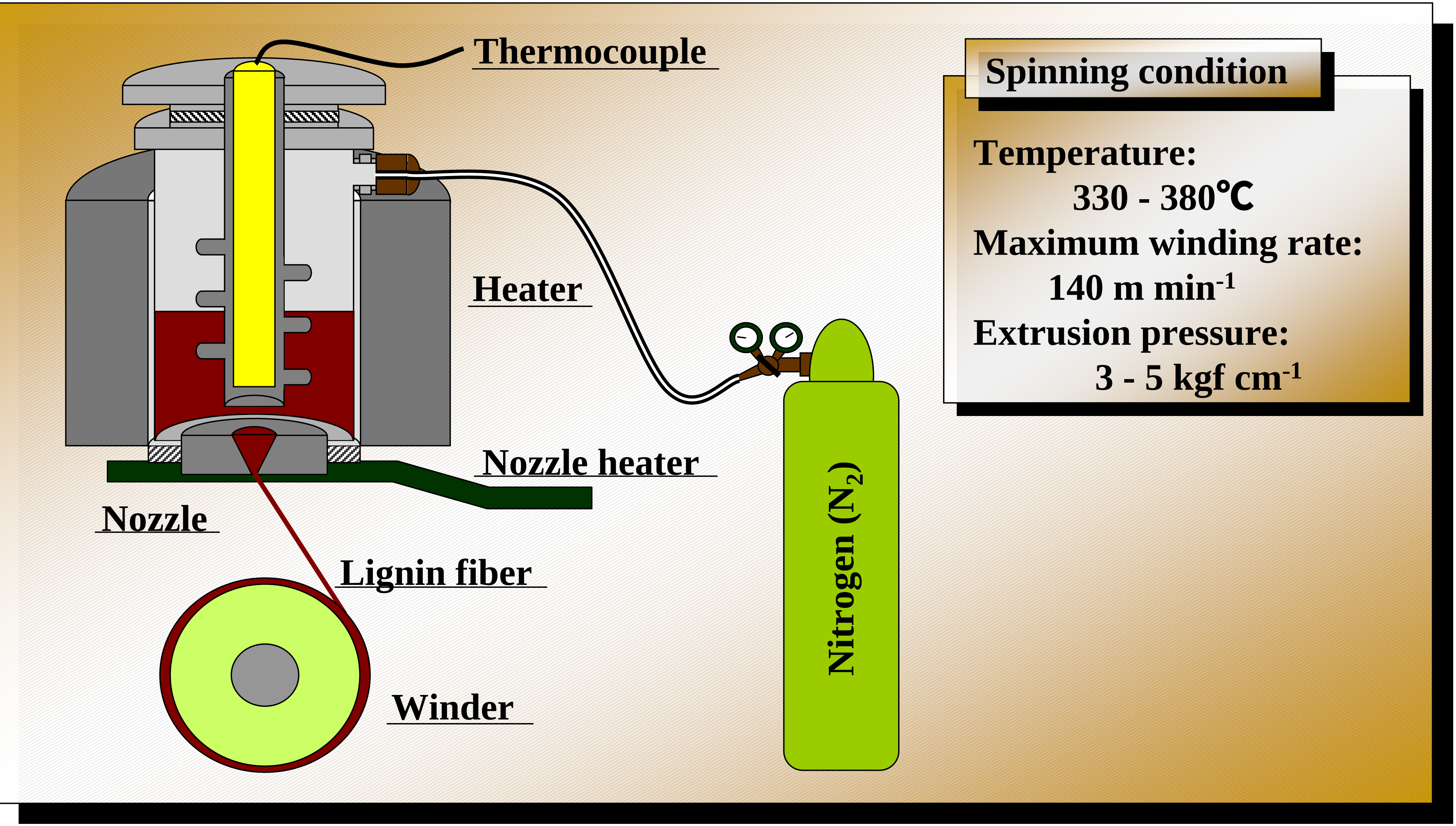
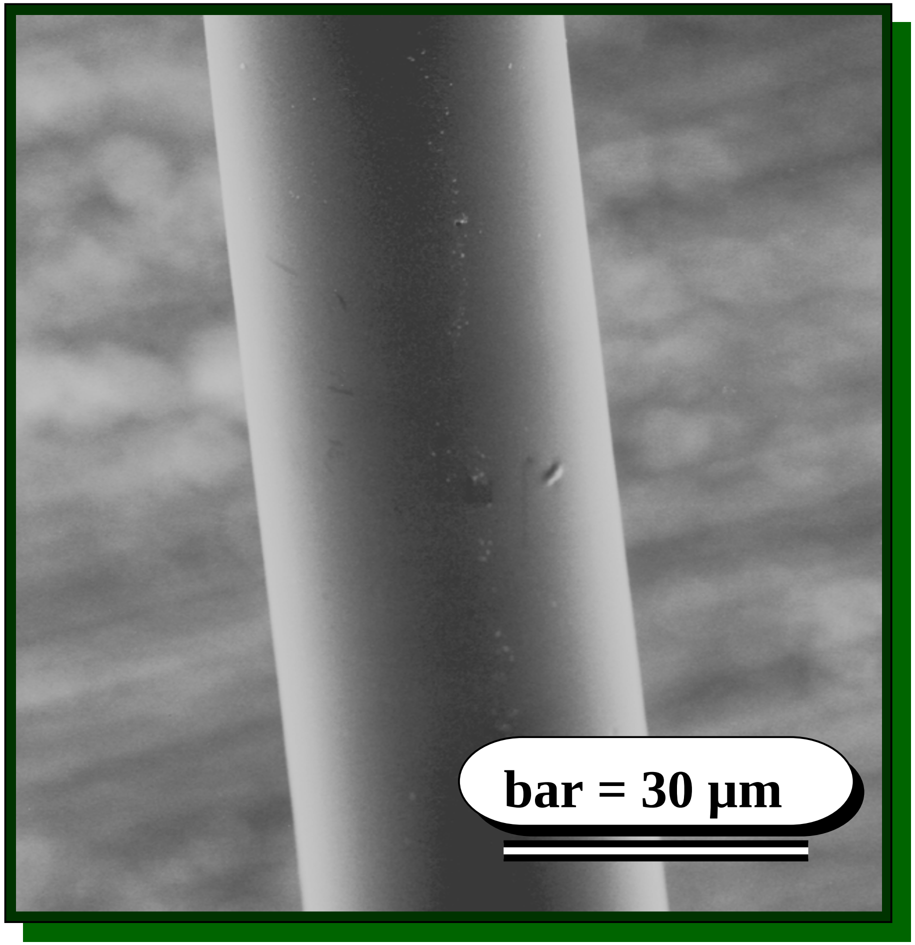
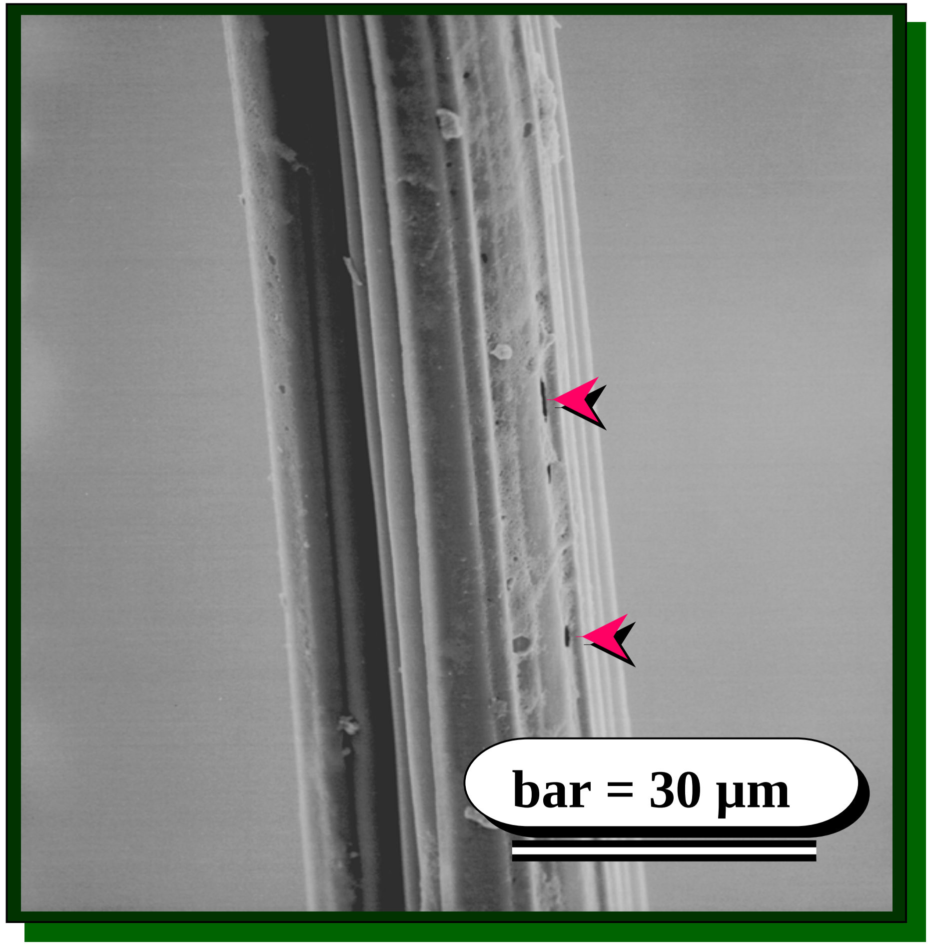


Fig. Laboratory spinning apparatus for fusion spinning of lignin.

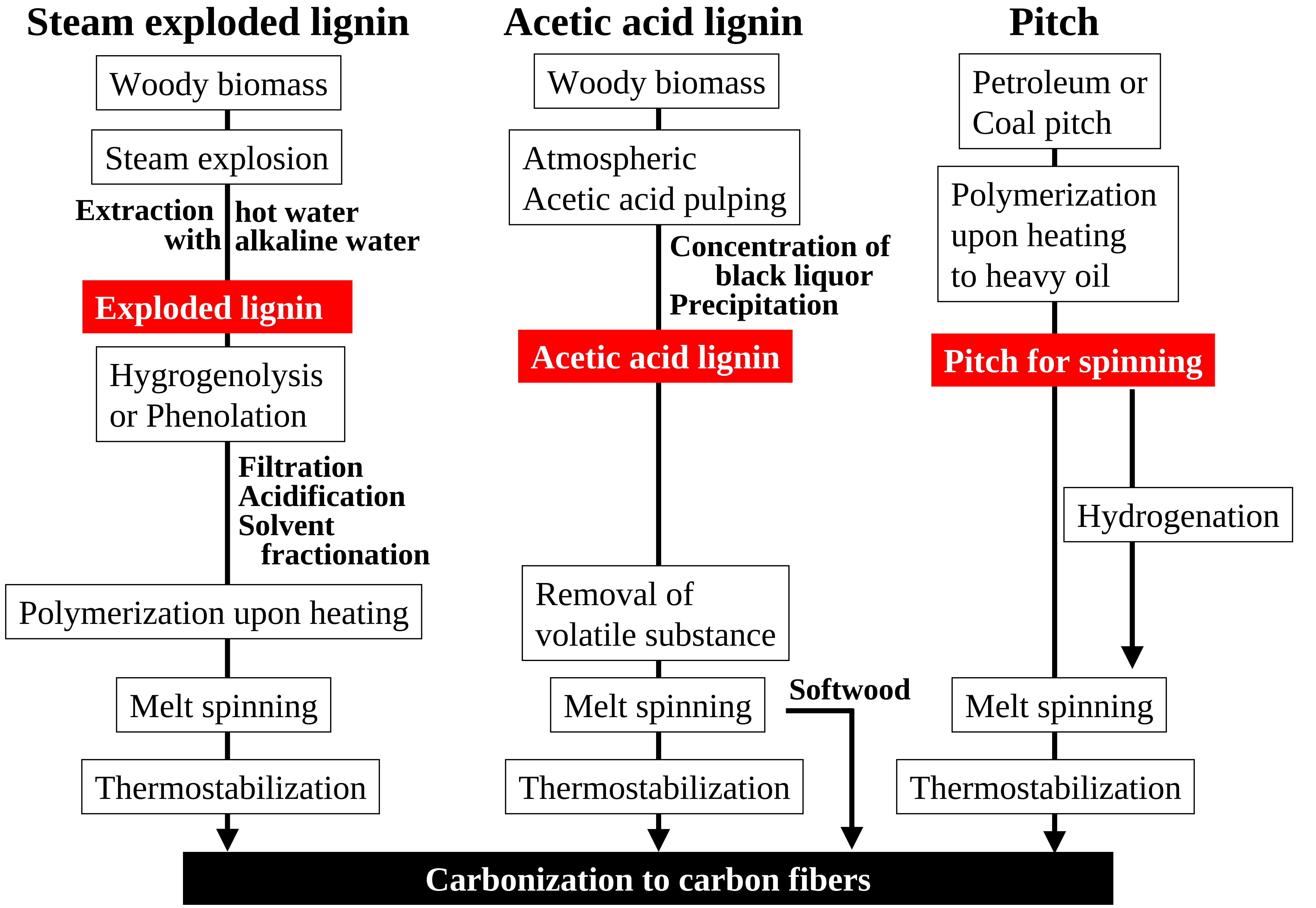


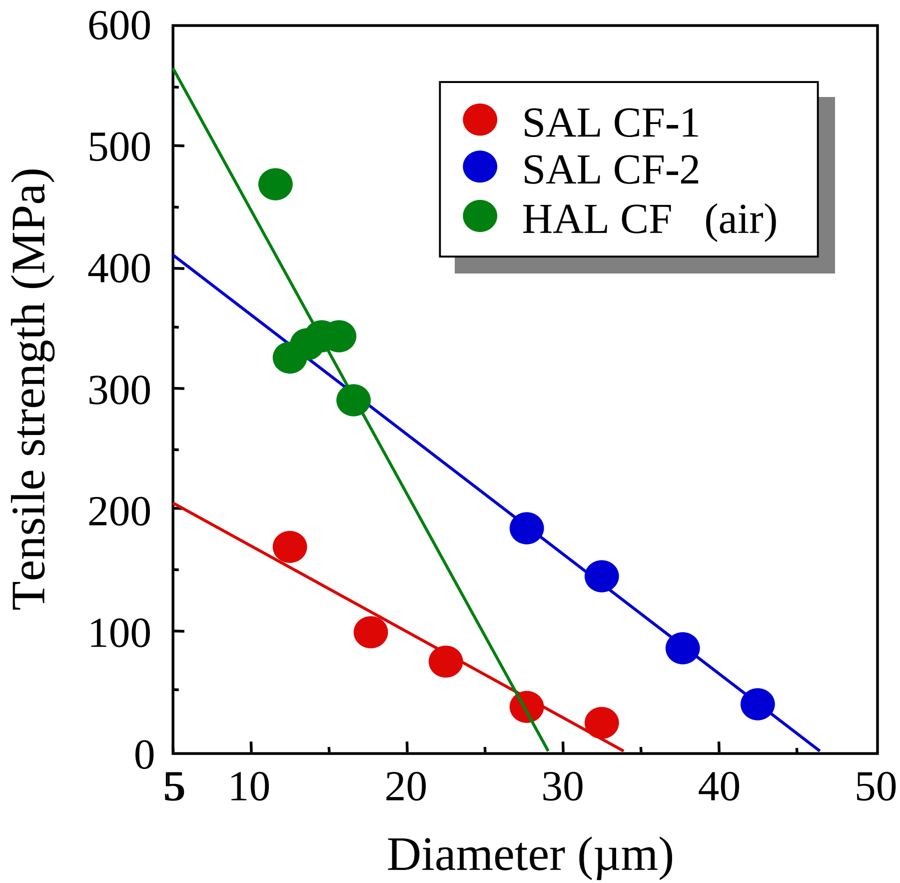
HAL carbon fiber (LAL-CF)
BET surface area of HAL-CF= 190 m^2 g^{-1}



SAL carbon fiber (NAL-CF)
BET surface area of SAL-CF = 370 m^2 g^{-1}

Fig. Scanning electron micrographs of AL-CF.


Steam exploded lignin
Woody biomass
Steam explosion
Extraction with
hot water
alkaline water
Exploded lignin
Hygrogenolysis or Phenolation
Filtration
Acidification
Solvent fractionation
Polymerization upon heating
Melt spinning
Thermostabilization
Acetic acid lignin
Woody biomass
Atmospheric Acetic acid pulping
Concentration of black liquor
Precipitation
Acetic acid lignin
Removal of volatile substance
Melt spinning
Thermostabilization
Softwood
Pitch
Petroleum or Coal pitch
Polymerization upon heating to heavy oil
Pitch for spinning
Hydrogenation
Melt spinning
Thermostabilization
Carbonization to carbon fibers



Note; SAL CF-1; prepared without thermostabilized,
SAL CF-2; prepared with thermostabilization in air,
HAL CF; prepared with thermostabilization in air.

Fig. Effect of Diameter on tensile strength of AL based CFs.

Lignin utilization II.

-Preparation of activated carbon fibers and Hot-melt type adhesive-

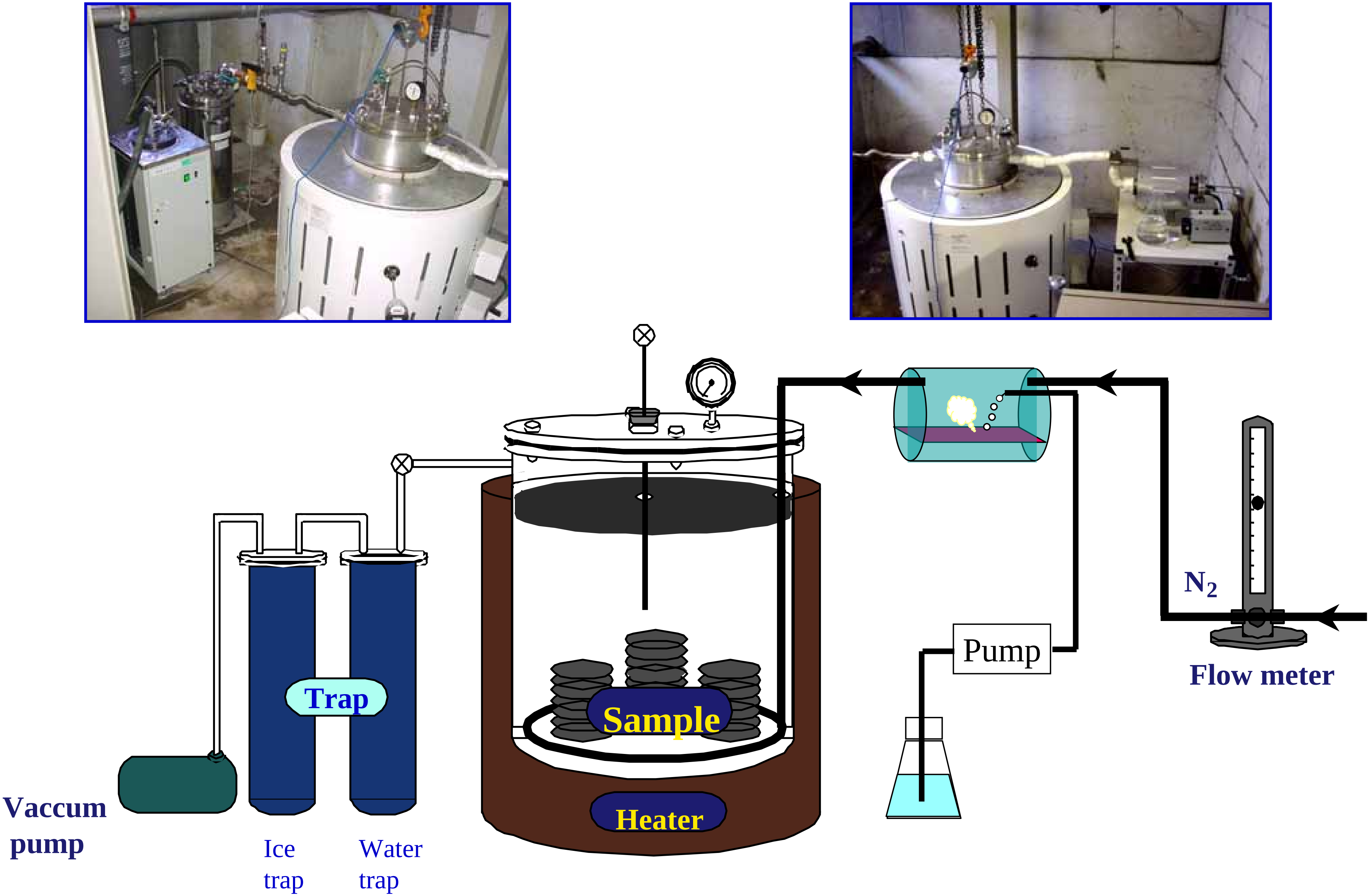


Fig. Steam activation system for producing activated carbon moldings

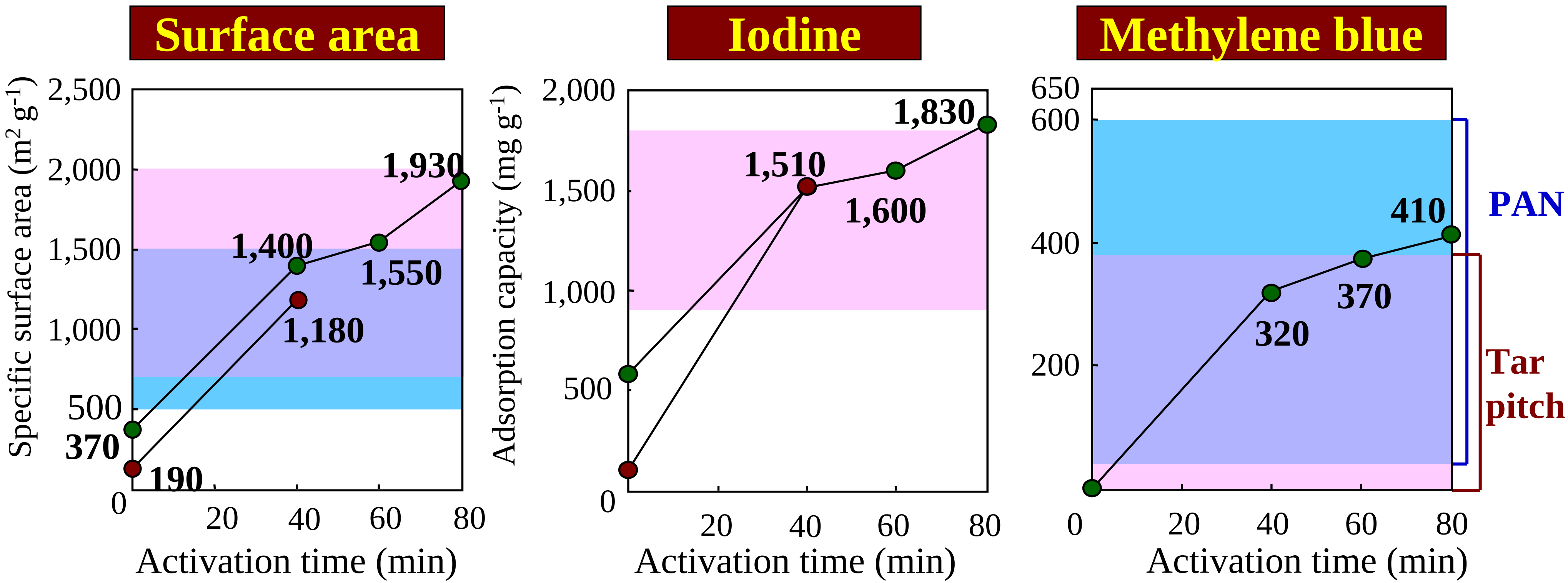


Fig. Adsorption performance of AL-based ACF

●; HAL ●; SAL

Preparation scheme of dry-formed board

Paper

+

Lignin
(from birch)

Mixed

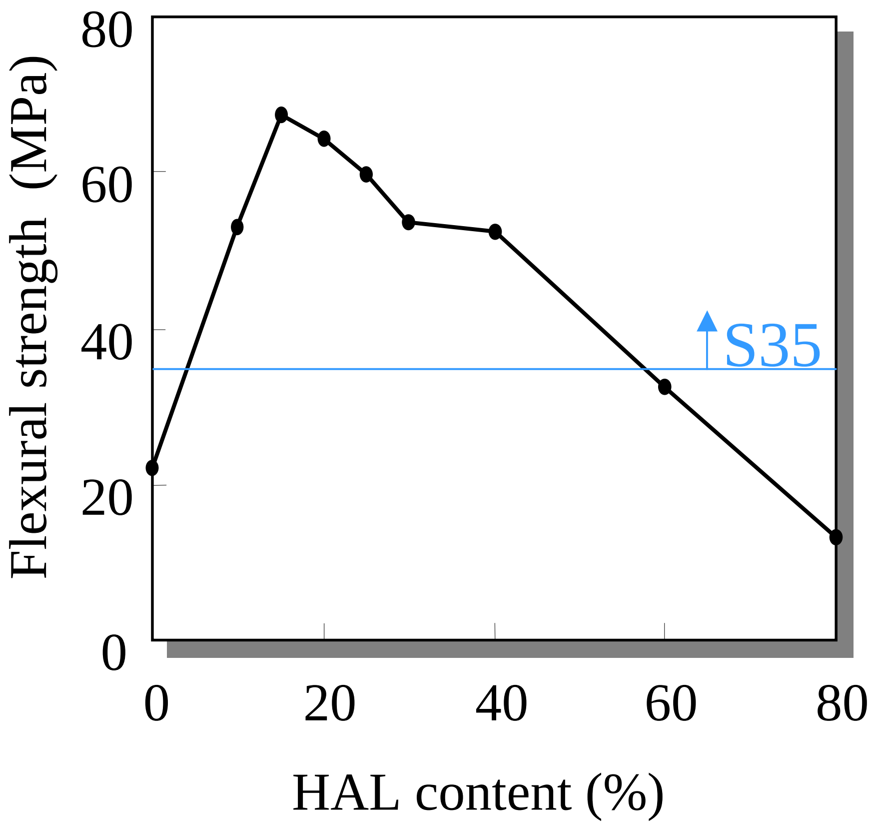
Dry mixture

Thermal press
with a mold

Medium density

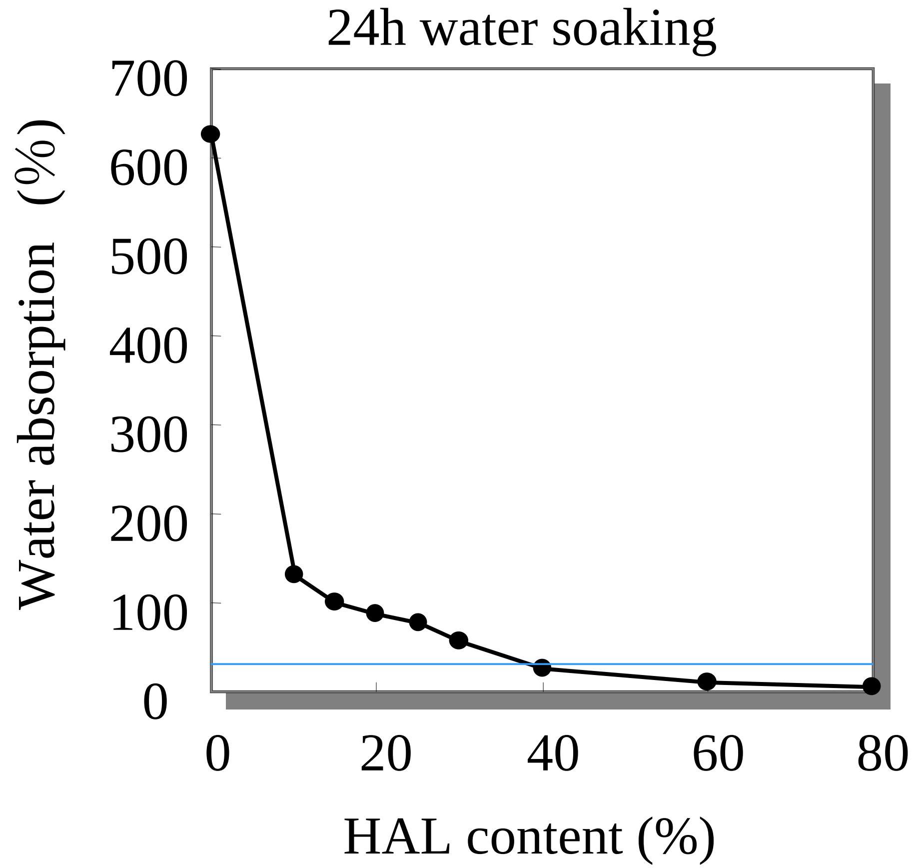
High density

Fiberboard



Pressure : 230 kgf/cm^2
Press temp : 130℃

Fig. Influence of lignin content on flexural strength



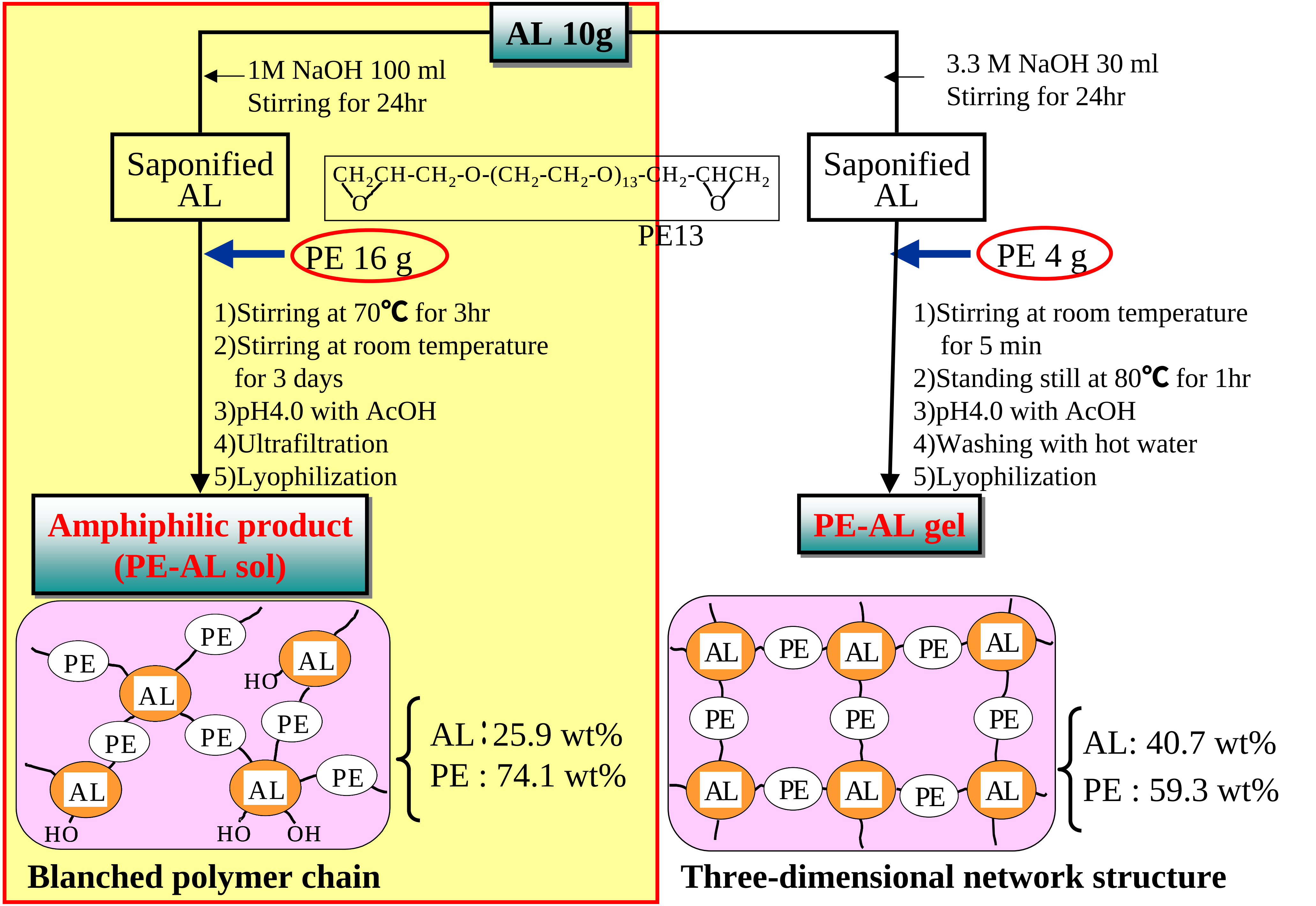
Press temp : 130℃
Pressure : 230 kgf/cm^2

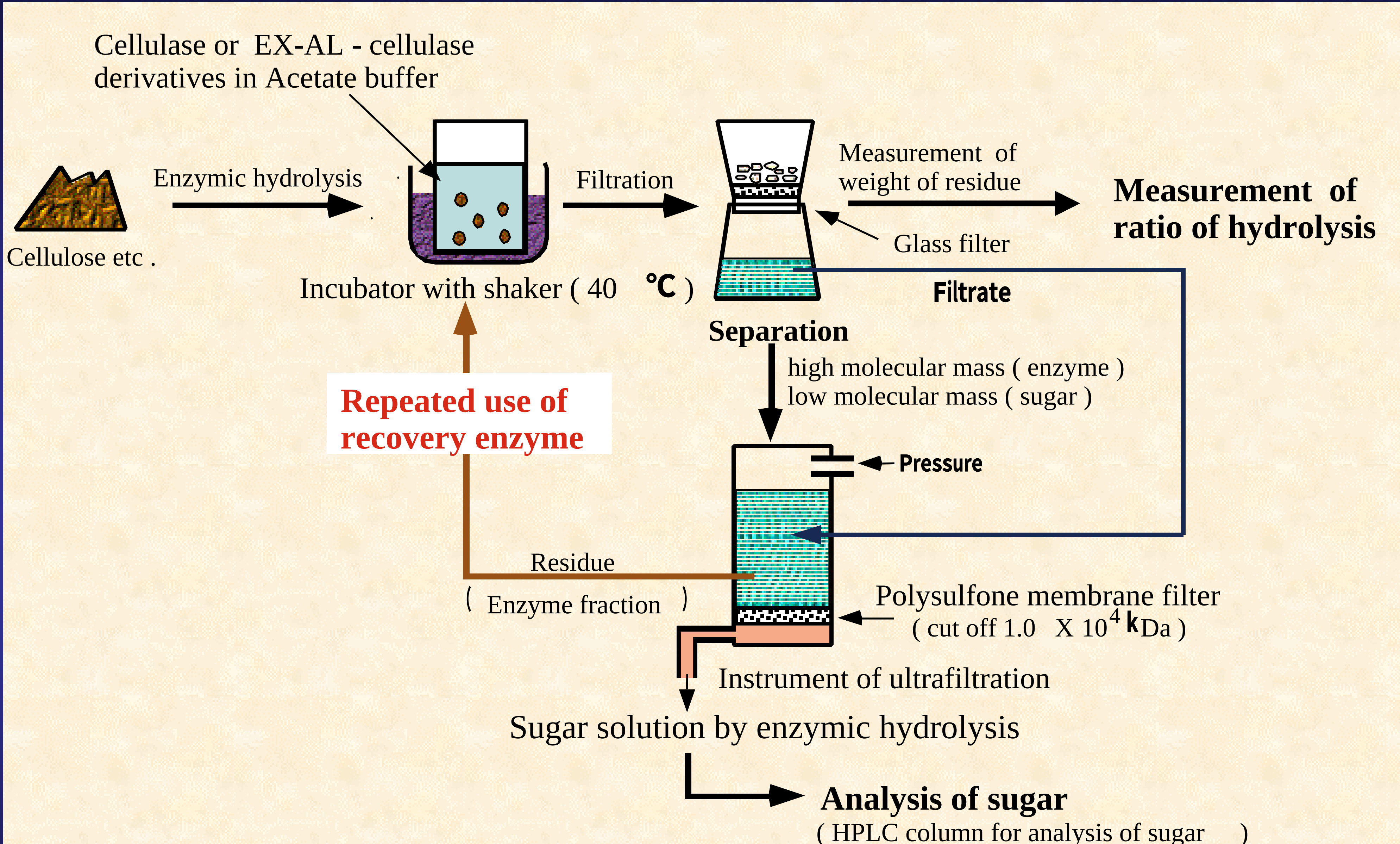
Fig. Influence of lignin content on water absorption

Properties of lignin-wastepaper fiberboard

Lignin utilization III.

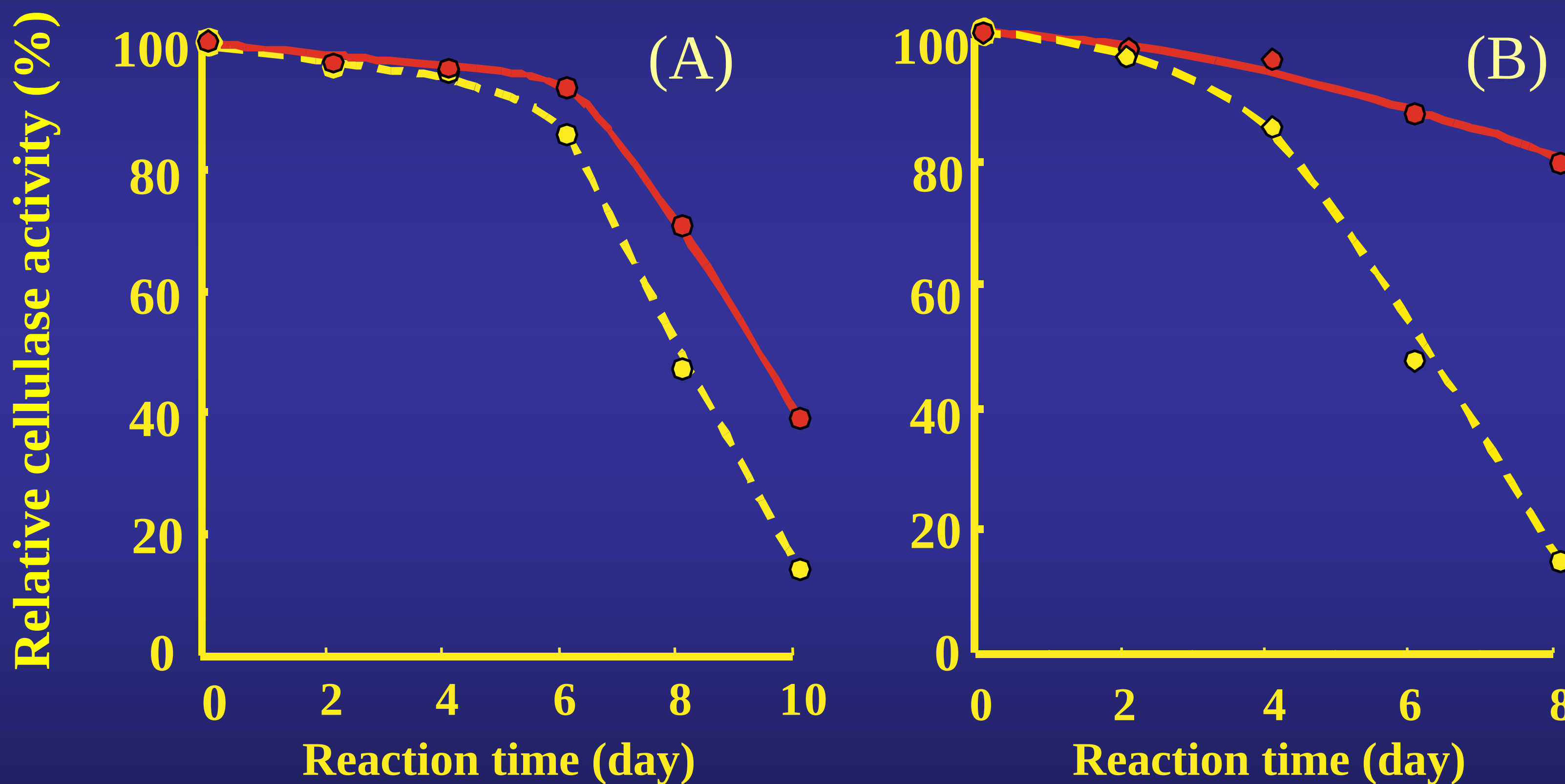
-Support for Water-soluble immobilized cellulase system and Surfactants-


AL 10g
1M NaOH 100 ml
Stirring for 24hr
3.3 M NaOH 30 ml
Stirring for 24hr
Saponified AL
Saponified AL
CH2CH-CH2-O-(CH2-CH2-O)13-CH2-CHCH2
O
O
PE13
PE 16 g
PE 4 g
1)Stirring at 70℃ for 3hr
2)Stirring at room temperature for 3 days
3)pH4.0 with AcOH
4)Ultrafiltration
5)Lyophilization
1)Stirring at room temperature for 5 min
2)Standing still at 80℃ for 1hr
3)pH4.0 with AcOH
4)Washing with hot water
5)Lyophilization
Amphiphilic product (PE-AL sol)
PE-AL gel
PE
AL
HO
OH
AL : 25.9 wt%
PE : 74.1 wt%
AL: 40.7 wt%
PE : 59.3 wt%
Blanched polymer chain
Three-dimensional network structure



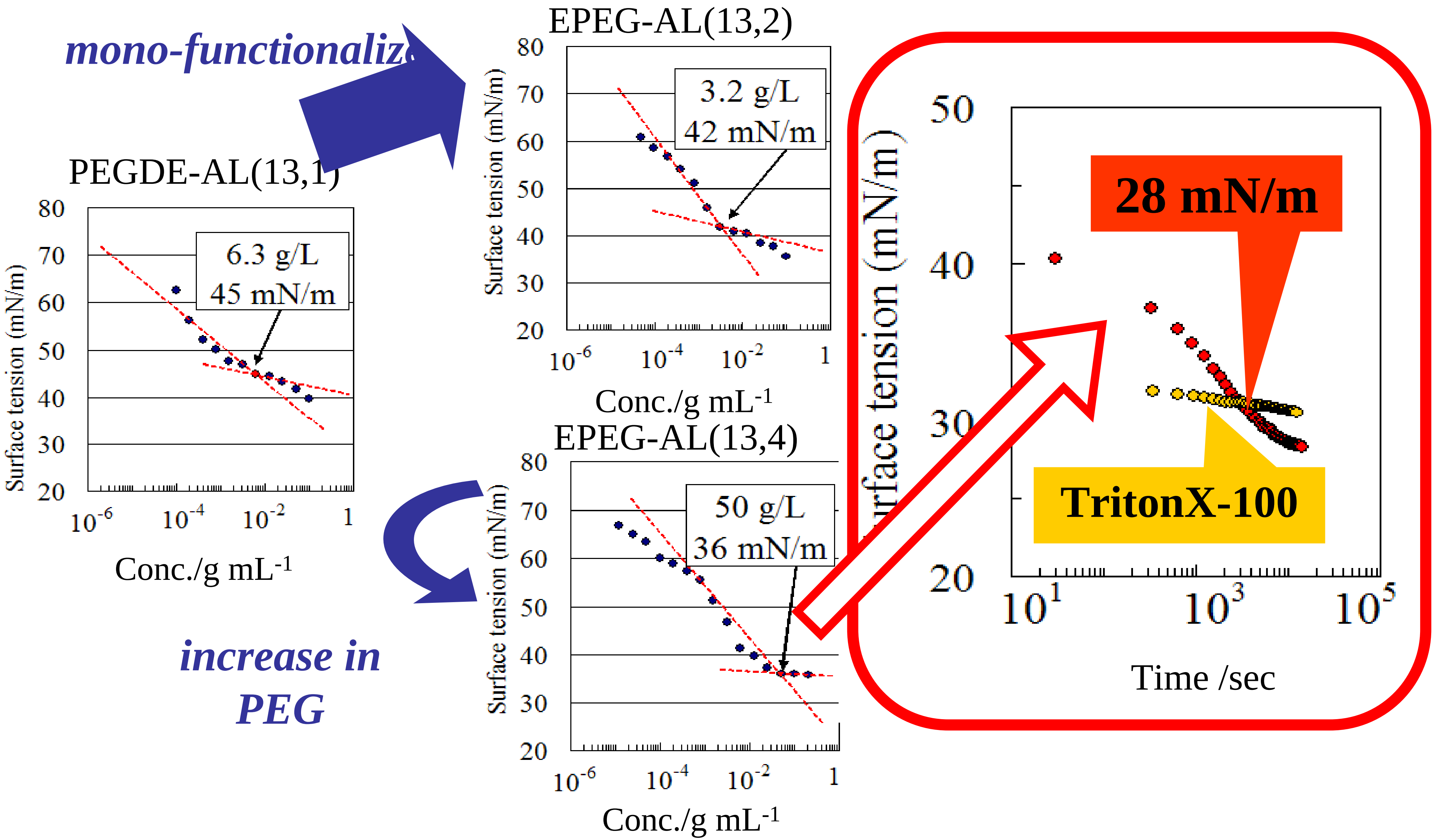
Scheme. Repeating hydrolysis of cellulosic materials by cellulase or PE-AL - cellulase complex using ultrafiltration.

Repeating hydrolysis of filter paper (A) and PHA-pulp (B) by cellulase and PE-AL - cellulase complex.



Hydrolysis conditions: Substrate, 3 g; Cellulase, 240 mg; PE-AL, 0 wt.% ( ) and 0.2 wt% ( ) based on 300 mL of the buffer solution.

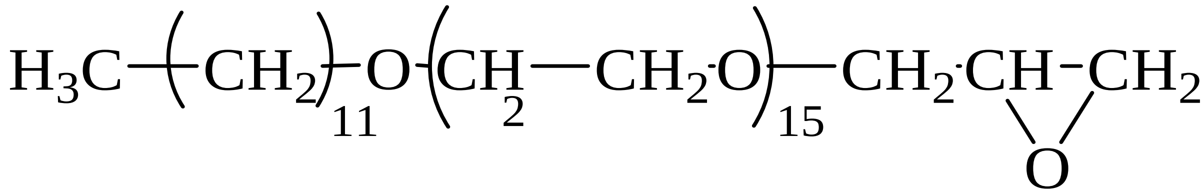
Introduction



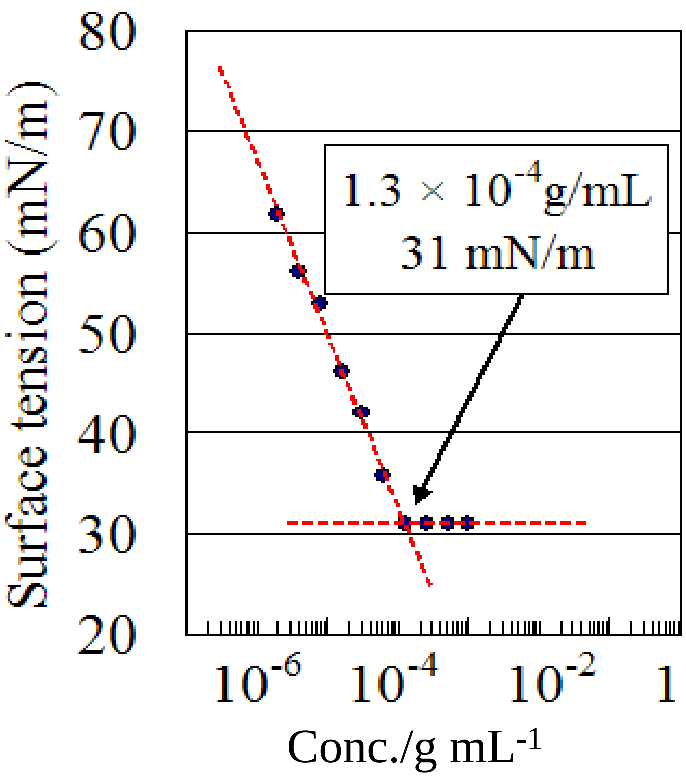
Preparation

LAEO-AL , LAEO-KL

LAEO



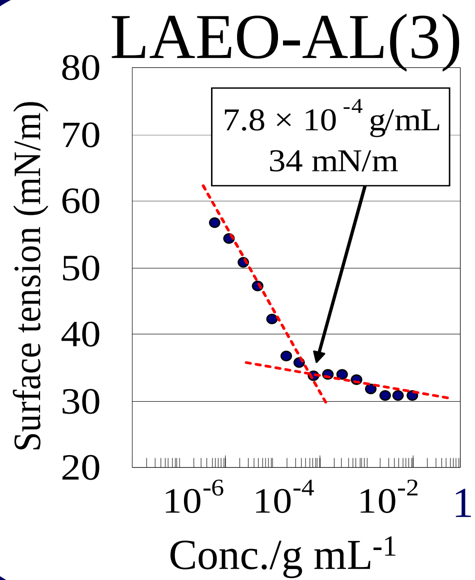
<u>l</u>auryl <u>al</u>cohol (<u>EO</u>) $_{15}$ glycidylether

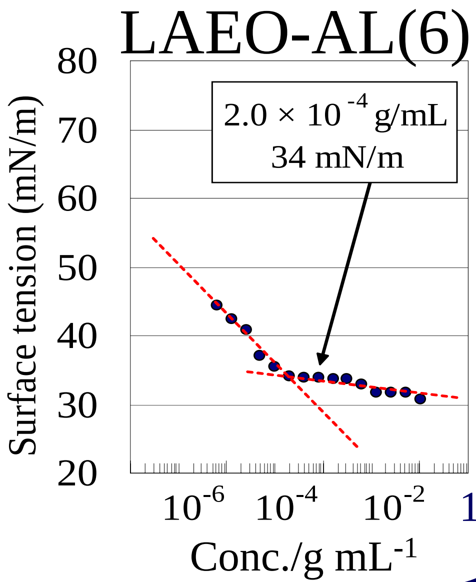


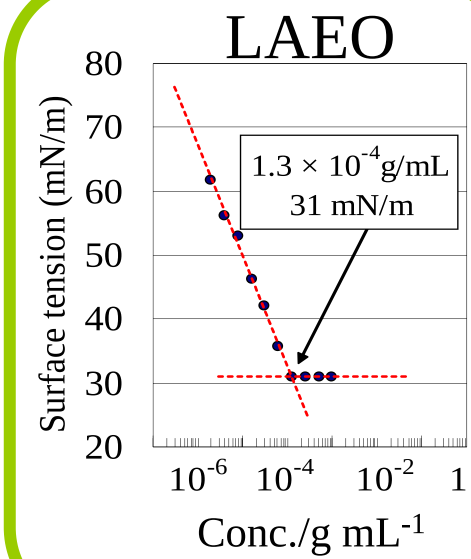
	EO (%)	HLB
LAEO-AL(3)	63.0	12.6
LAEO-AL(6)	68.4	13.7
LAEO-KL(5)	65.4	13.1
LAEO-KL(10)	70.5	14.1

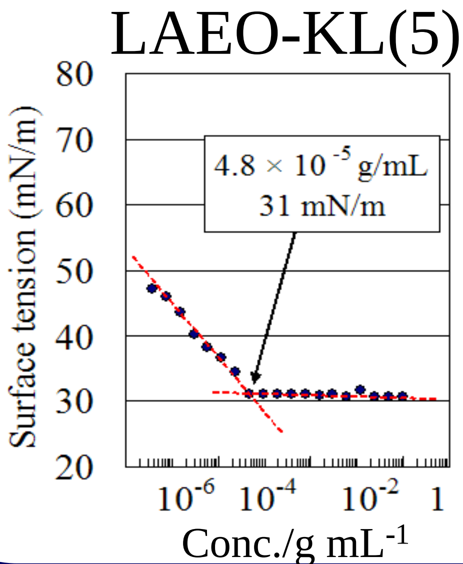
* Parenthesis is a weight ratio of LAEO/lignin

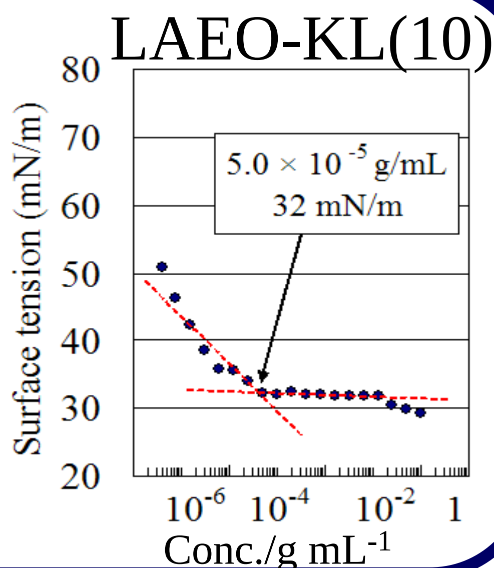
Surface Activity *LAEO-AL , LAEO-KL*











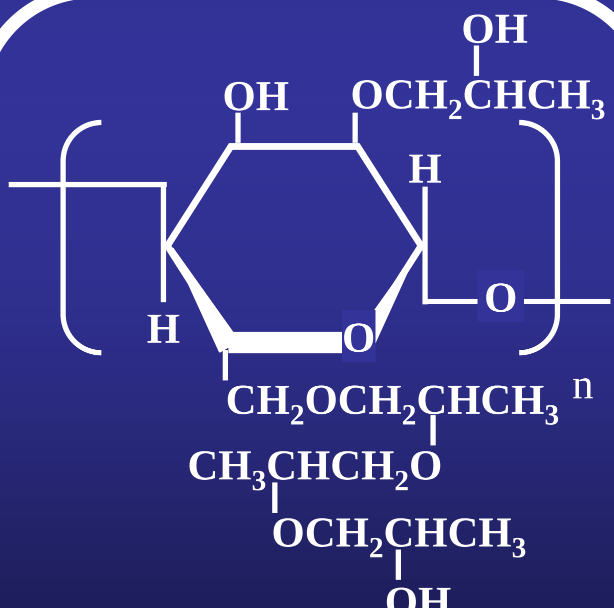
Utilization of unbleached pulp.

-Inclusion compounds and Stimuli-responsive gel-

Chemical properties of HP-samples

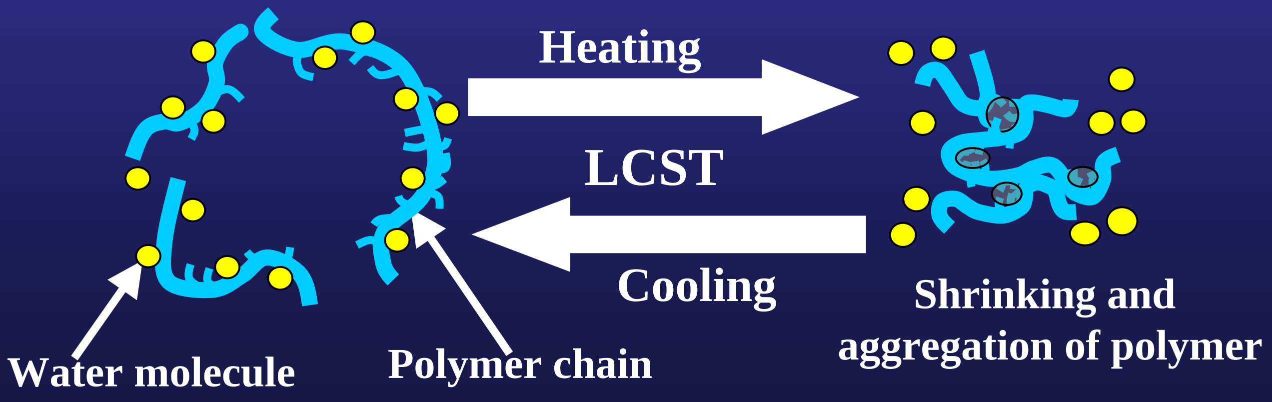
	Lignin content(%)[1]	Mw[2]	MS[3]	LCST(°C)[4]
HPC	—	3.40×10^5	4.2	43
HPC･L	6.63	7.09×10^5	3.2	38

[1]The lignin content was estimated by UV absorption. [2]Mw is weight average molecular-mass determined by high performance size-exclusion chromatography. [3]Degree of molar substitution. [4]Lower critical solution temperature.

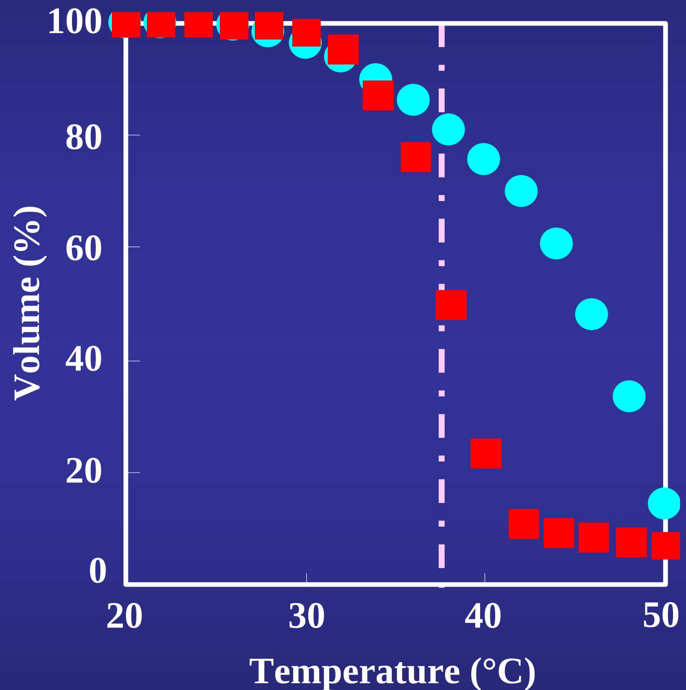


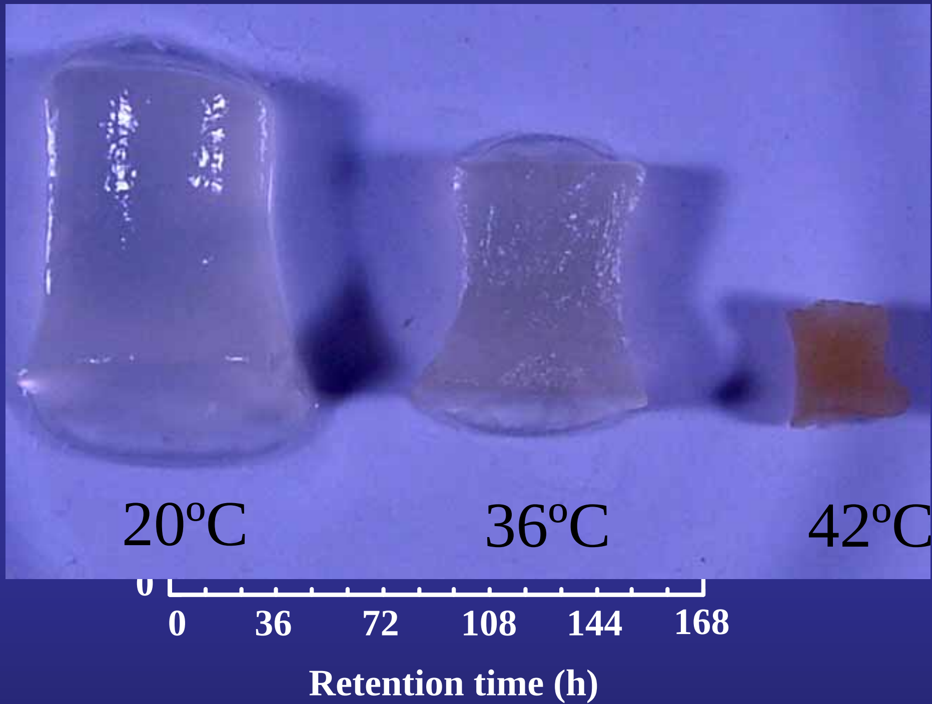
Hydroxypropylcellulose (HPC)

(Ex. DS=2, MS=4)



Thermoresponse and thermoreversibility of gel ~Epoxy type~



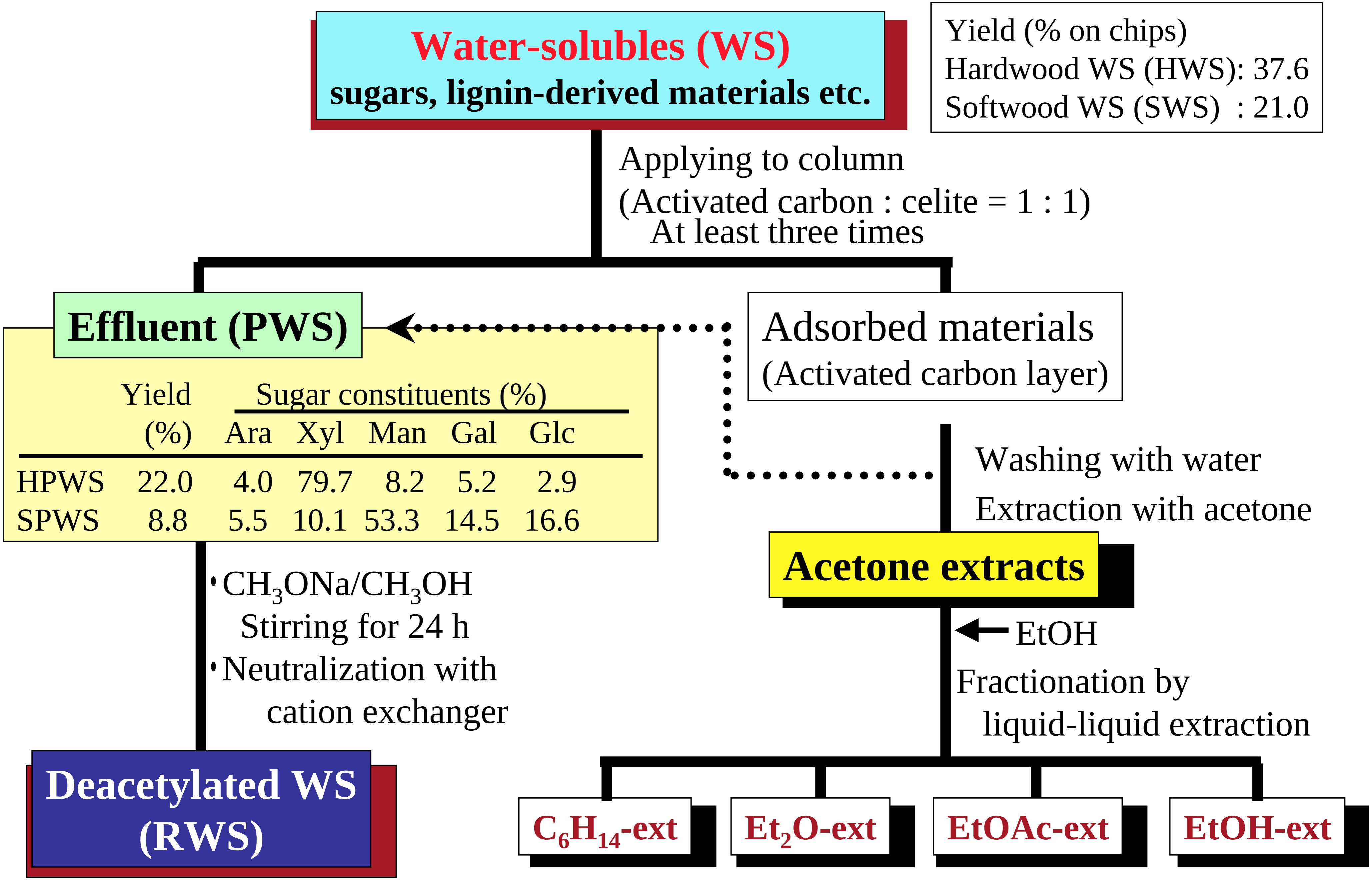


Initial polymer concentration: 3.0% (w/v),
Addition of EGDE: 50% based on polymer.

HPC gel ( ) and HPC-L gel ( ).

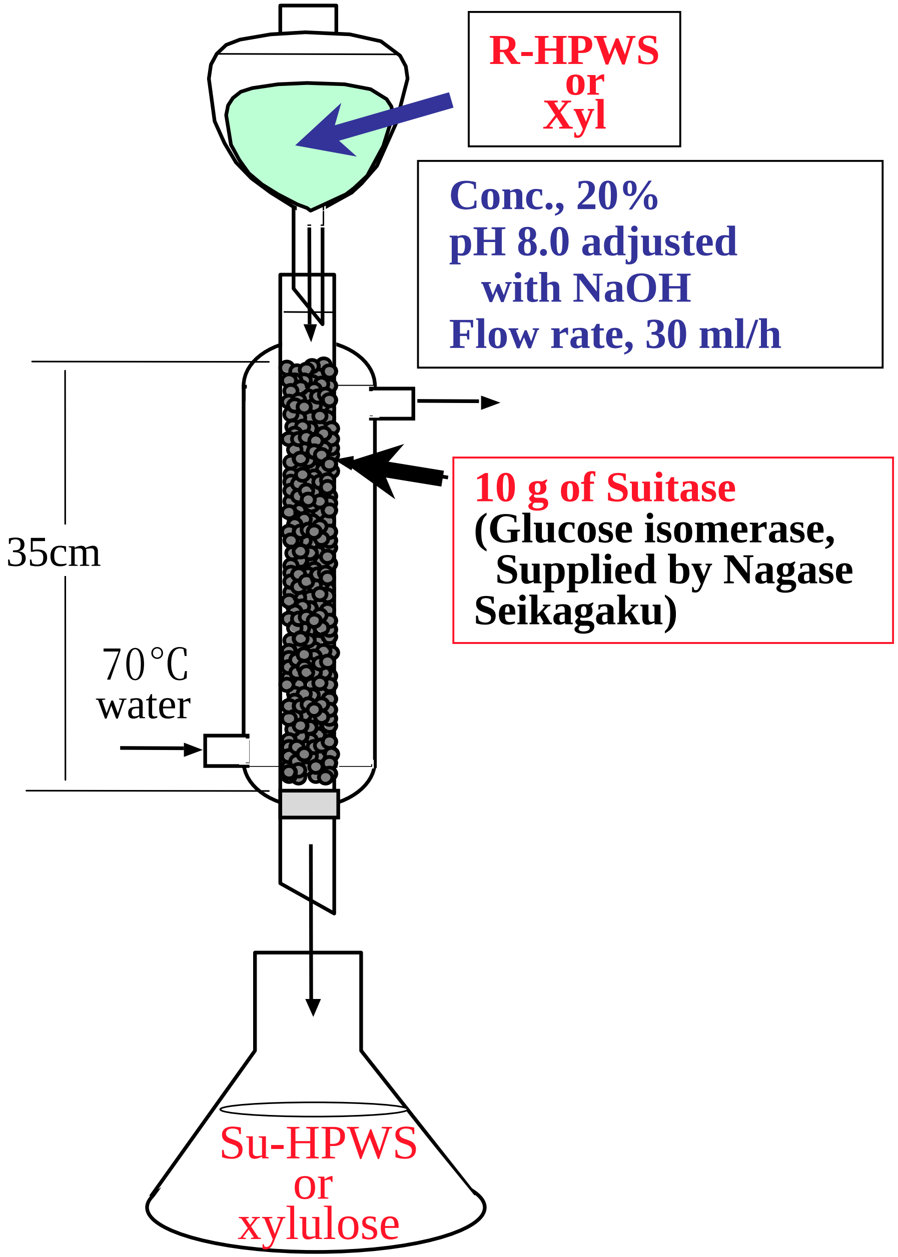
A drastic volume transition of the HPC-L gel occurred at 38ºC

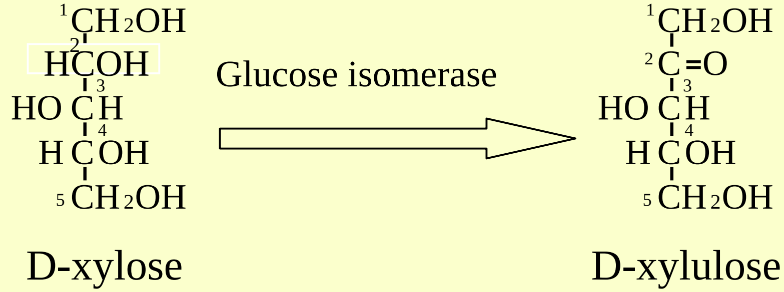
Hemicellulose utilization
and
Artificial woody cell wall using honeycomb-patterned cellulose .



	Yield (%)	Sugar constituents (%) Ara	Xyl	Man	Gal	Glc
HPWS	22.0	4.0	79.7	8.2	5.2	2.9
SPWS	8.8	5.5	10.1	53.3	14.5	16.6

Fig. Purification sheme of water-solubles





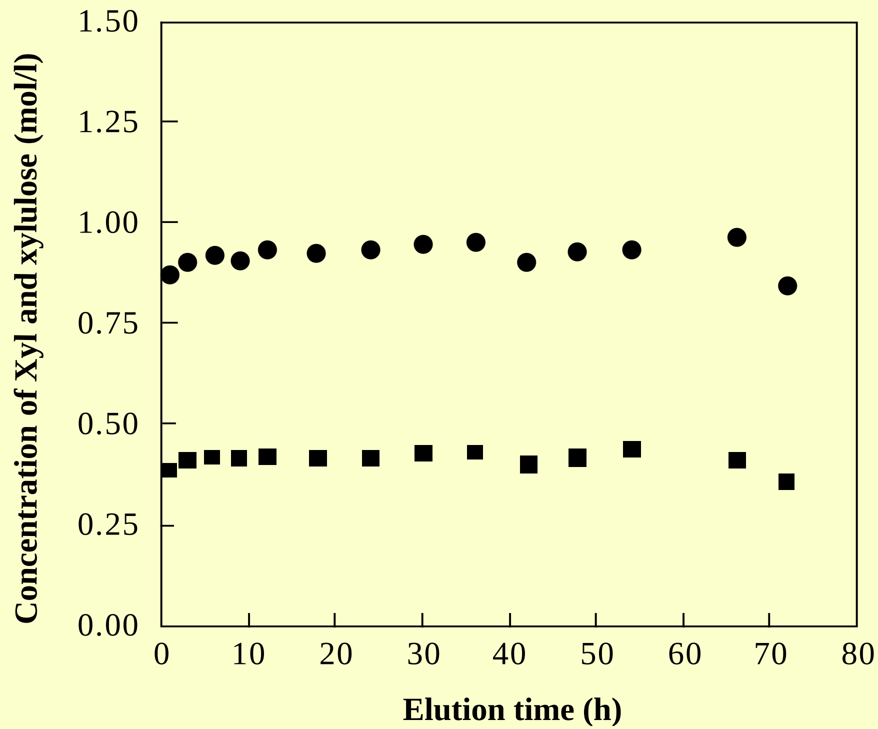


Fig. Xyl conversion to xylulose by glucose isomerase (Suitase)

Modification of Xyl and hardwood WS (HPWS)

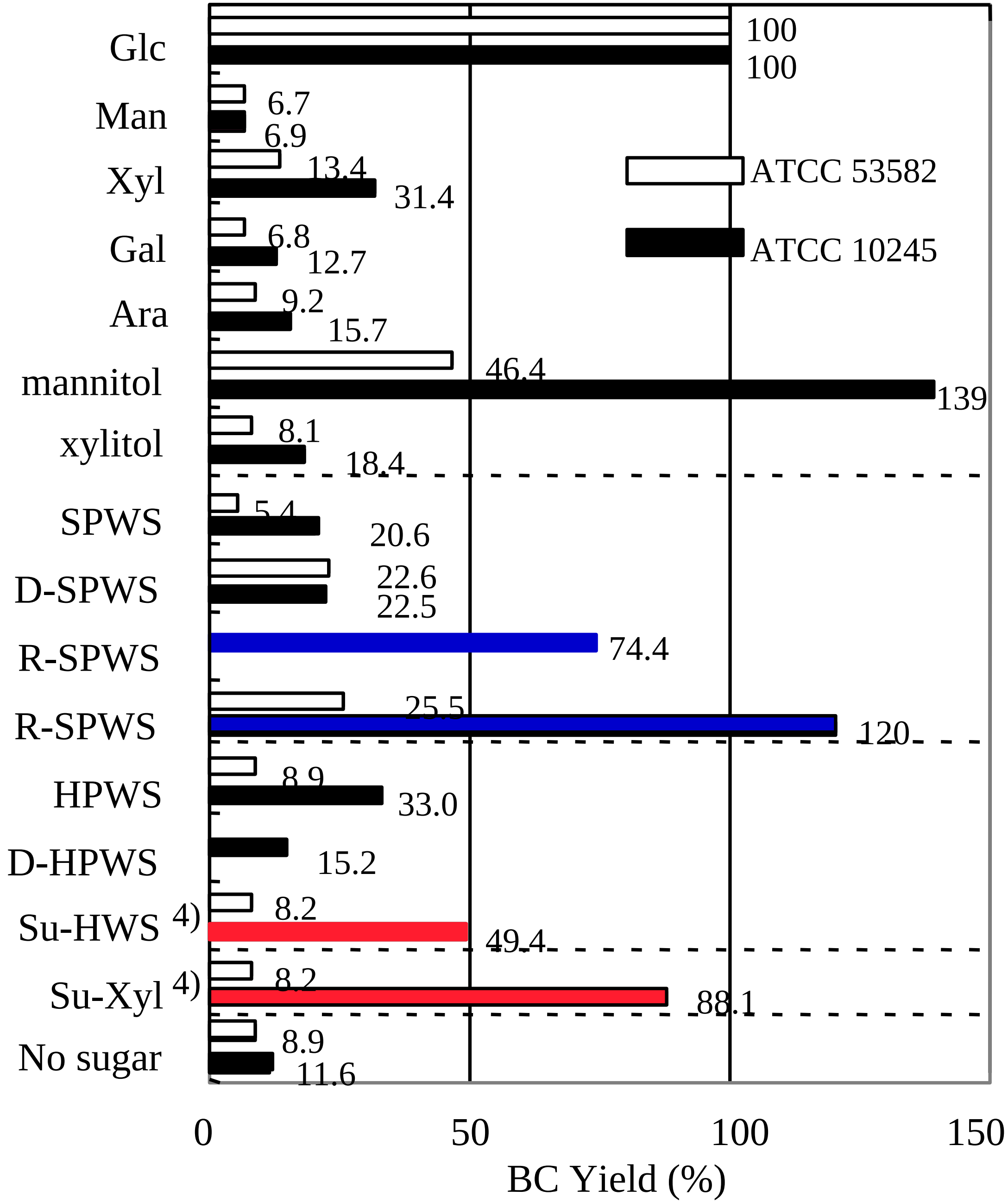
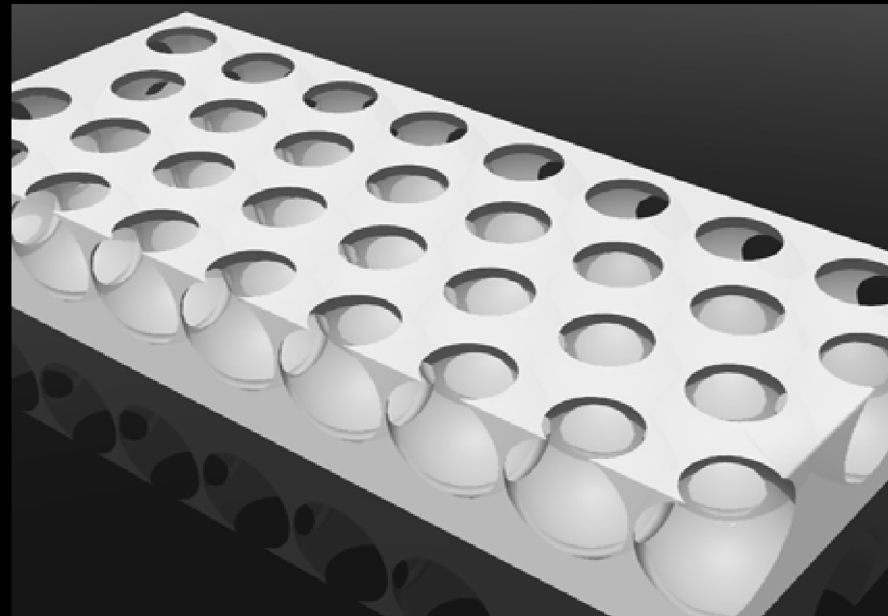
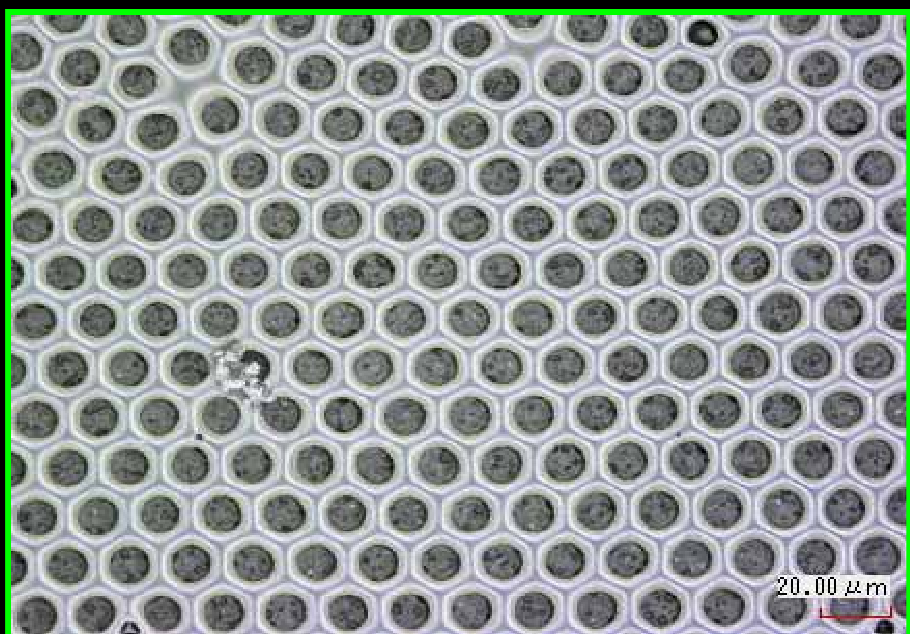
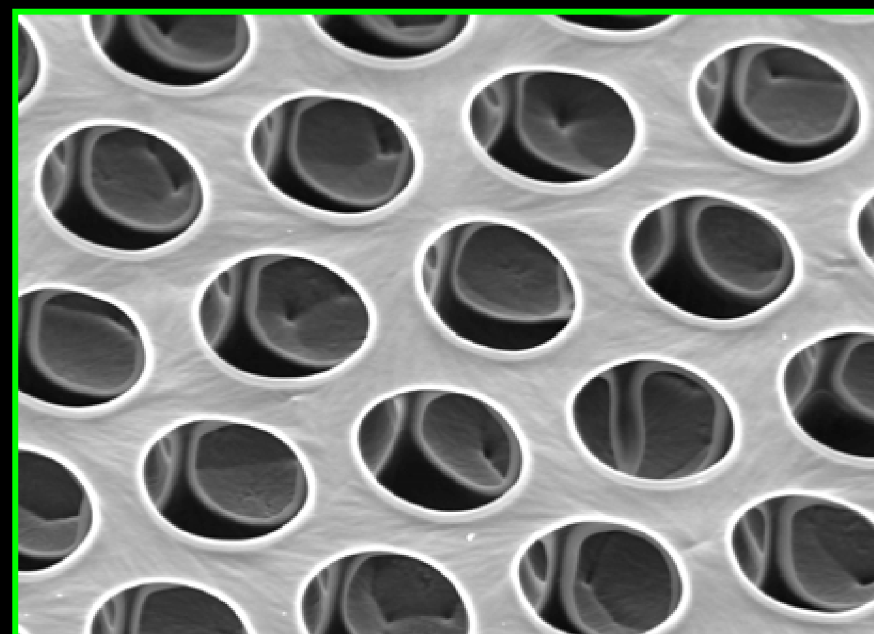


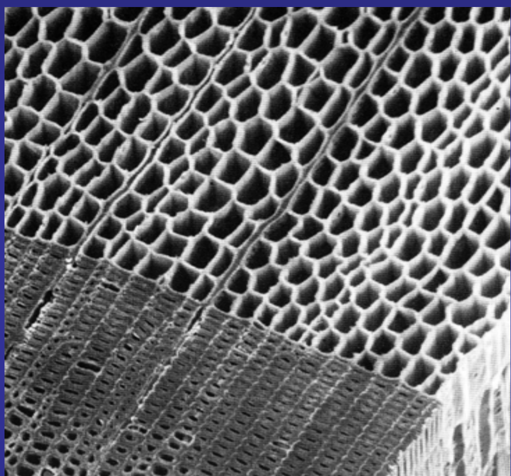
Fig. Bacterial cellulose production from various sugars.



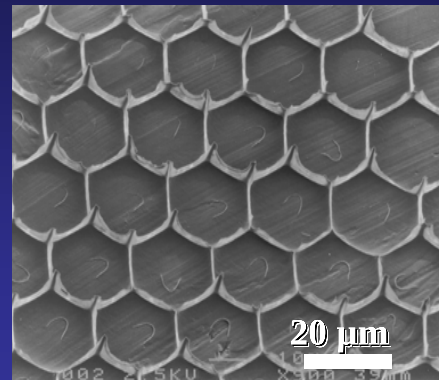

20.00 μm



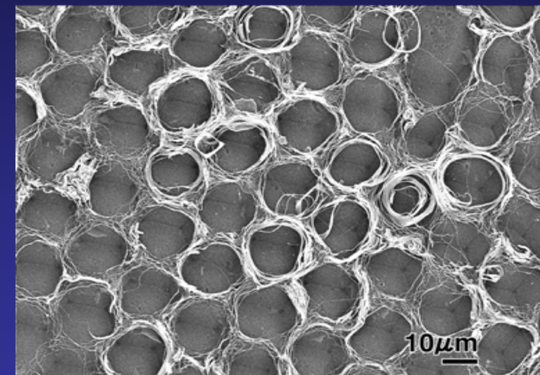
Recent study is to Create Artificial Cell Wall



Mimic

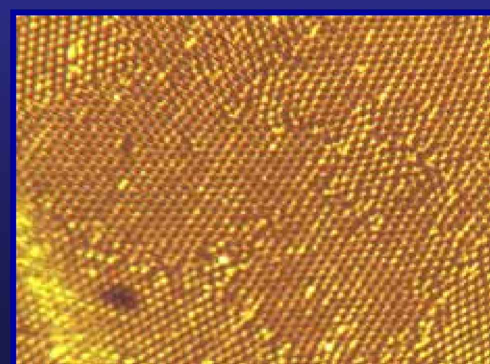


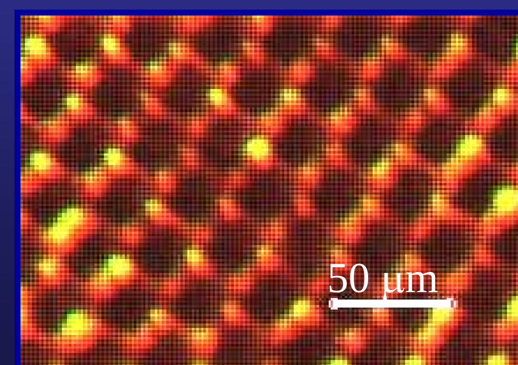
Regenrated cellulose honeycomb



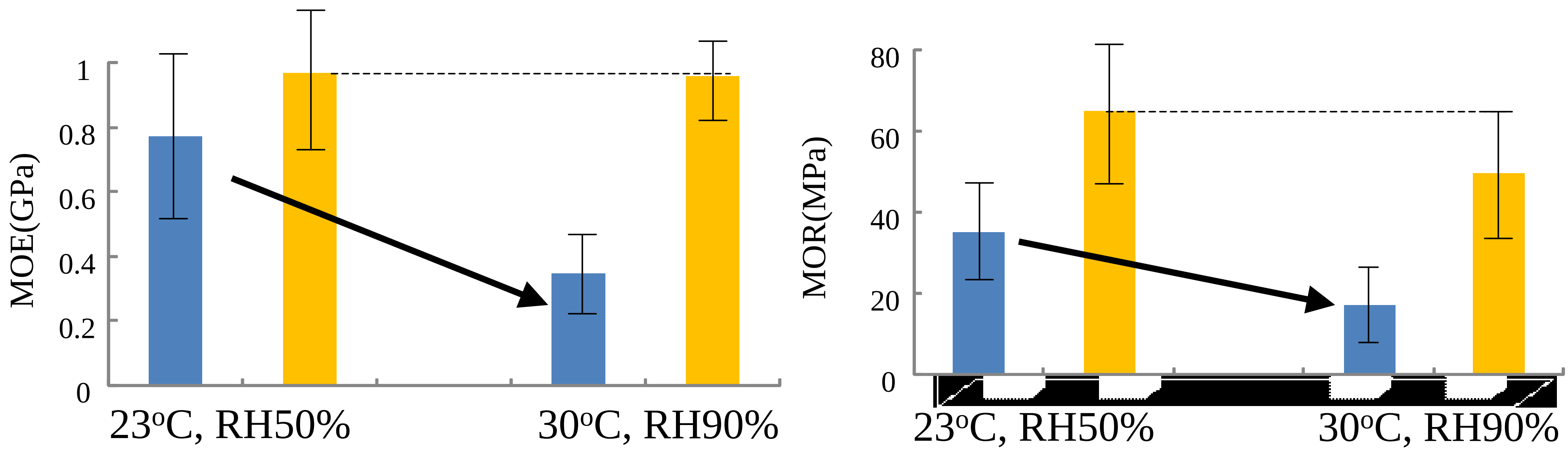
Bacterial cellulose honeycomb

Lignin deposition





Effect of lignin adsoprtion on the tensile strength of honeycomb-patterned cellulose film.



■ **Honey-patterned BC**

■ **Honey-patterned BC with lignin**

Thank you for attention