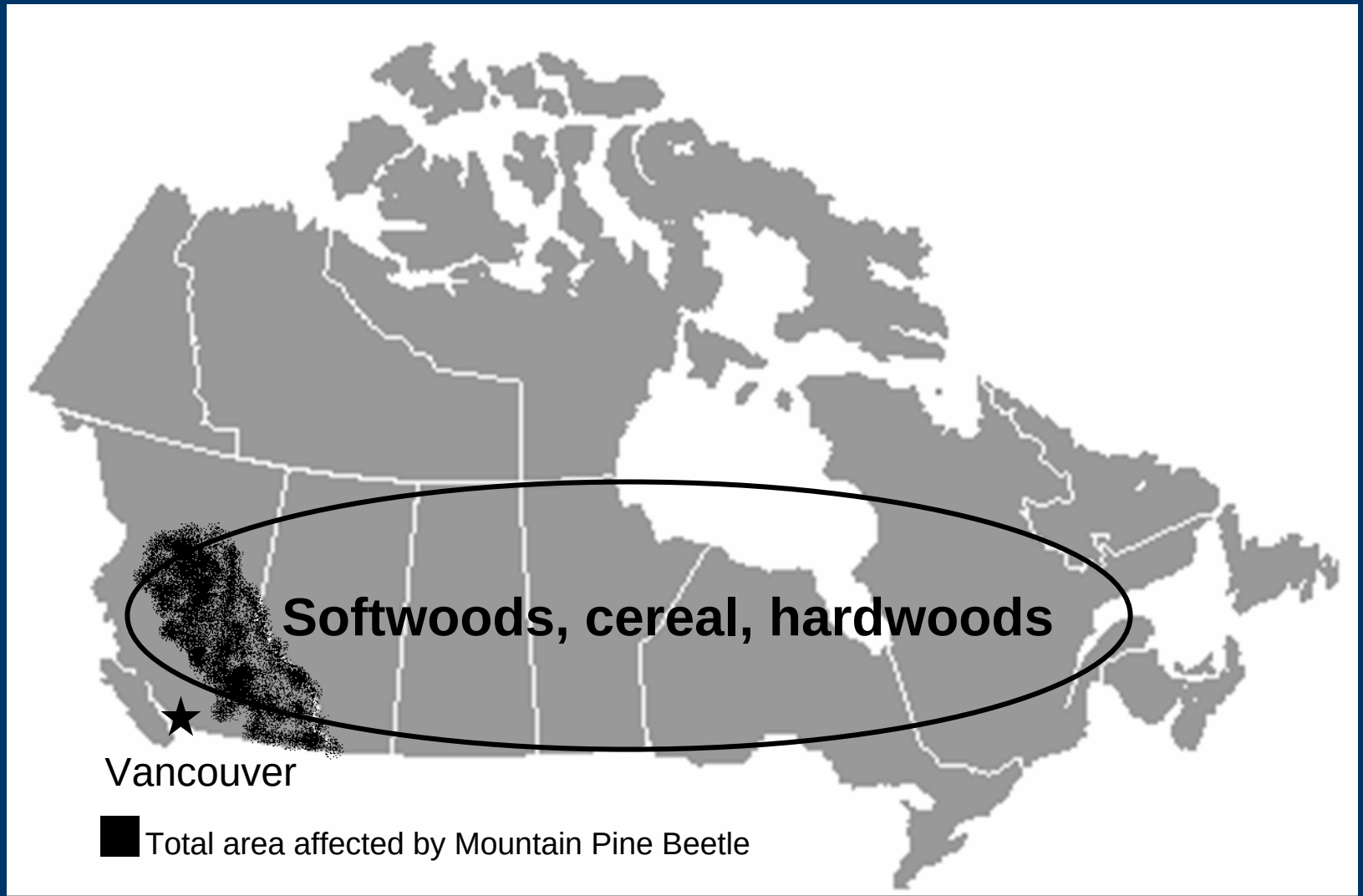
It is not the enzyme, it is the substrate; but it is not the substrate so much as the pretreatment method

Renata Bura, A. Berlin, R. Chandra, P. Chung, C. Hsieh, S. Ewanick, D. Lam, W. Mabee, J. Pan, M. Tu, and J. Saddler

Forest Products Biotechnology Group
The University of British Columbia

August 29th, 2006

Biomass resources in Canada



Variety of feedstocks at UBC

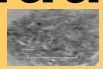
Agricultural residues

- Corn fibre 
- Corn stover 
- Rice straw 
- Wheat straw

Hardwood residues

- Hybrid poplar 
- Maple 

Softwood residues

- Spruce 
- Lodgepole pine 
- Douglas fir 

Steam explosion

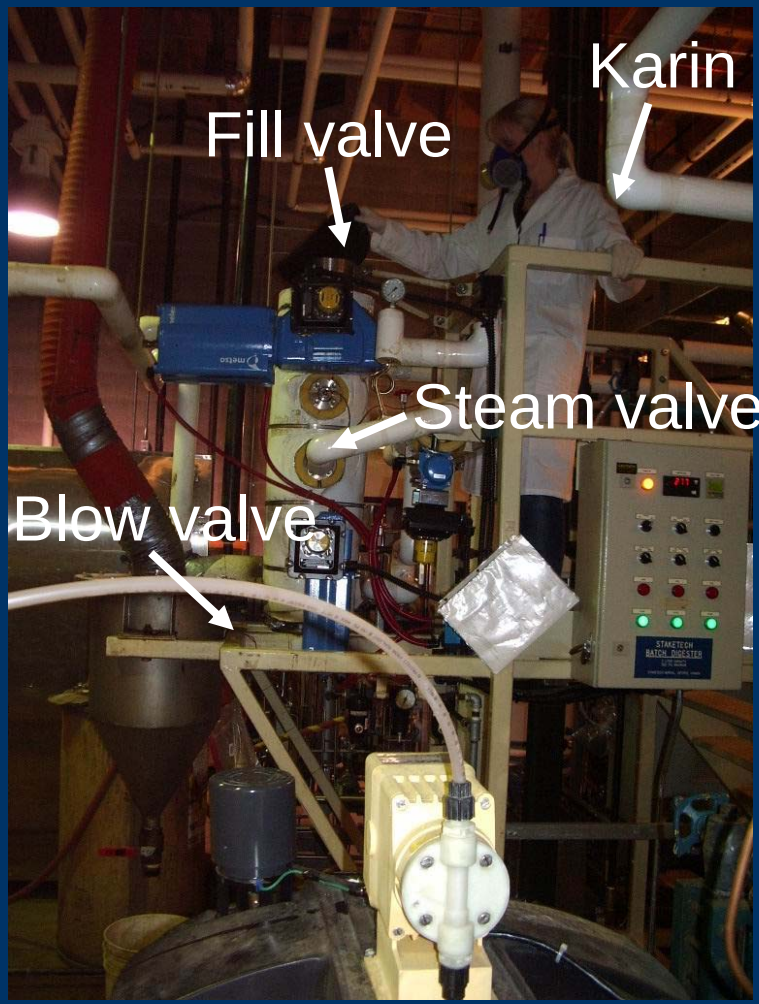
- One of the most cost effective and efficient pretreatment for agricultural, hardwood and softwood residues
- 3 variables: time, temperature and pH
- Use of SO_2 as catalyst:

↓ reaction time and temperature

↑ enzyme accessibility to cellulose

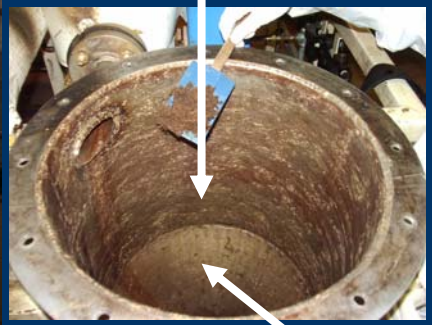
↑ recovery of hemicellulose

Pretreatment methods-steam explosion



Receiving vessel

Receiving vessel

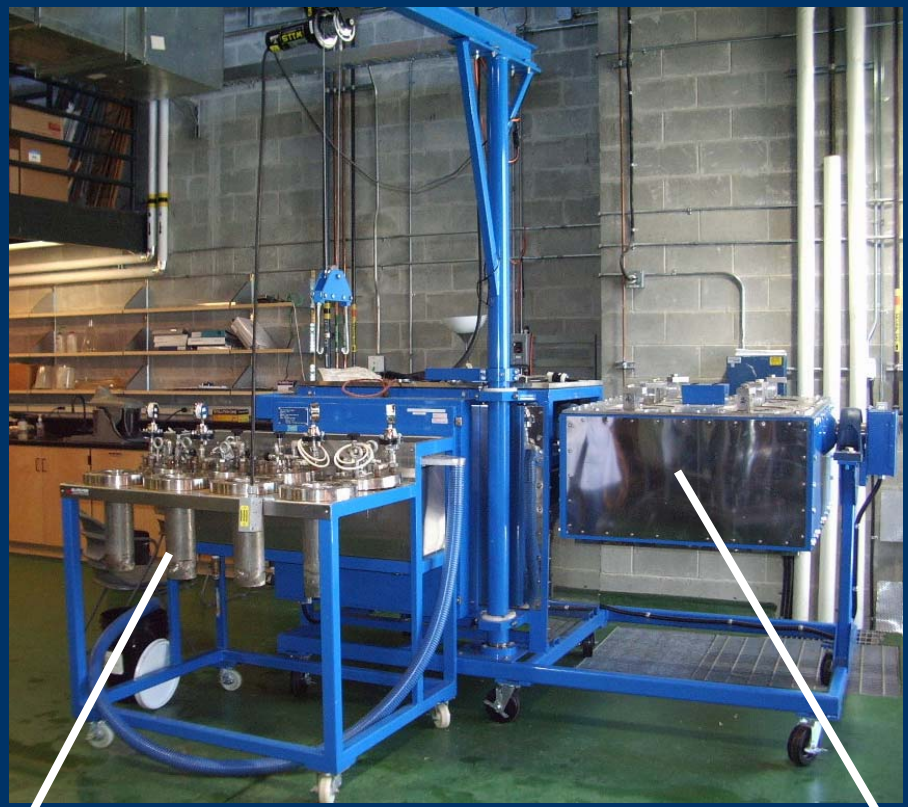


Pretreated corn stover

Organosolv pulping

- Separation of the hemicellulose, lignin and cellulose
- Lignin as a co-product
- 4 variables: time, temperature, pH and ethanol concentration

Pretreatment methods-organosolv pulping



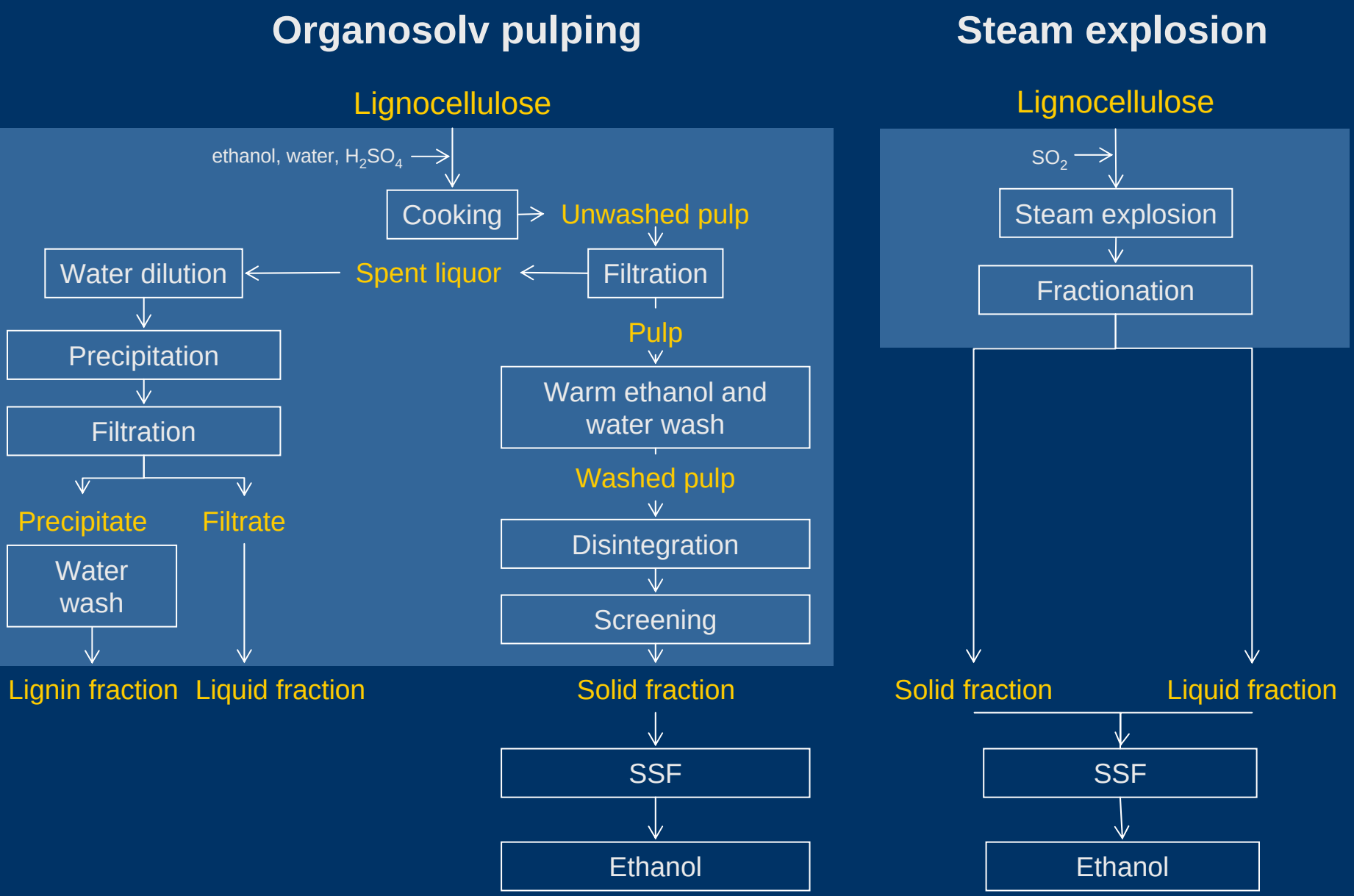
Carmen

Screening

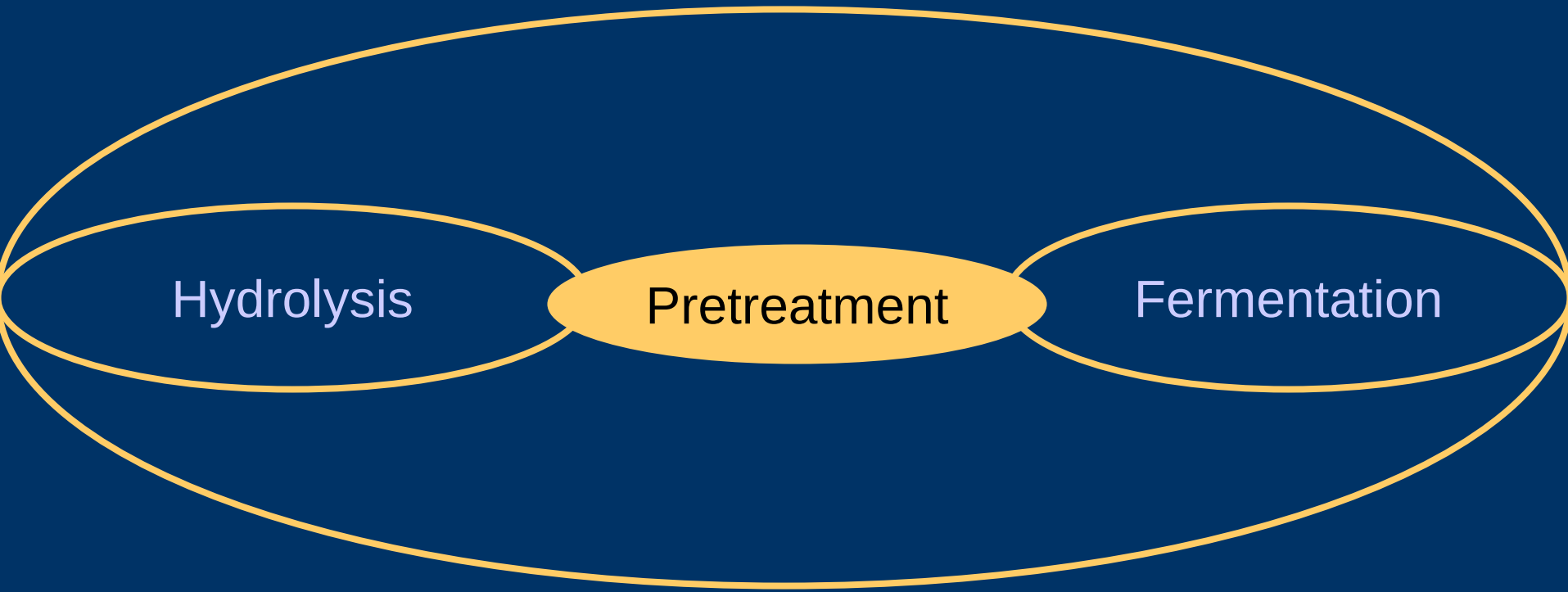
Pressure vessels

Rotary digester

Process flow



Research themes



Optimization of pretreatments

Low severity
↑ fermentation yield
↓ solids hydrolysis

Medium severity
good fermentation yield
good solids hydrolysis

High severity
↓ fermentation yield
↑ solids hydrolysis

Corn fibre:190ºC, 5 min, 3% SO_2, Bura *et al.,* 2003
Corn stover:190ºC, 5 min, 0% SO_2, Bura *et al.,* 2005
Hybrid poplar:200ºC, 5 min, 3% SO_2, Bura *et al.,* 2006
Hybrid poplar:180ºC, 60 min, 1.25% H_2SO_4, 60% E, Pan *et al.,* 2006*
BKLP:205ºC, 5 min, 4% SO_2, Ewanic *et al.,* 2006
BKLP:180ºC, 60 min, 1.25% H_2SO_4, 60% E, Pan *et al.,* 2006*
Douglas-fir:195ºC, 4.5 min, 4.5% SO_2, Boussaid *et al.,* 2000

Overall sugar recovery

Feedstock	Glucan recovery (%)	Xylan or mannan * recovery (%)
Corn stover[1]	100	98
Hybrid poplar[2]	100	87
Beetle killed lodgepole pine[3]	100	80*

[1]Bura *et al.*, 2006
[2]Bura *et al.*, 2006
[3]Ewanic *et al.*, 2006

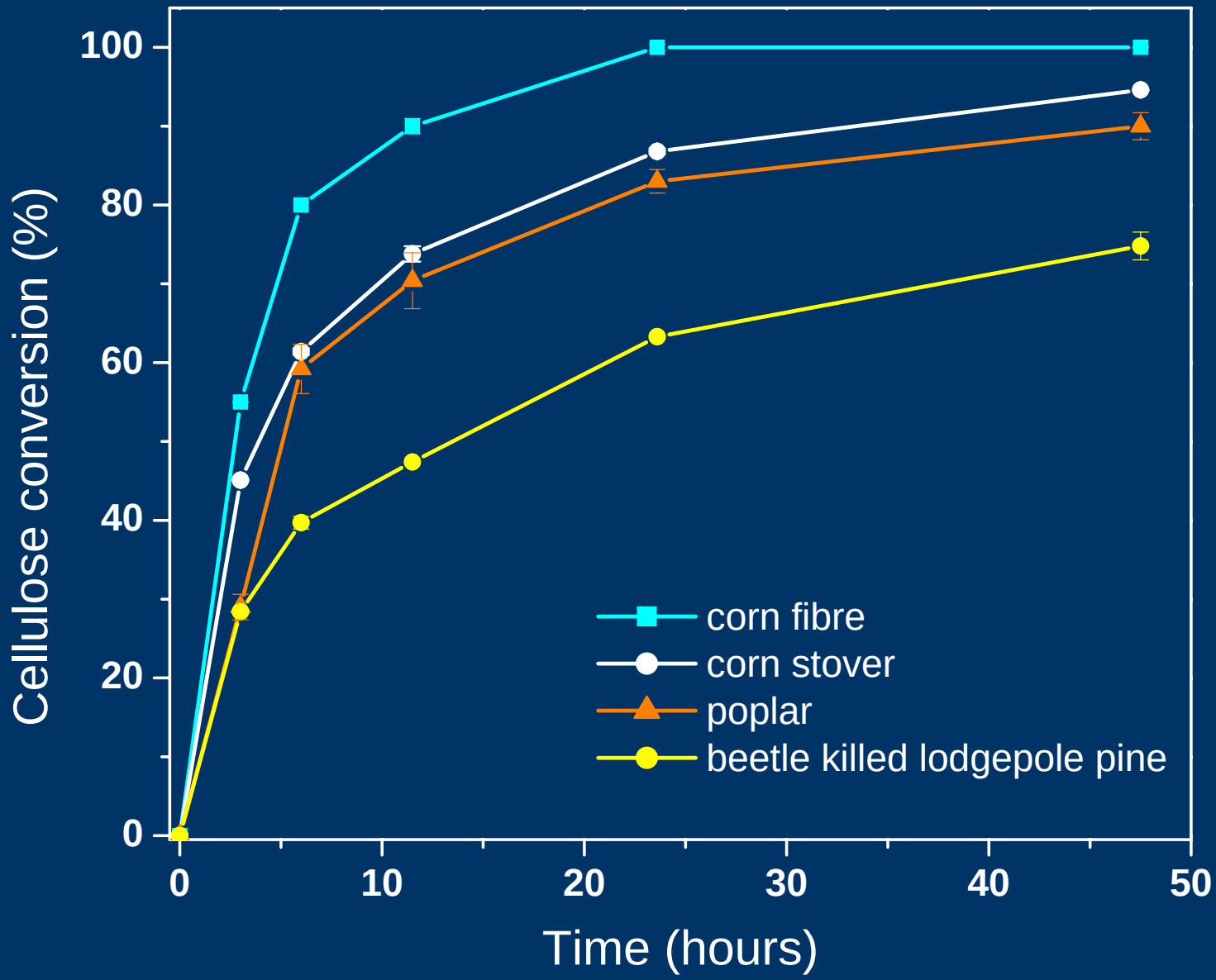
Fermentability of water soluble stream

Feedstock	Total fermentable sugars (g/L)	Relative ethanol yield (%)
Corn stover[1]	28	100
Corn fibre[2]	35	95
Hybrid Poplar[3]	32	75
Beetle killed lodgepole pine[4]	30	75

[1]Bura *et al.*, 2006
[2]Bura *et al.*, 2004
[3]Bura *et al.*, 2006
[4]Ewanic *et al.*, 2006

Hydrolysis of solids-2% (w/v) a.c buffer

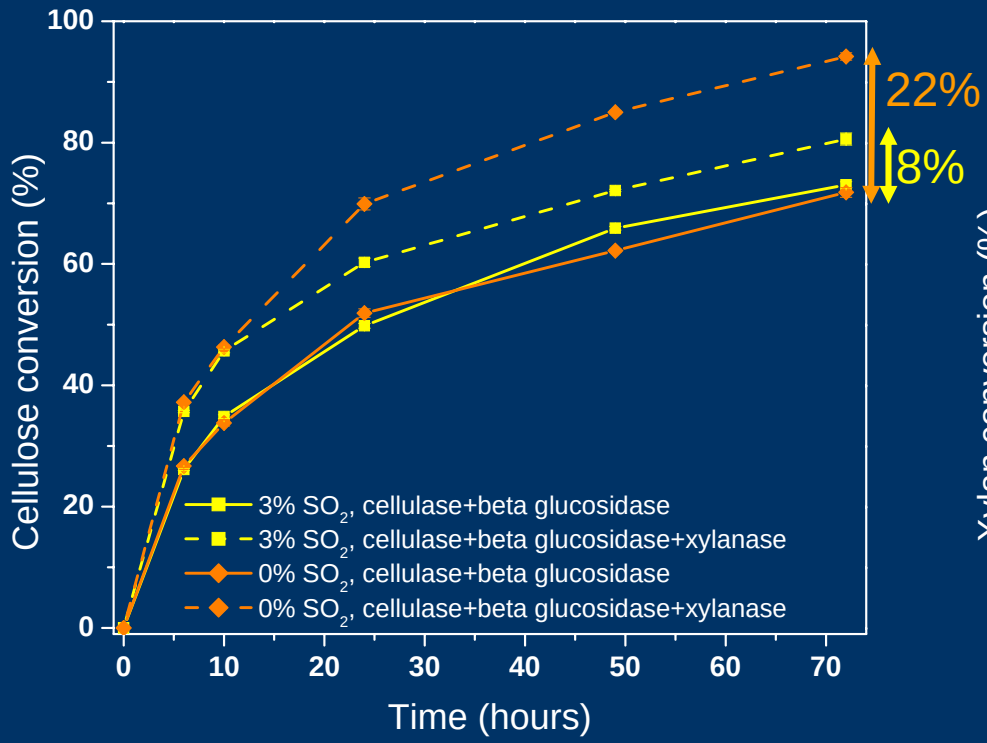
Steam explosion, 20FPU/g of cellulose, IU:FPU 2:1

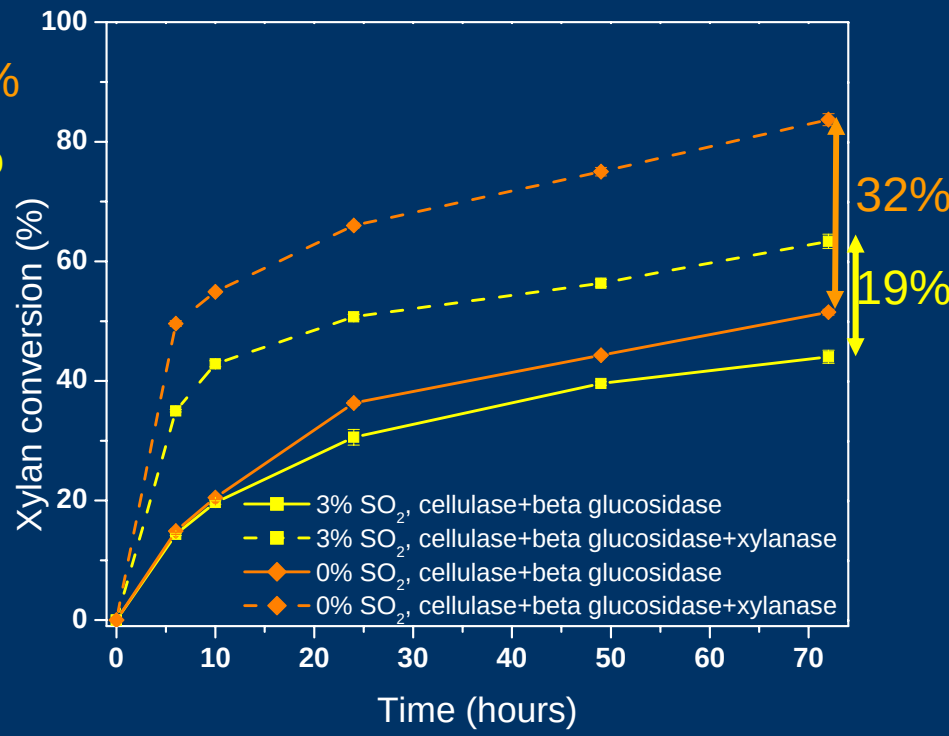


Xylan-with the solid or liquid stream?

Pretreatment	Glucan (%)	Xylan (%)
190°C, 5 min, O% SO_2	56	18
190°C, 5 min, 3% SO_2	57	10

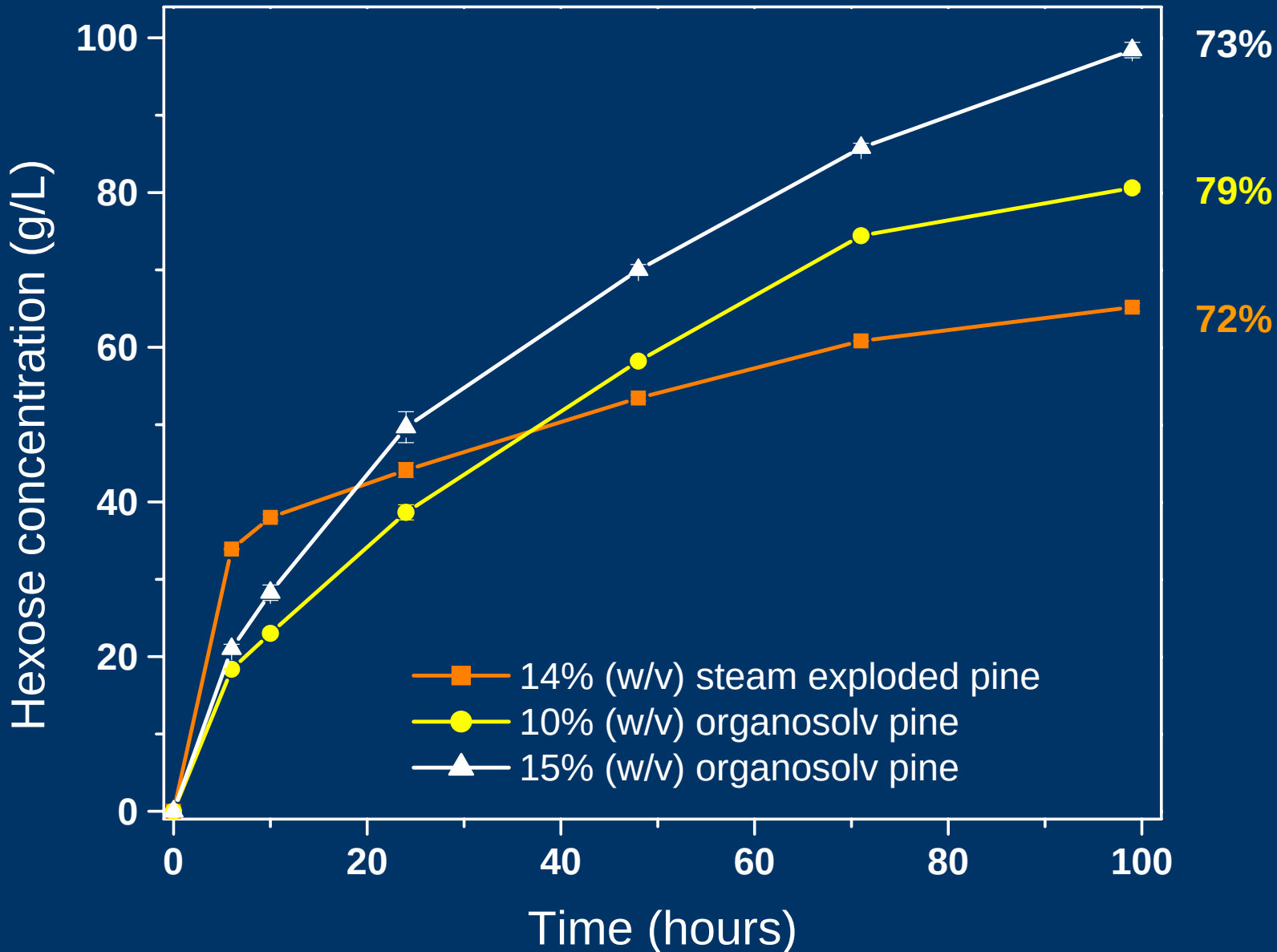
Corn stover, hydrolysis, 8% (w/v), 10FPU/g of cellulose, IU:FPU 2:1



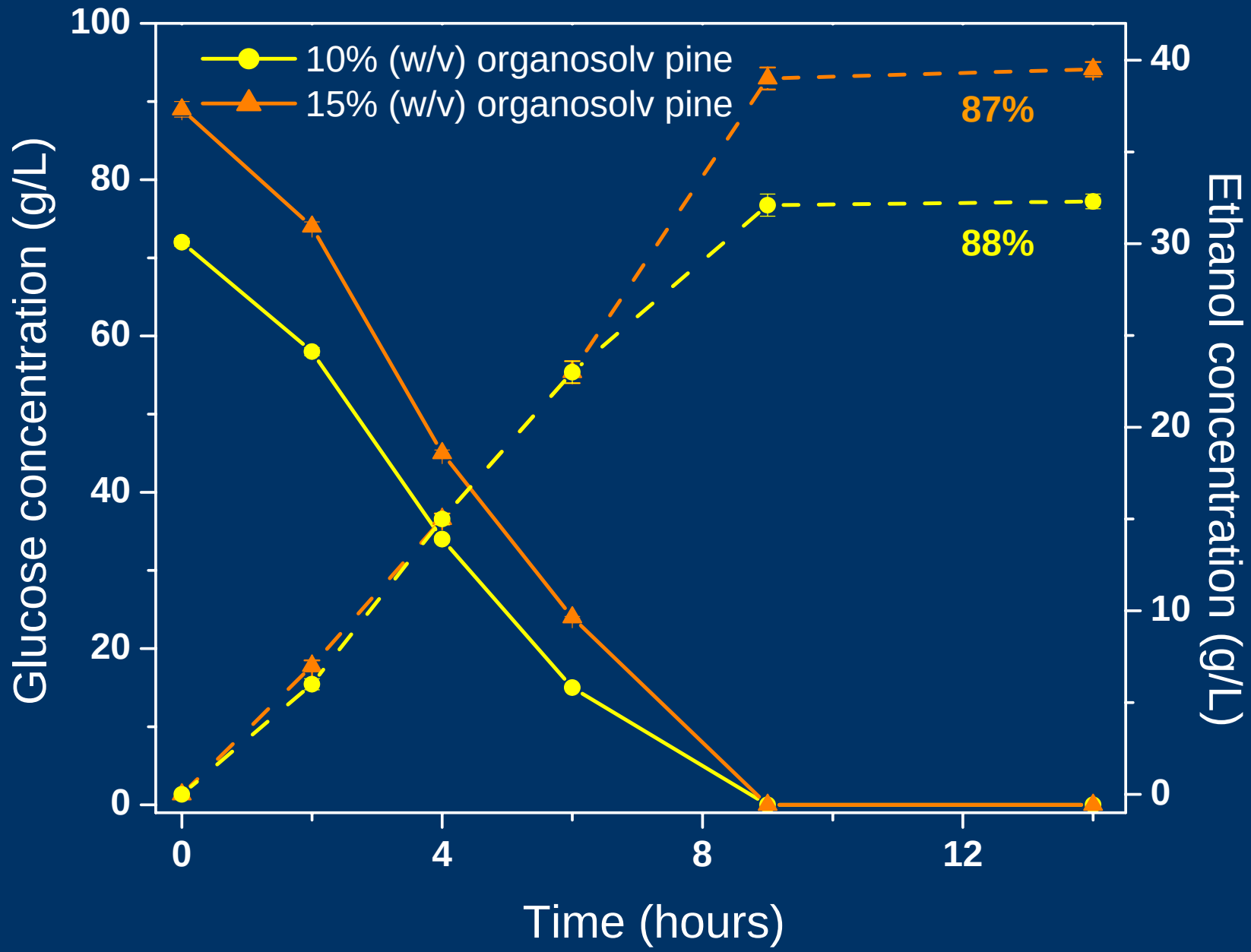


High consistency hydrolysis

Lodgepole pine, SE-20FPU/g of cellulose, IU:FPU 2:1, organosolv- 10FPU/g of cellulose



High consistency SHF



Summary

- UBC can tailor the pretreatment and substrate characteristics to industry specifications
- The characteristics of pretreated substrates influence the performance of hydrolysis and fermentation
- SO_2 catalysed steam explosion works well with:
  - ☑ Agricultural residues (corn fibre, corn stover)
  - ☑ Hardwood residues (poplar, maple)
  - ☑ Softwood residues (lodgepole pine, spruce)
- Organosolv pulping
  - ☑ Extensive fractionation of cellulose, hemicellulose and lignin
  - ☑ The use of co-products (lignin) in the future biorefinery
  - ☑ High consistency hydrolysis and SSF

Acknowledgements

- Natural Resources Canada
- Dr. B. Cruickshank
- CAFI, USDA, NREL, Novozymes, Genencor Inc.
- Tembec Ltd.
- Forest Products Biotechnology group members