Extraction, Hydrolysis and Fermentation of Levoglucosan Derived from Pyrolysis Oil

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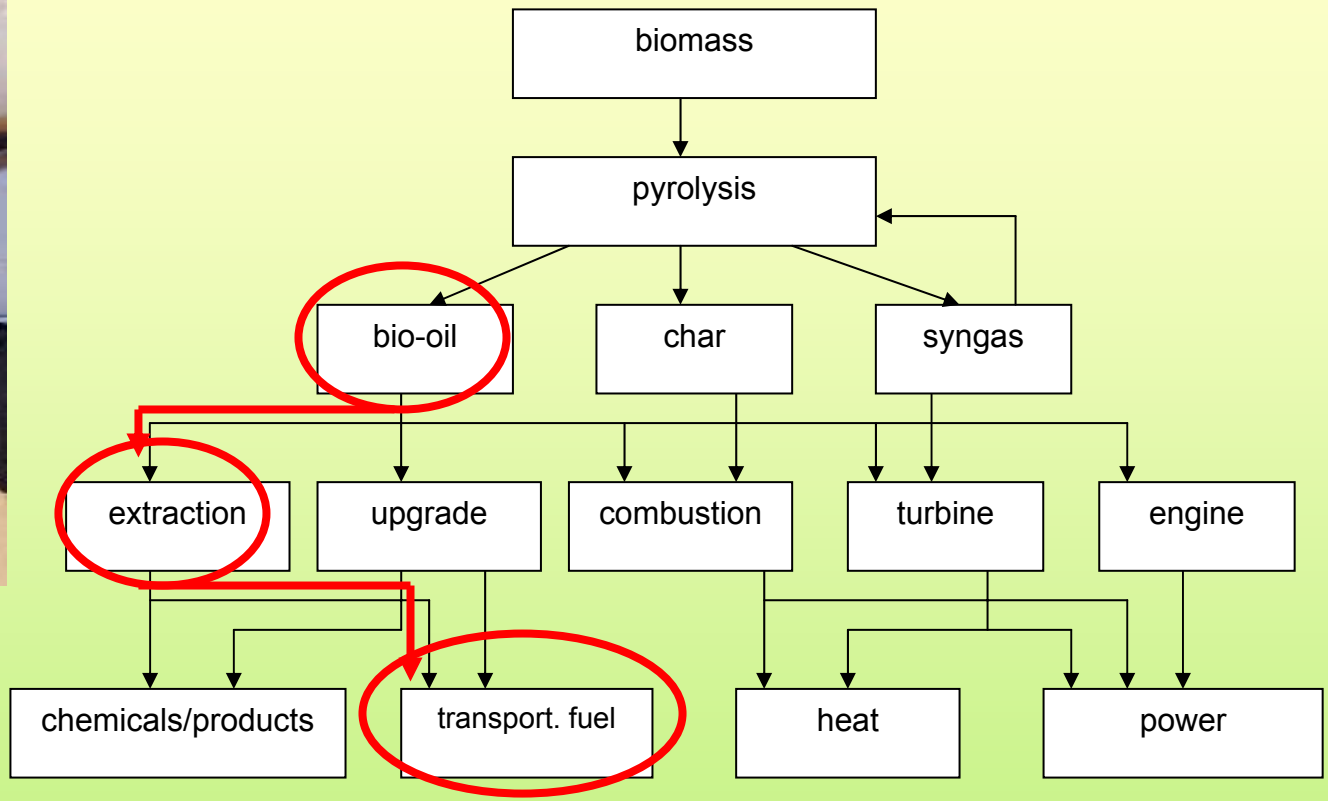
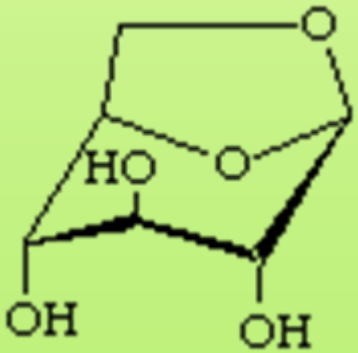
IEA Bioenergy

Vancouver, B.C. August 27-30, 2006

Background



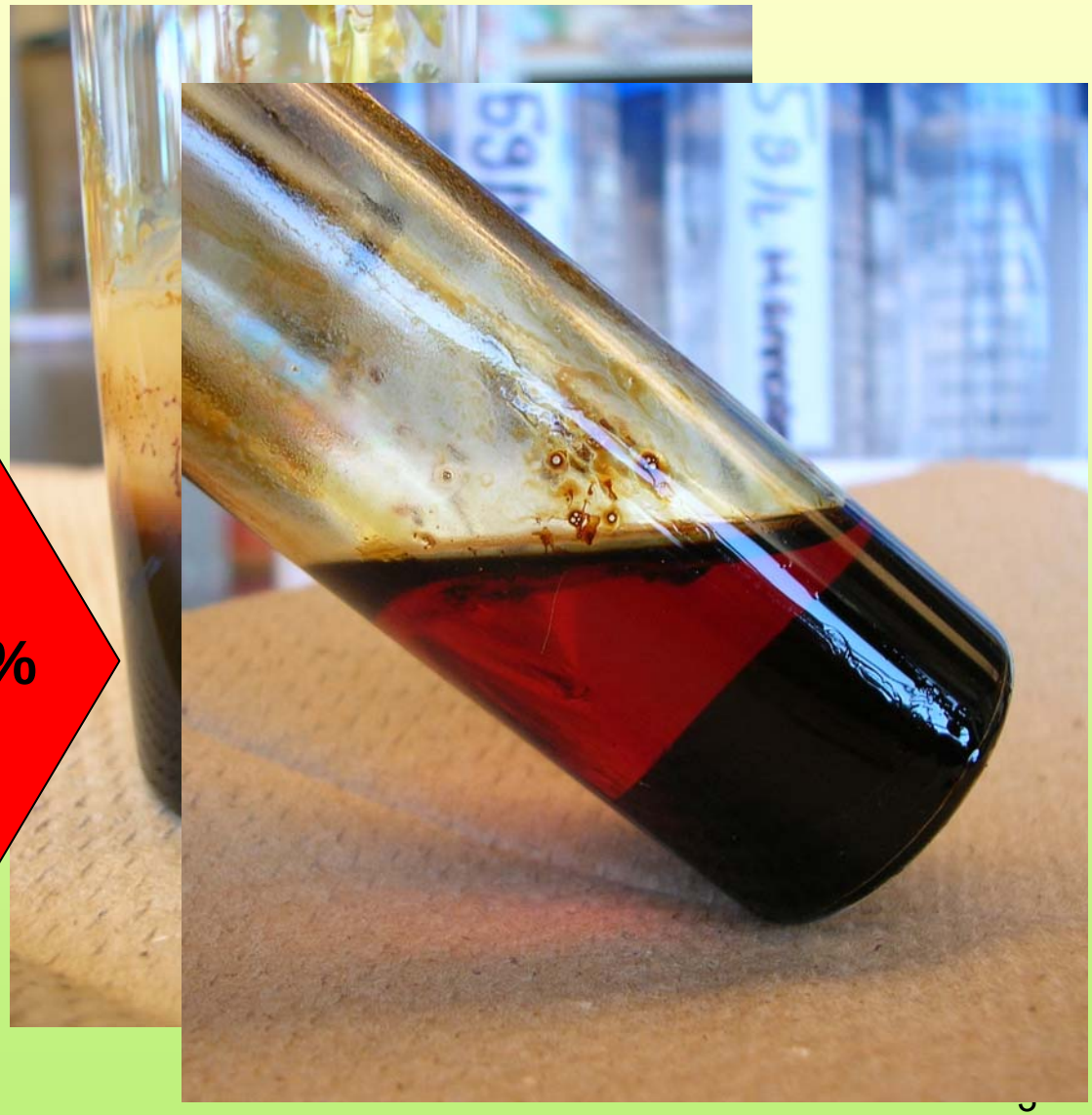


Levoglucosan (LG)
1,6-anhydro-β-D-glucopyranose
$C_6H_{10}O_5$

Phase Separation

21 wt.%

32-35 wt.%

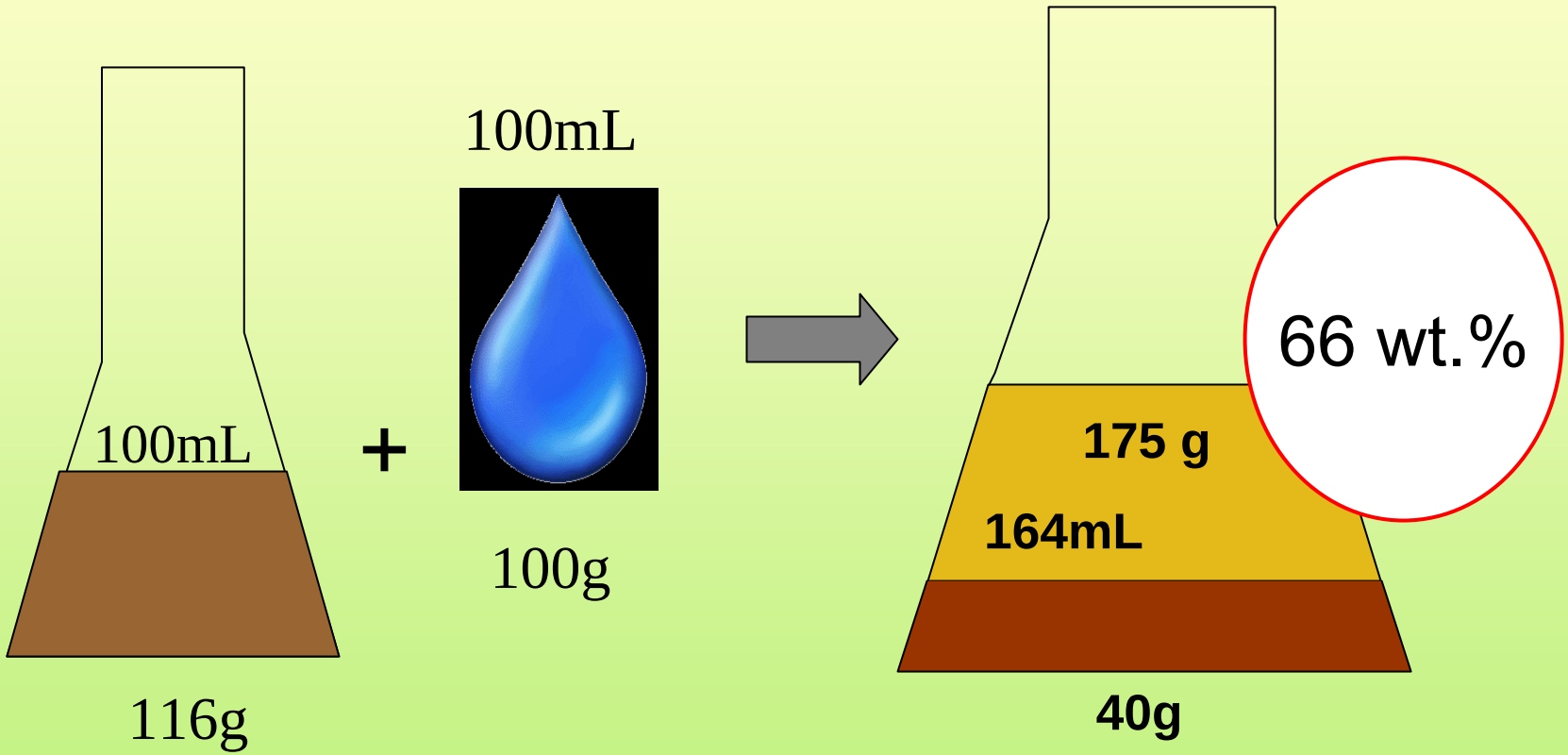


Extraction: Effect of Bio-oil-to-Water Ratio on Fractionation Mechanism

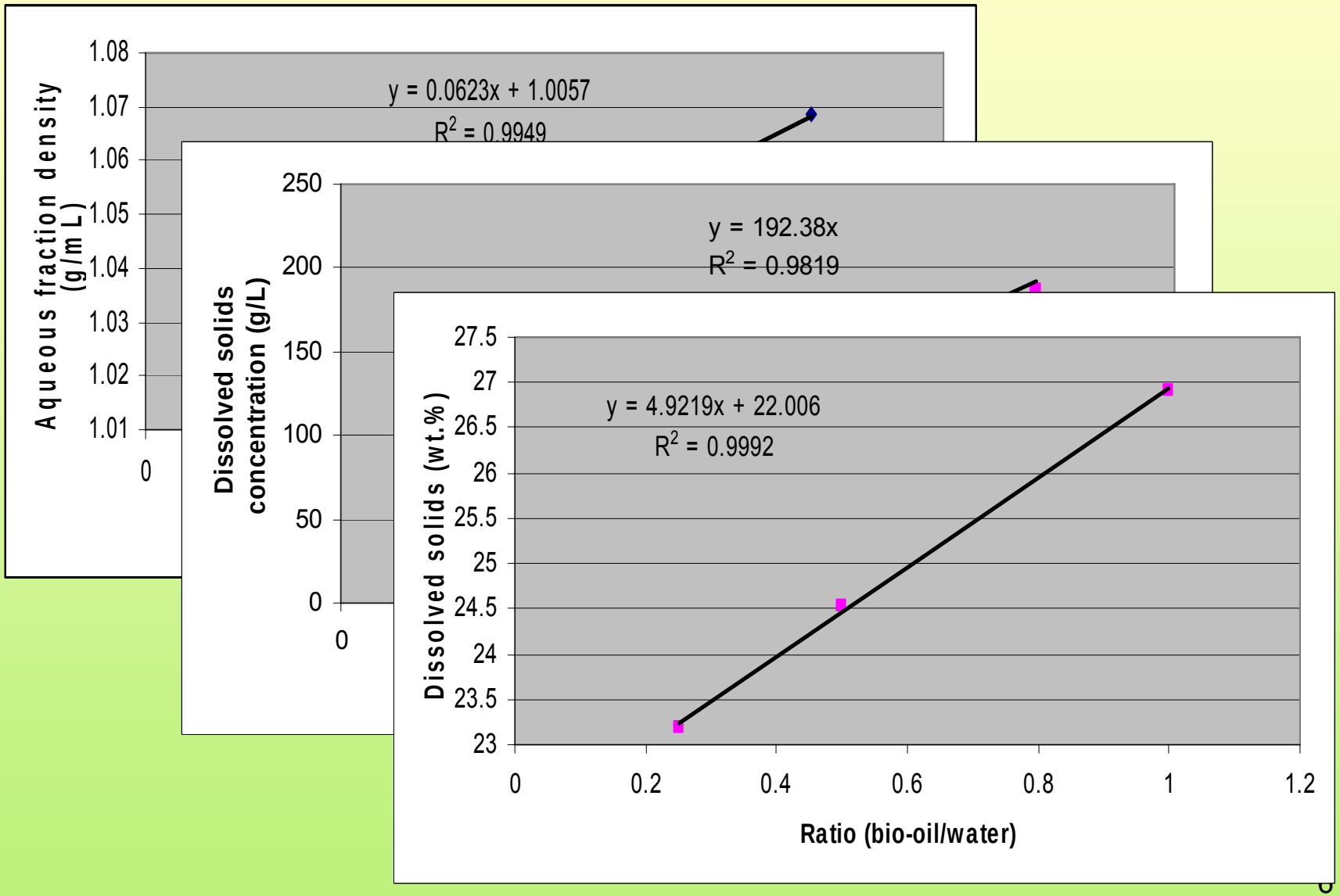
	Bio-Oil (mL)	Water (mL)	Ratio: BioOil/Water
Extract 1	25	25	1
Extract 2	15	30	0.5
Extract 3	10	40	0.25

- Mass transfer
- Characterization of components
  - acids, sugars, and dissolved solids

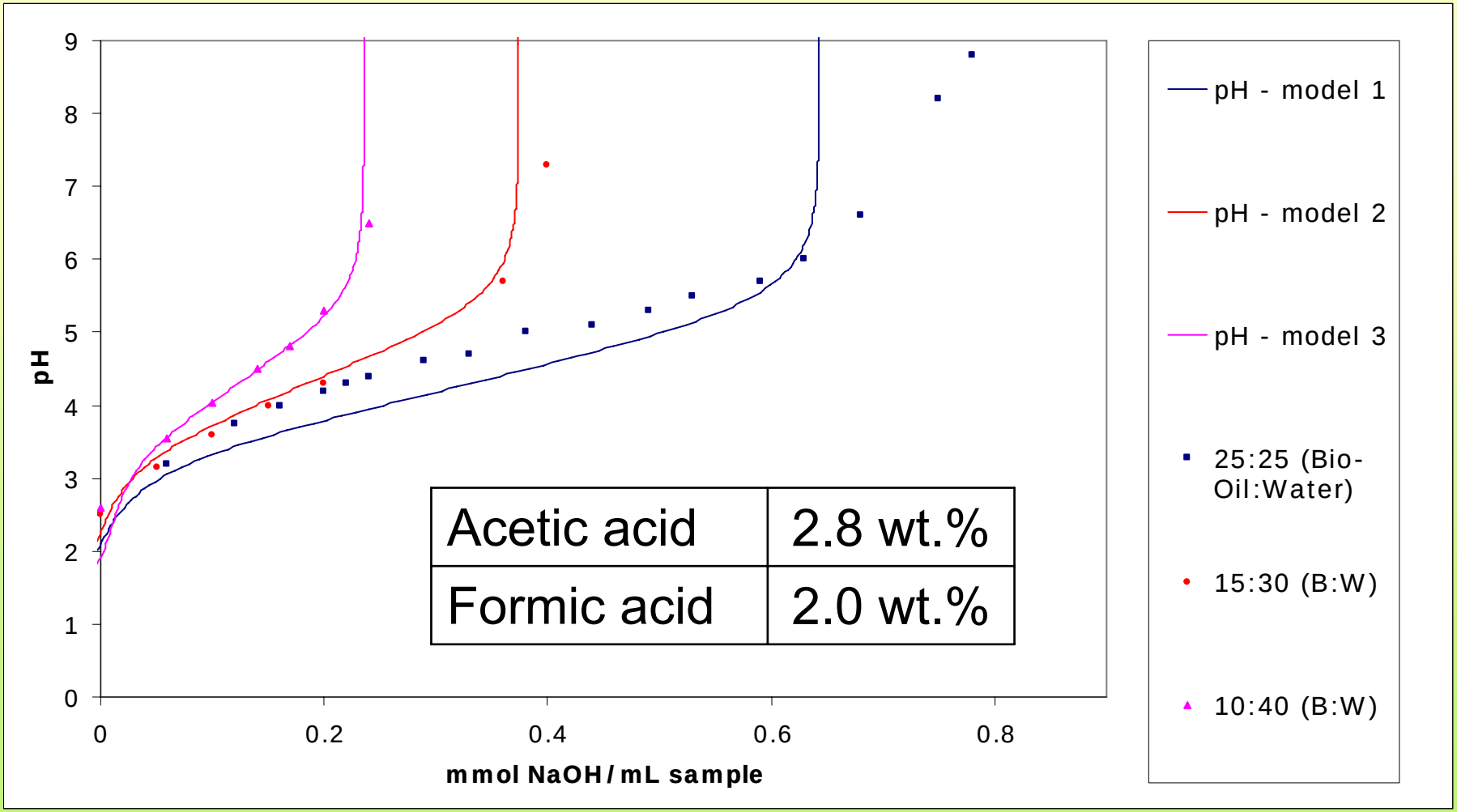
Extraction: Mass Transfer



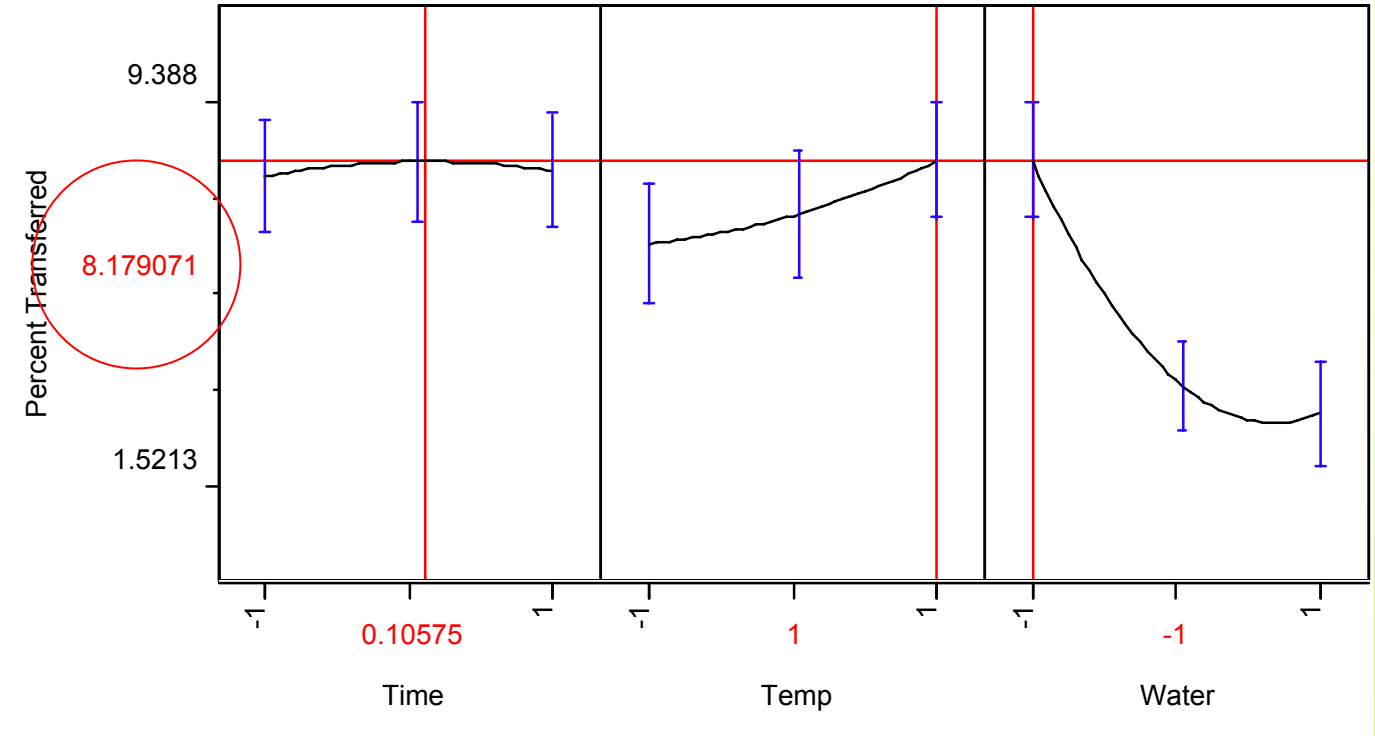
Extraction: Components Transferred into Aqueous Phase



Extraction: Organic Acids

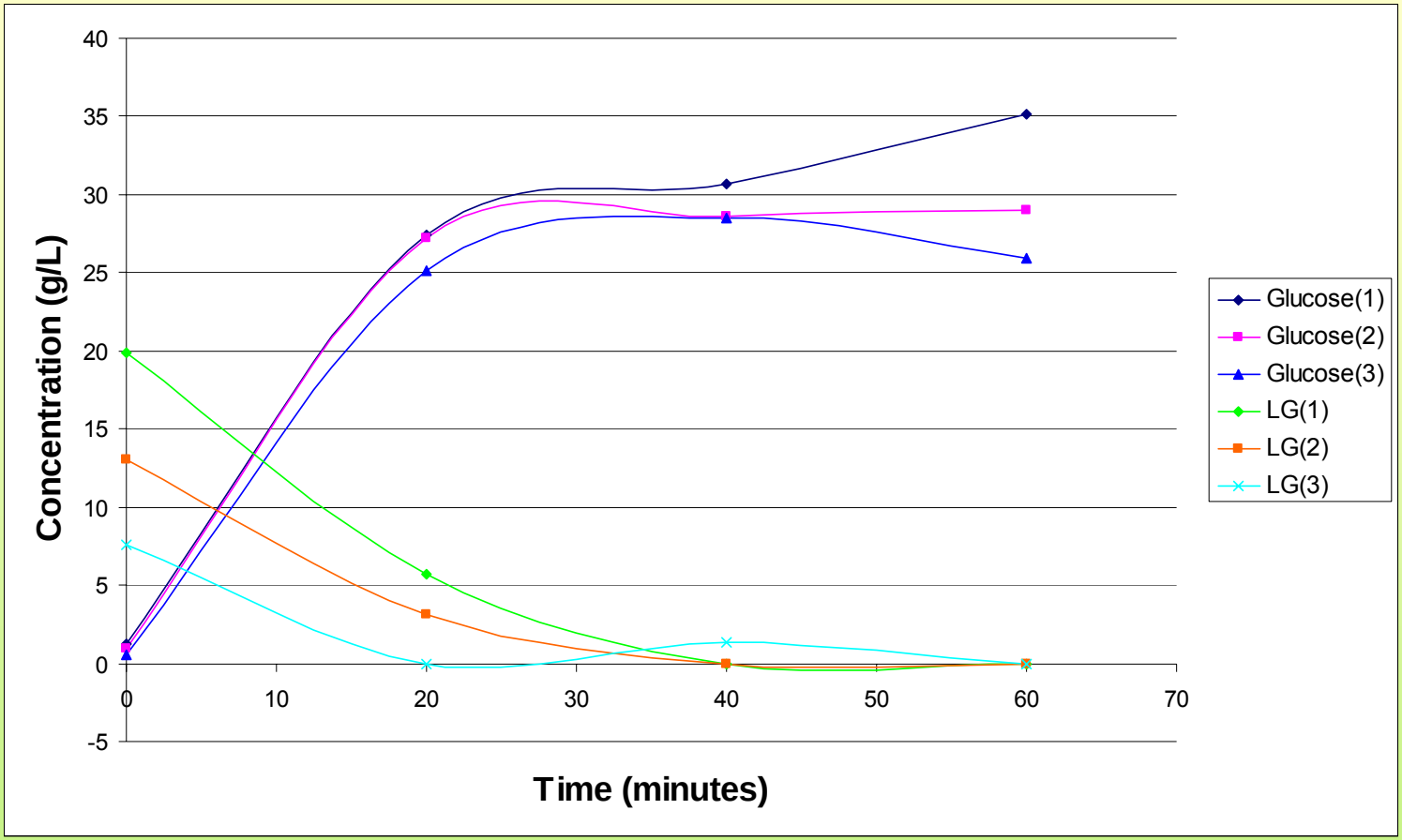


Extraction: Parameters Effects on LG Recovery



- 25 min, 34°C, 2(B):1(W) → 8.2 wt.%
- Limited by phase separation

Hydrolysis: Rate of LG into Glucose



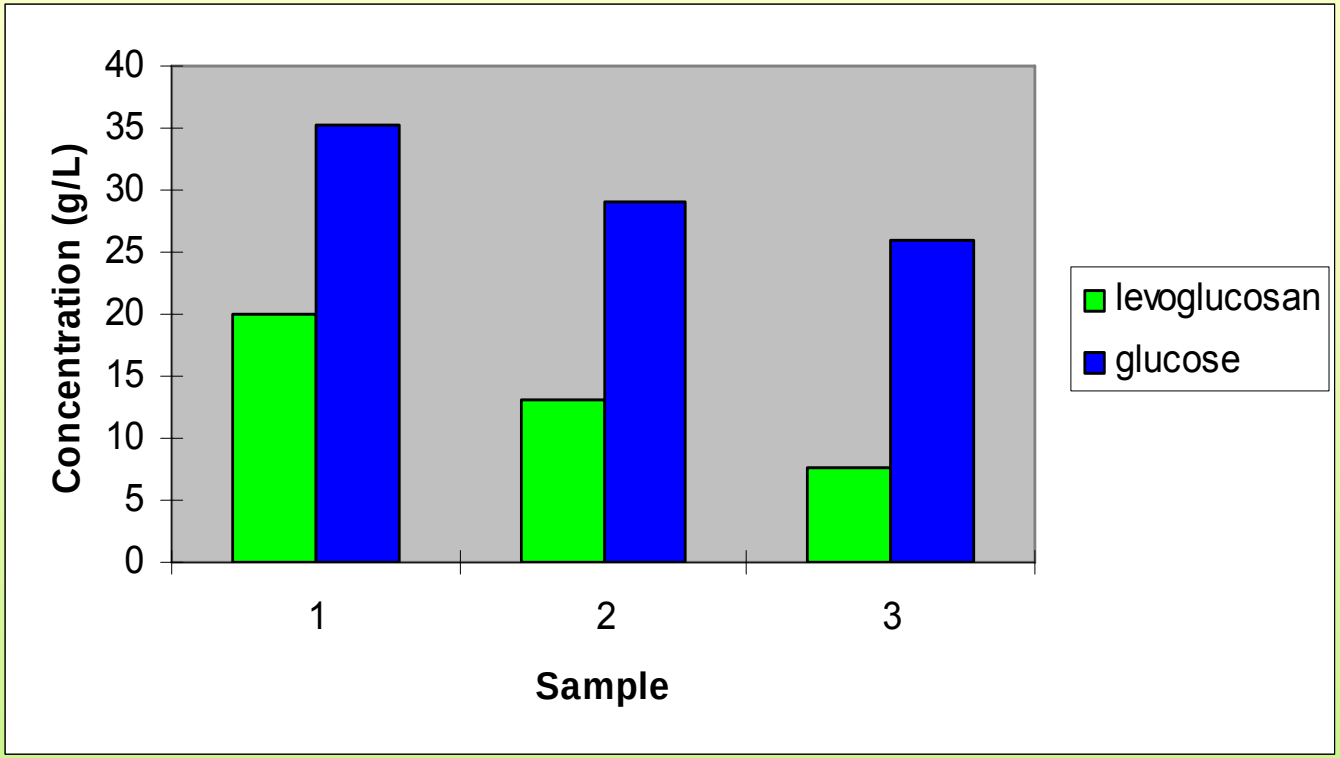
Conditions

120°C

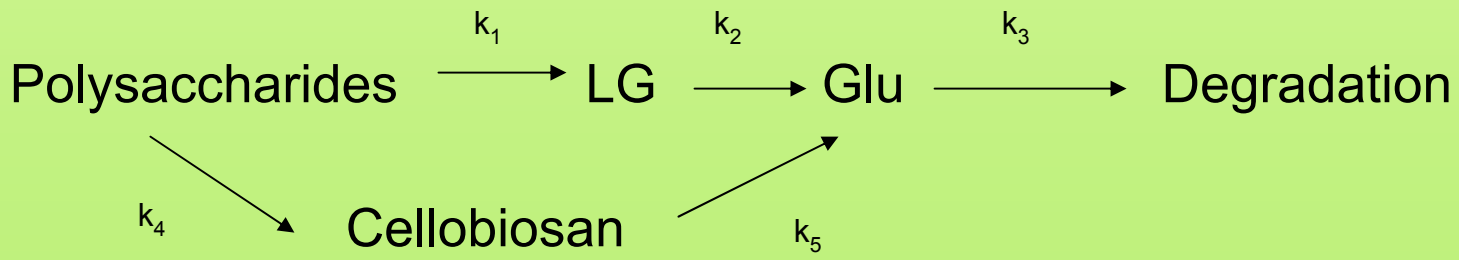
0.5M

- Rapid, first-order, reaction
- Three different end results
- Newly formed LG

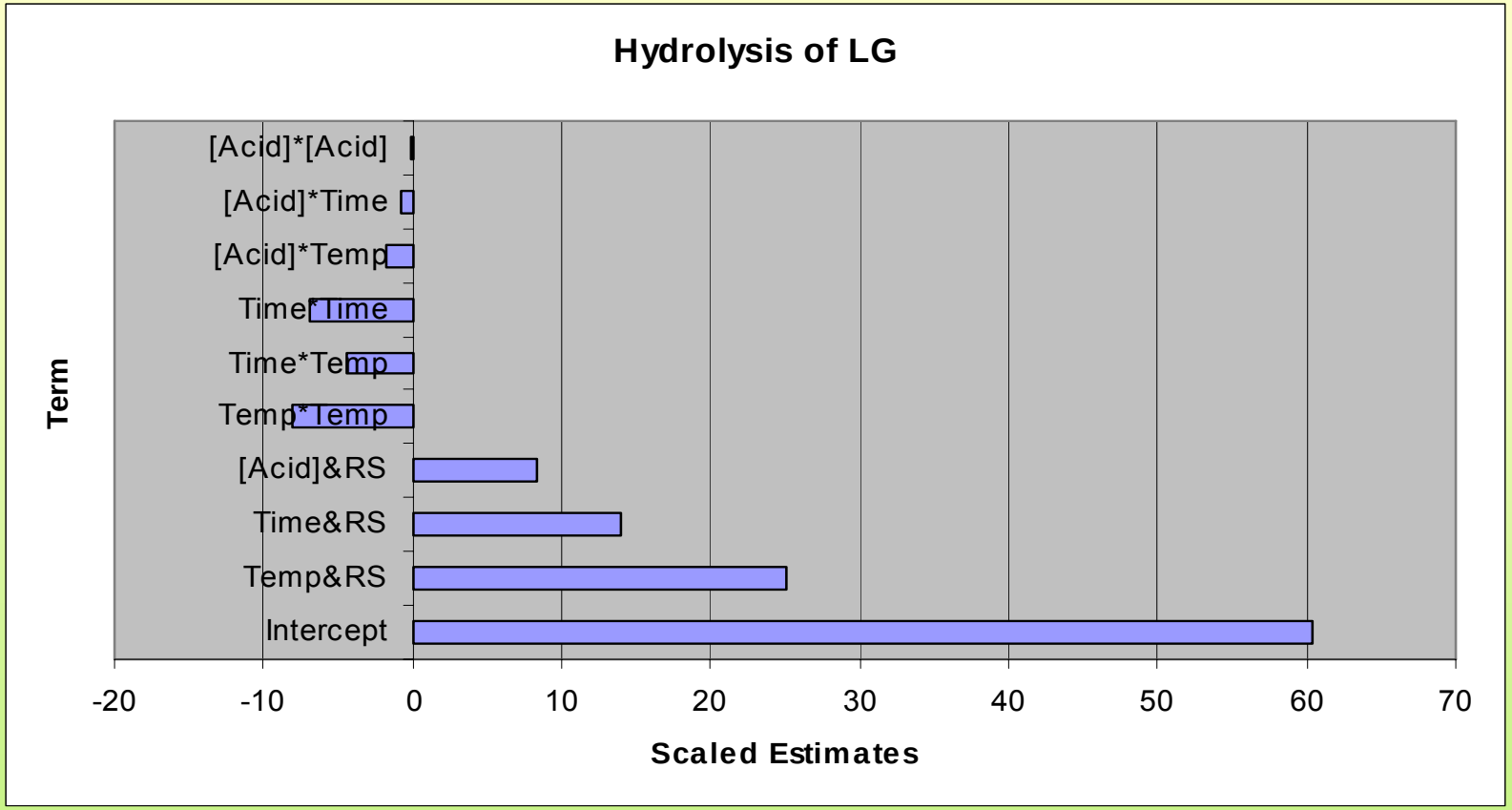
Hydrolysis: Yield



- Yields MUCH greater than 100%; evidence of other sources of glucose
- 1 g LG → 1.11 g GLU

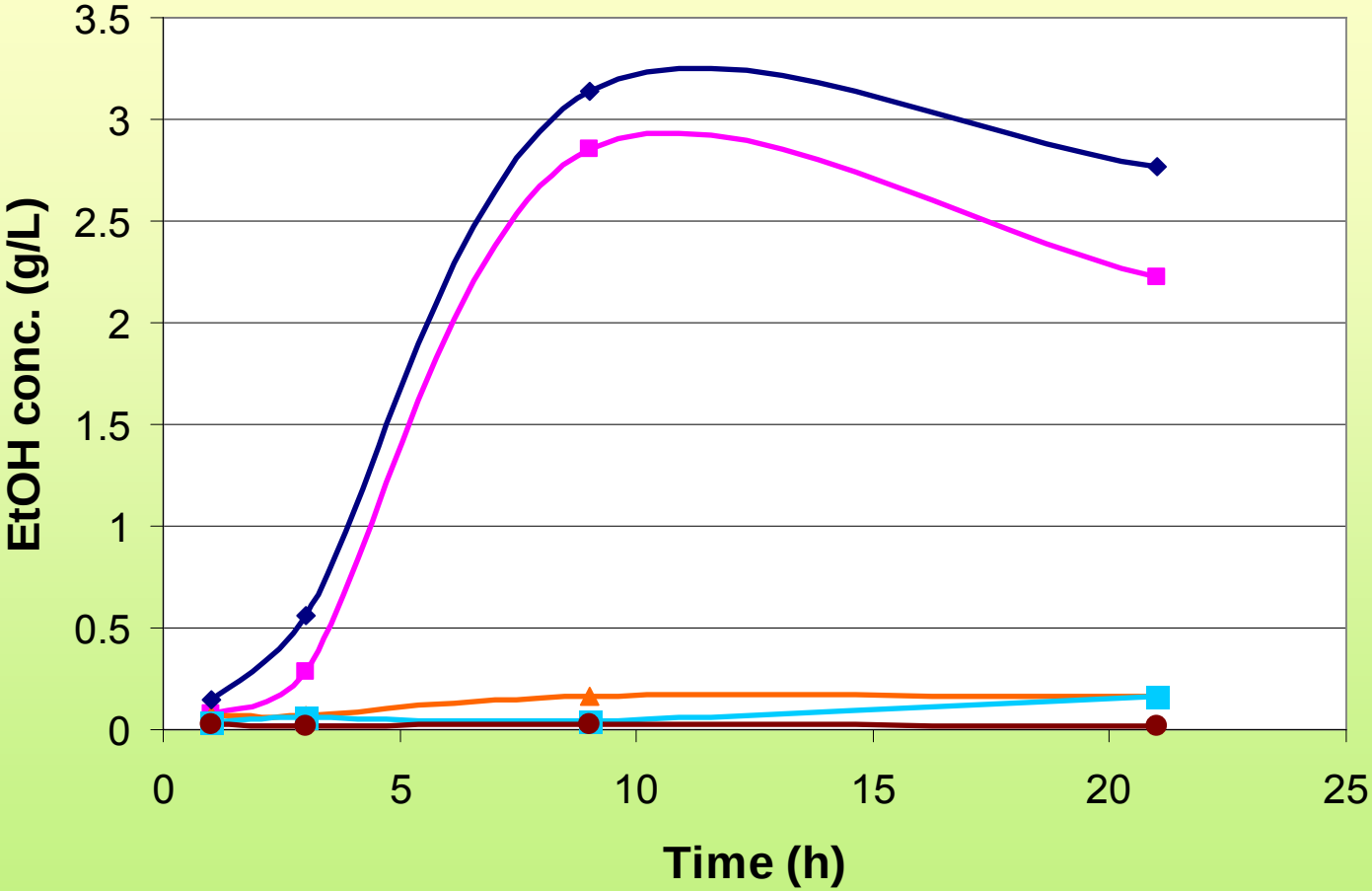


Hydrolysis: Interactive Effects of Parameters



- Primary effects are dominant and positive: temp > time > acid
- Strong interactive effects, all negative
- Optimal combination = 118°C, 30 min, 1.0M H_2SO_4 (85% g/g)

Fermentation: Toxicity



Blue - control

Pink - 2%

Orange - 5%

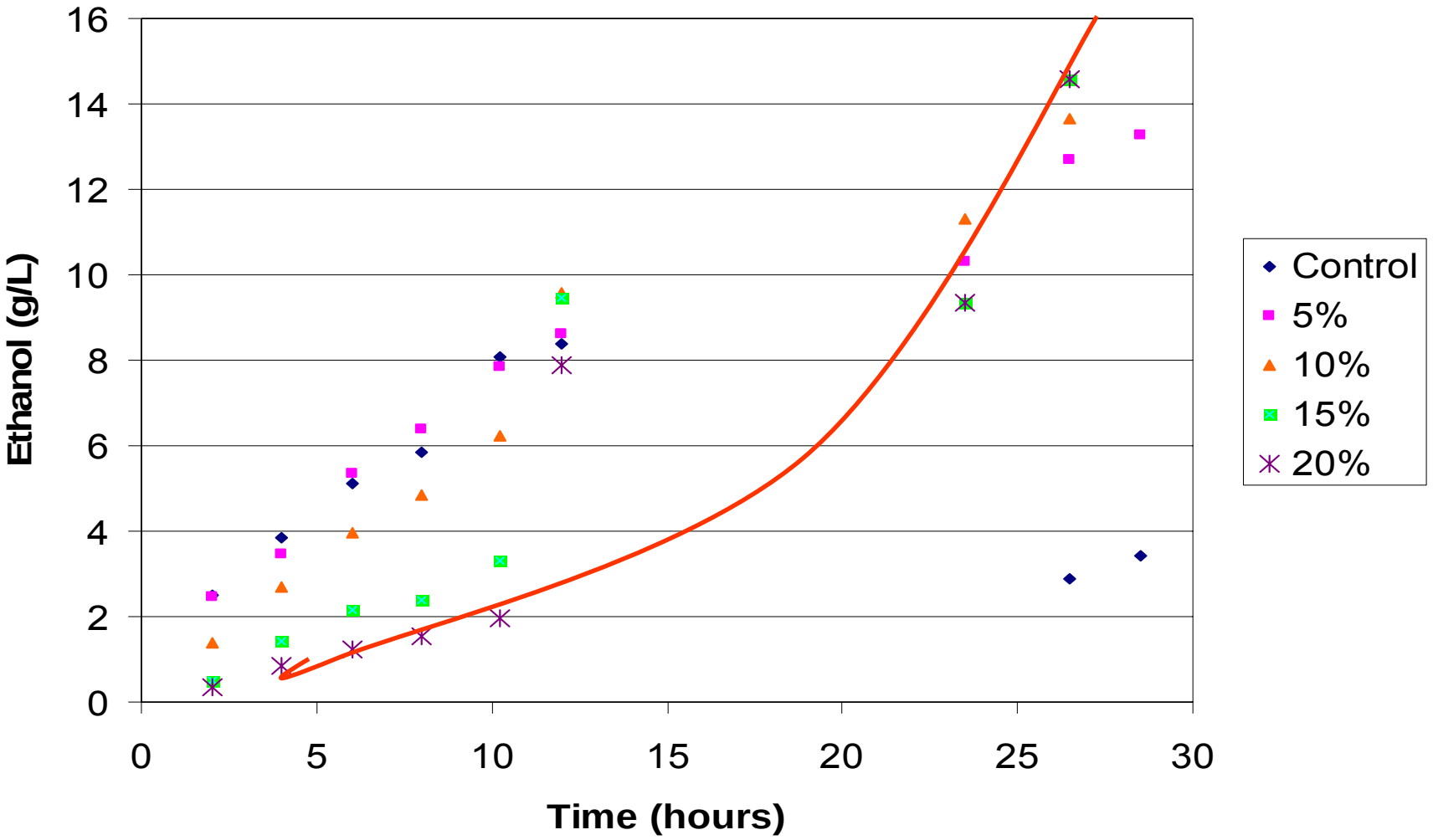
Aqua - 10%

Brown - 15%

High level of toxicity: alcohols, organic acids, lignin derivatives, aromatic compounds

Fermentation: Yields and Production

20	1	44	0.05	0.37	0.1	10.2


Ethanol (g/L)
16
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
Time (hours)
Control
5%
10%
15%
20%

Conclusions

Extraction

- Use smallest solvent volume possible
- Toxic levels of “other” extractives

Hydrolysis

- Parameters can be optimized for acid, temp and time
- Glucose yields over 100%
  - Cellobiosan

Fermentation

- Inhibitory conditions overcome using fermentation techniques (micro-aerophilic and high inoculum)
- Greater than theoretical yields
  - Mannose

Acknowledgements

NSERC

BIOCAP Foundation of Canada

VTT

Dr. Sheldon Duff

Questions?