FERMENTATIVE UPGRADING OF A BIOMASS PYROLYSIS BYPRODUCT

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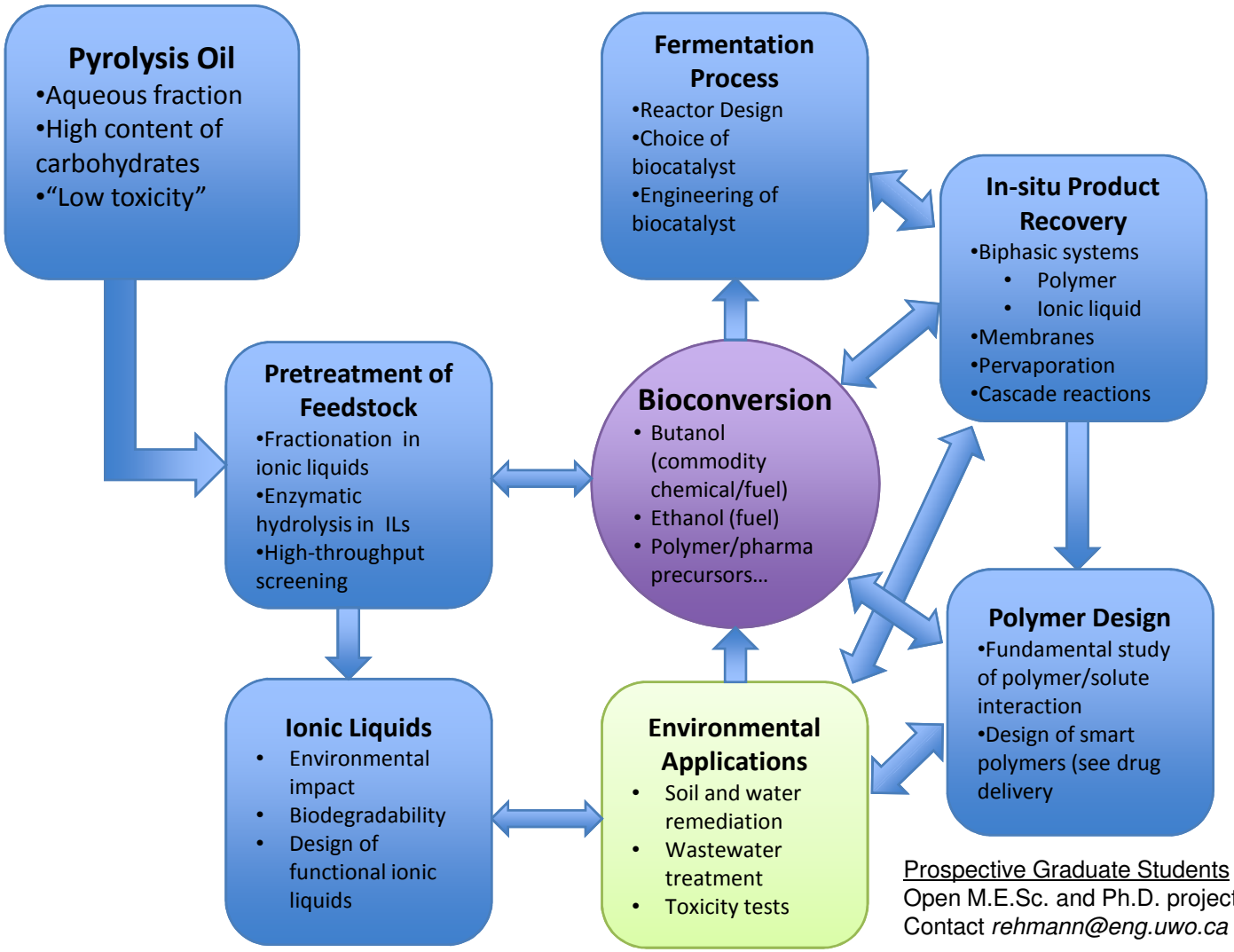

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Preliminary Objectives

1. Use aqueous phase of pyrolysis oil as fermentation feedstock

2. Convert carbohydrates to ethanol

3. **Profit**

Preliminary Results

- Corncob pyrolysis oil aqueous fraction as feedstock for bio-ethanol production
- Two biocatalysts
  - *Saccharomyces cerevisiae*
  - *Zymomonas mobilis*

Addition of 1% aqueous fractions stops all cell activity

Revised Objectives

1. Evaluation of bio-oil aqueous phase as feedstock for microbial ethanol production

2. Identification and removal of potential inhibitory compounds

3. Definition of a synthetic bio-oil aqueous phase for fundamental studies

Aqueous Phase…

- Composition varies based on operating conditions and feedstock
- Proposed Synthetic Aqueous Phase (SAP):

Substance	C. in bio-oil[1] (%w/w)	$P_{o/w}$	C. in SAP (%w/w)
m-cresol	0.02 – 0.04[b]	87.1	0.149
Phenol	0.1-2.55[b]	40.74	0.069
Guaiacol	0.05-0.31[b]	17.78	0.03
2,6-DMP	0,04-0.34[b]	18.2	0.031
Pyrocatechol	0.08-0.48[b]	12.59	0.02
Furfural	1.58-2.52[b]	1.622	2.0
Furfuryl alc.	n.s.	0.977	1.7
Formic acid	n.s.	0.537	1.5
Acetic acid	13.84-18.57[a]	0.513	1.5
Glucose	n.s.	0.0032	6.0
Galactose	n.s.	0.0032	0.8
Xylose	n.s.	0.0074	1.2

Testing of Microbial Activity

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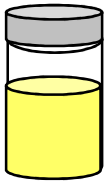
High Throughput Experiment:

Stock culture:

→ Exponential phase



Batch-fermentations:

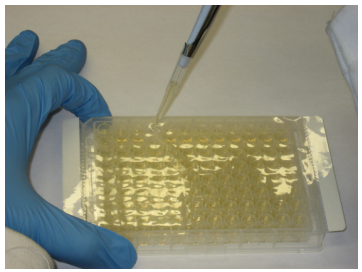
→ Micro titer plate

→ 8 experiments

→ Reaction volume: 200µl

→ Addition of aq. phase

→ Plate Reader



Sample preparation:

- Centrifugation

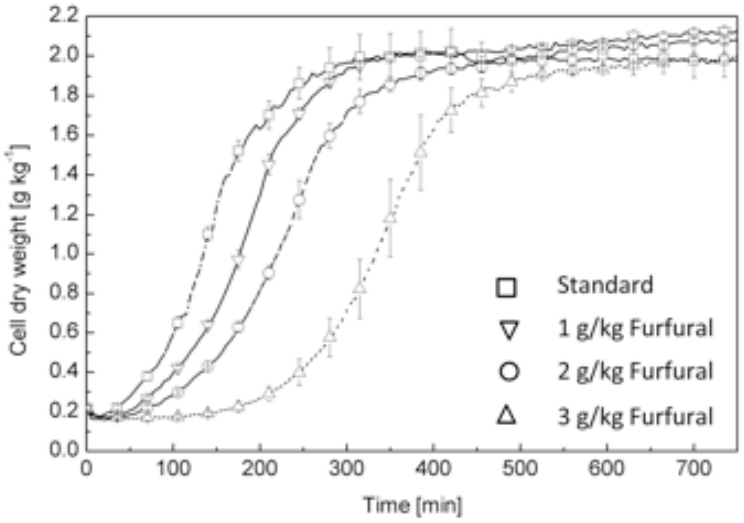
Further Analyses of the samples:

- Gas Chromatograph
- HPLC

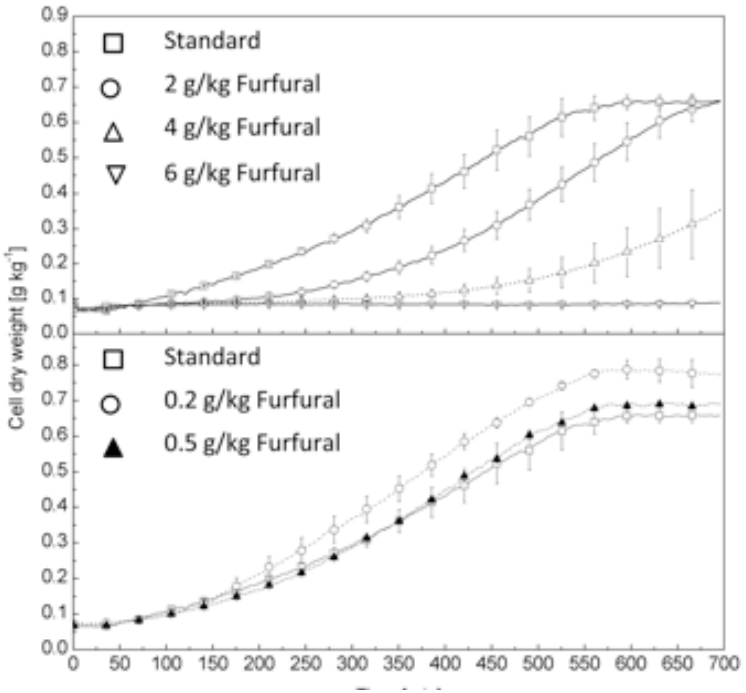
→ **Increased efficiency because of small volumes**

Furfural

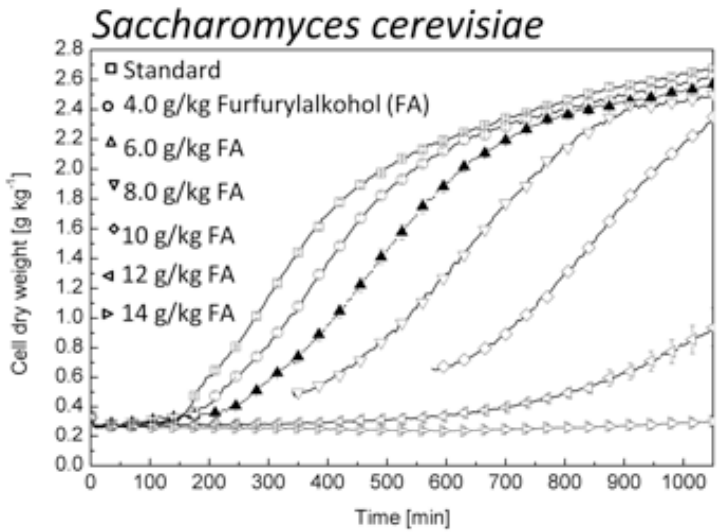
Saccharomyces cerevisiae

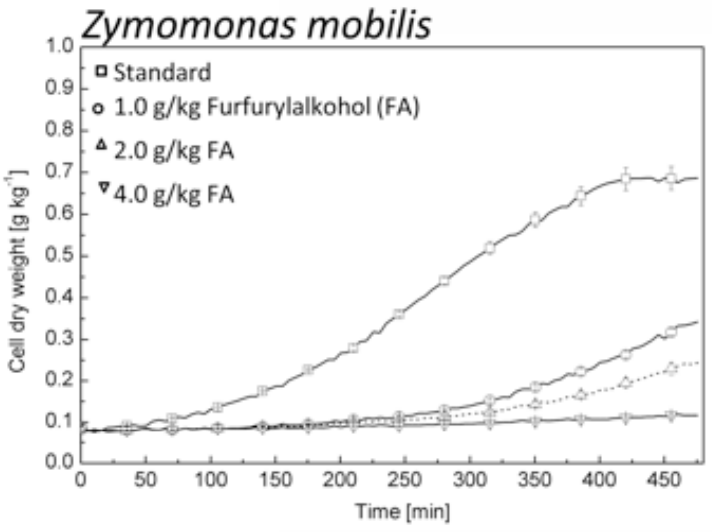


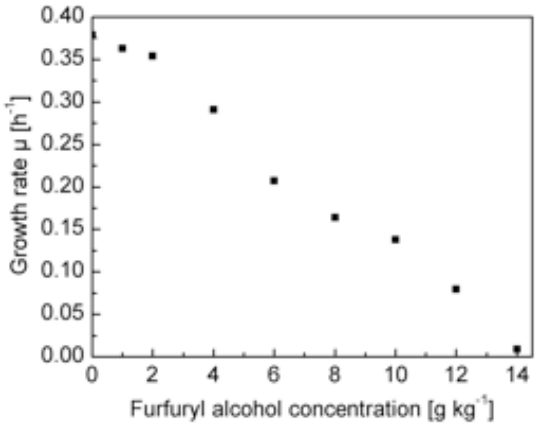
Zymomonas mobilis

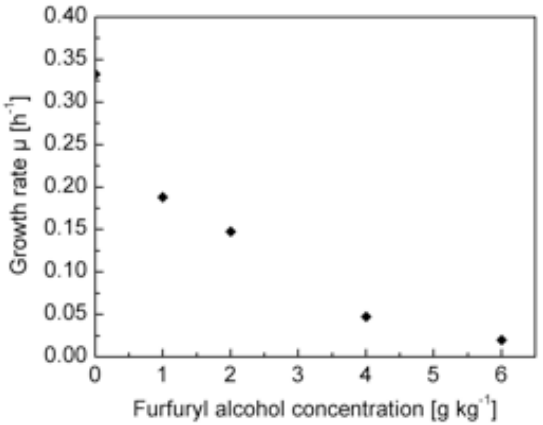


Furfuryl Alcohol

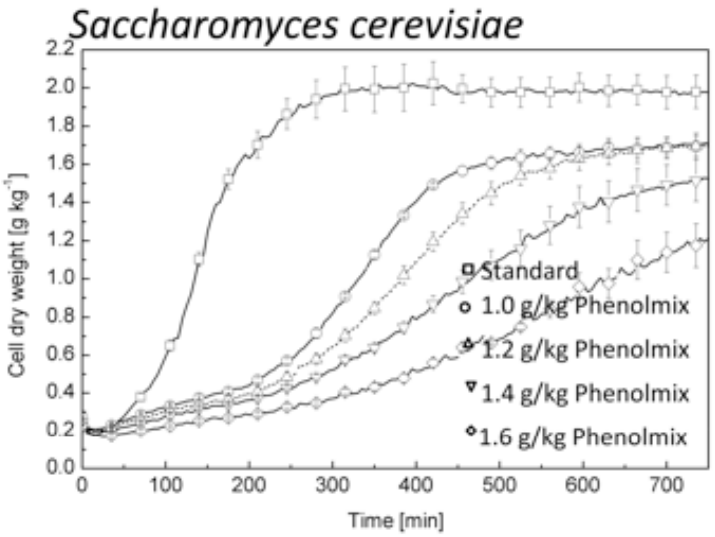


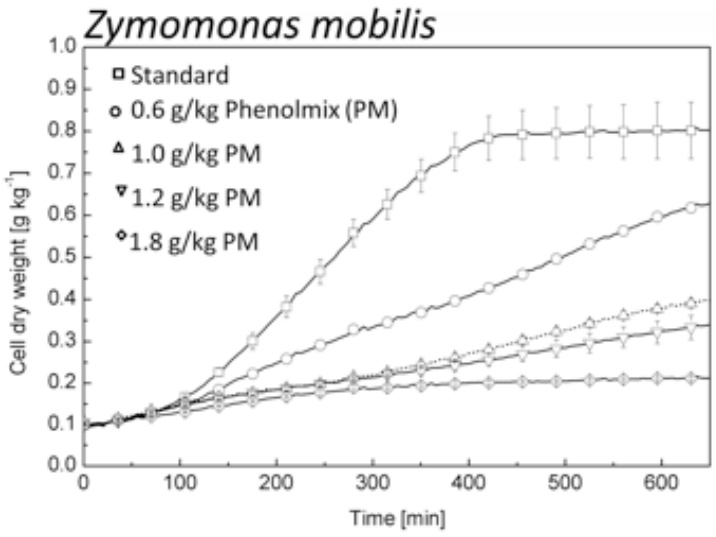


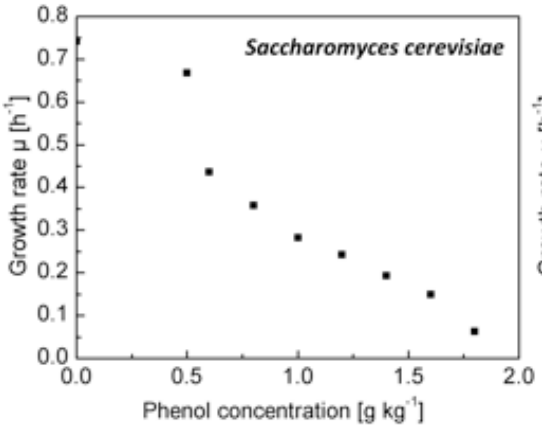


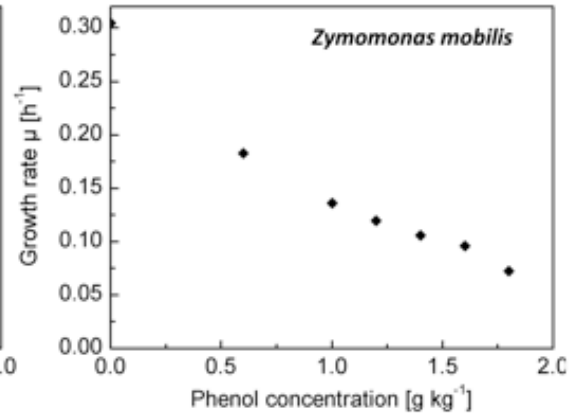


Phenols


Saccharomyces cerevisiae
Cell dry weight [g kg^{-1}]
Time [min]
Standard
1.0 g/kg Phenolmix
1.2 g/kg Phenolmix
1.4 g/kg Phenolmix
1.6 g/kg Phenolmix

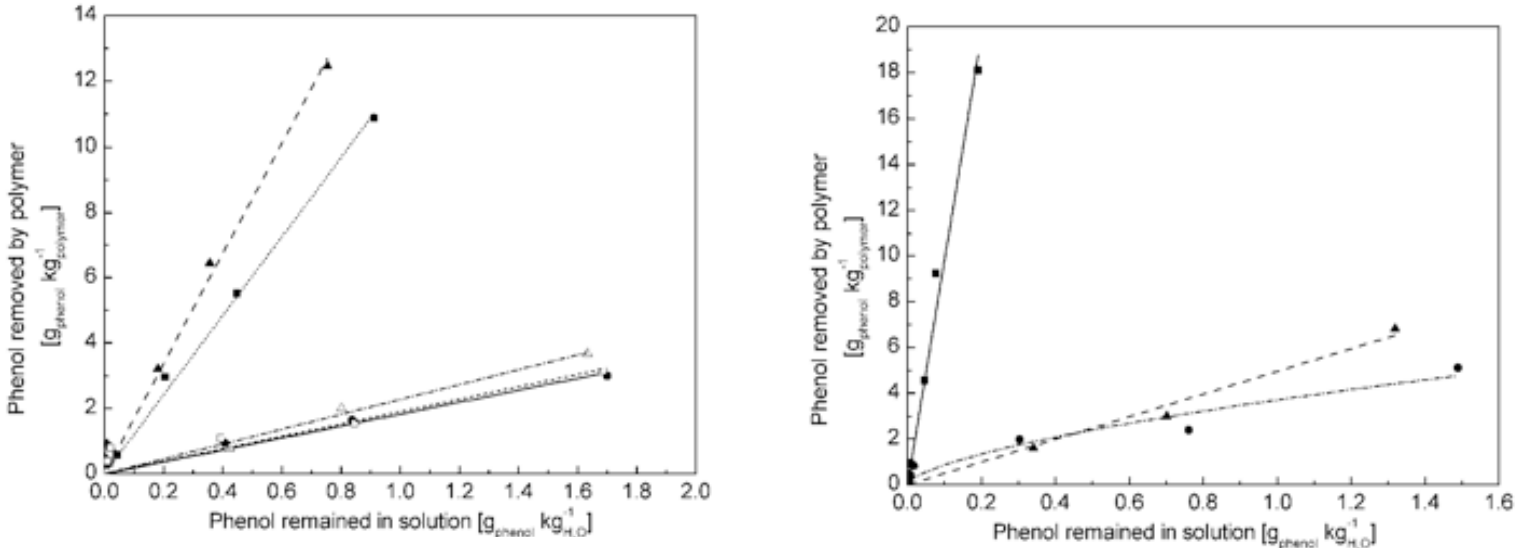

Zymomonas mobilis
Cell dry weight [g kg^{-1}]
Time [min]
Standard
0.6 g/kg Phenolmix (PM)
1.0 g/kg PM
1.2 g/kg PM
1.8 g/kg PM


Saccharomyces cerevisiae
Growth rate μ [h^{-1}]
Phenol concentration [g kg^{-1}]


Zymomonas mobilis
Growth rate μ [h^{-1}]
Phenol concentration [g kg^{-1}]

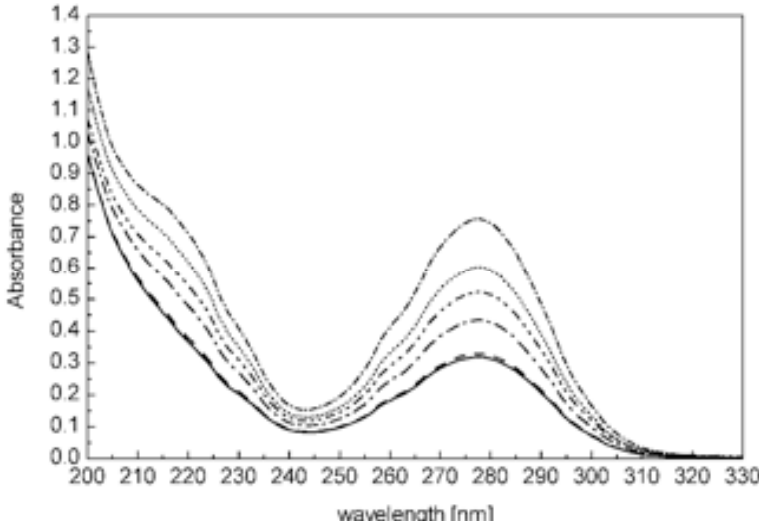
Detoxification

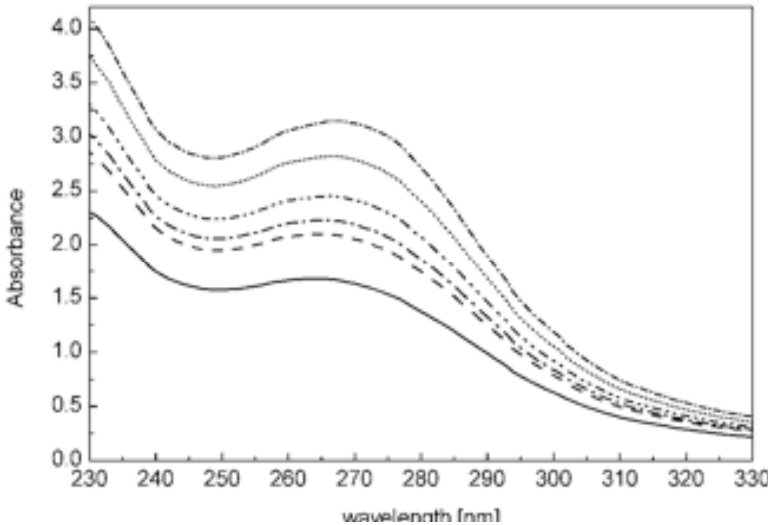
Phenol Removal



Phenol adsorption isotherms for the textile recycle polymers nylon (■), polyamide (▲), PET (●), cotton balls (△) and cotton cloth (○) (left) and XAD4 (■), switchgrass (▲), paper towel (●) (right).

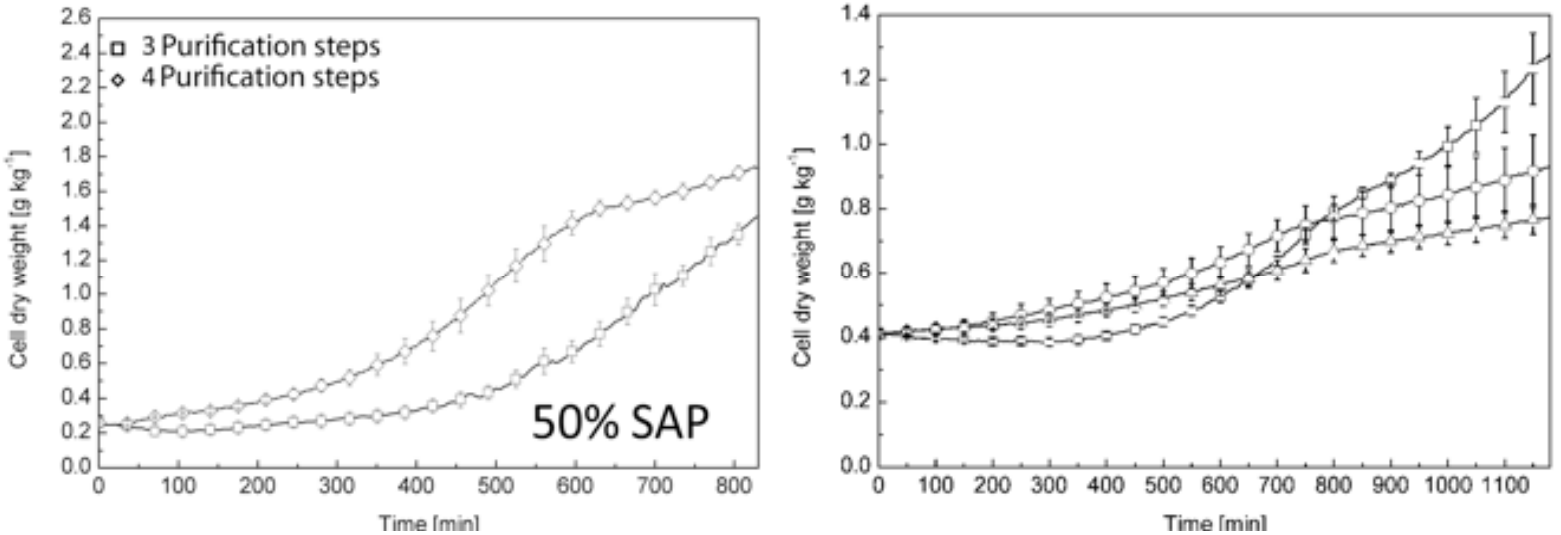
Detoxification





Absorption spectra of SAP (left) and of corncob bio-oil aqueous phase after multiple purification steps using nylon

Bioconversion



S. cerevisiae microscale batch fermentations. 50% (v/v) (□), 40% (v/v) (○) and 30% (v/v) dilutions (△) of corncob bio-oil aqueous phase (6 purification steps, nylon) (right). No carbohydrates added.

Conclusions

- Bio-oil aqueous phase needs to be treated prior to bio-conversion.
- Defined synthetic composition can be used to study effects of individual inhibitors.
- Recycled polymers can be used as sorption materials for inhibitor removal.
- Yeast cells can convert purified aqueous phase.

Ongoing and Future Work

- Development of continuous sorption column
- Recycling of sorption material via microbial degradation on inhibitors
- Scale-up of process to bench-scale
- Quantification of ethanol production
- Evaluation of bio-oil as substrate for butanol fermentation

Acknowledgements