

# Effective Fractionation of Lignocellulose Using a Mild Acetone-based Organosolv Process

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EUBCE, Stockholm

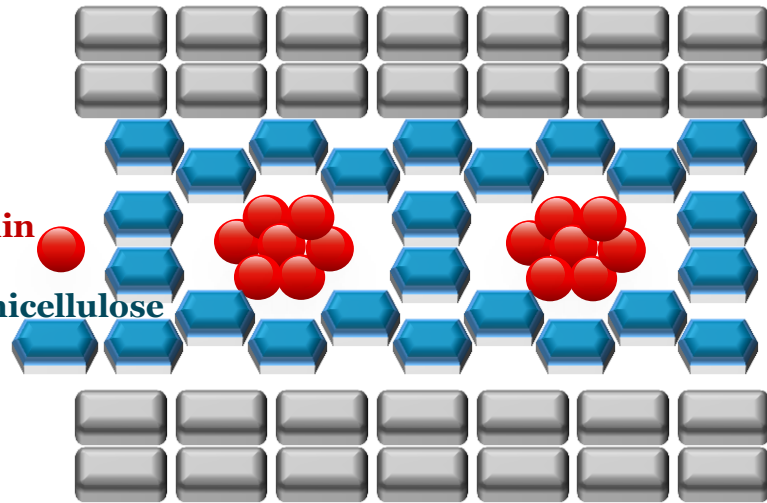
June, 2017

# Organosolv pretreatment

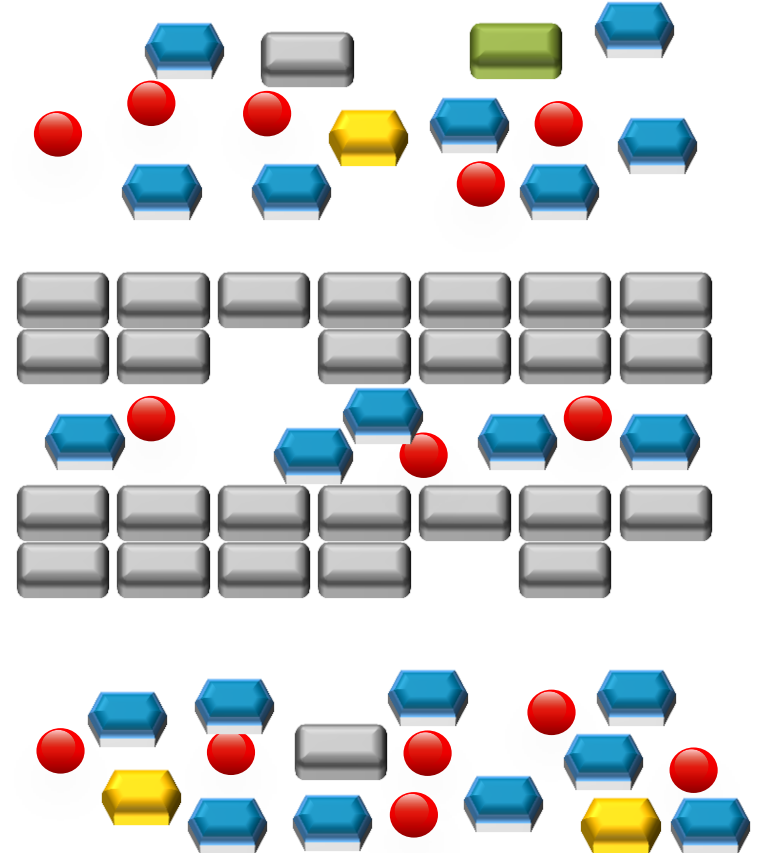
Cellulose microfibril

Lignin

Hemicellulose

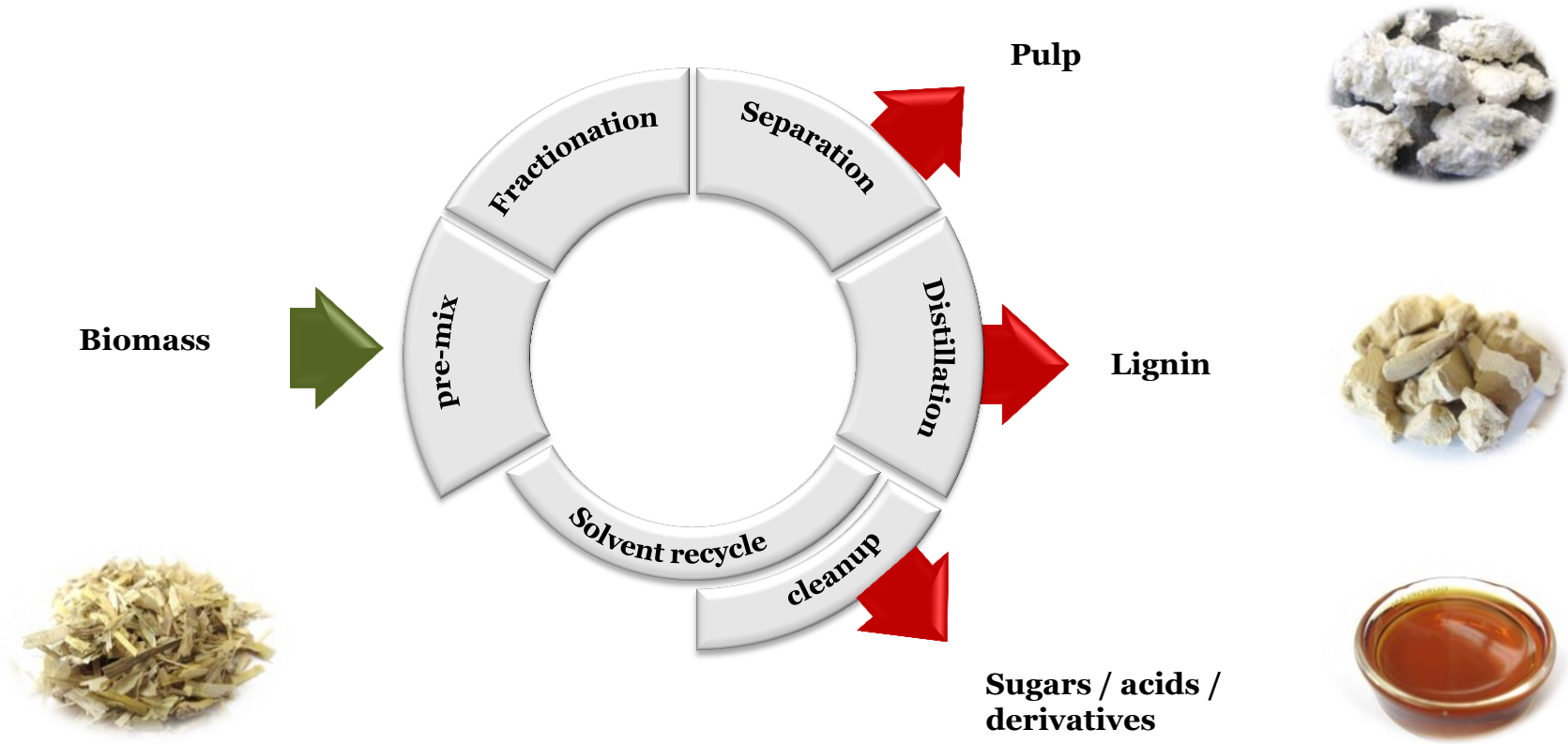


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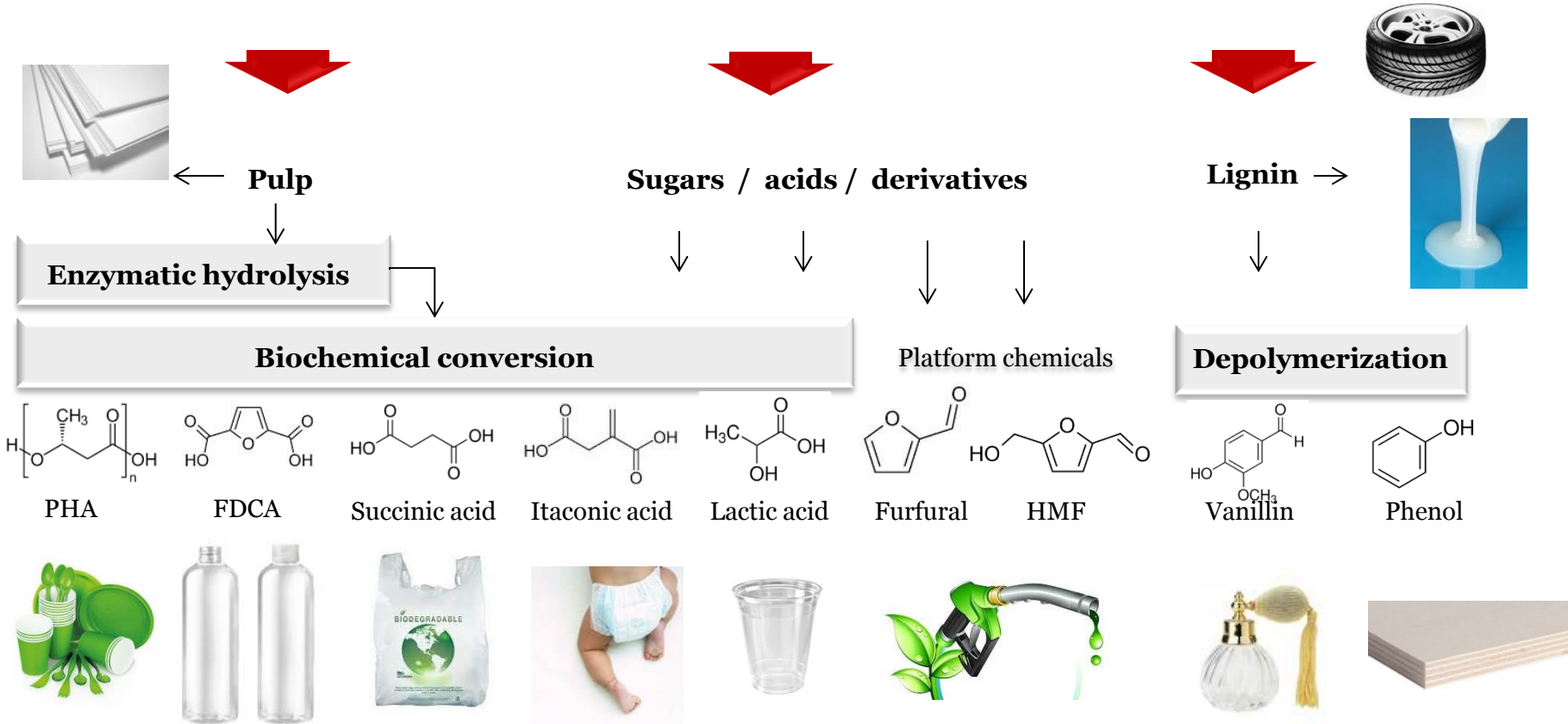


# Organosolv process

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# Organosolv products





# Mild acetone organosolv

# Development - fractionation

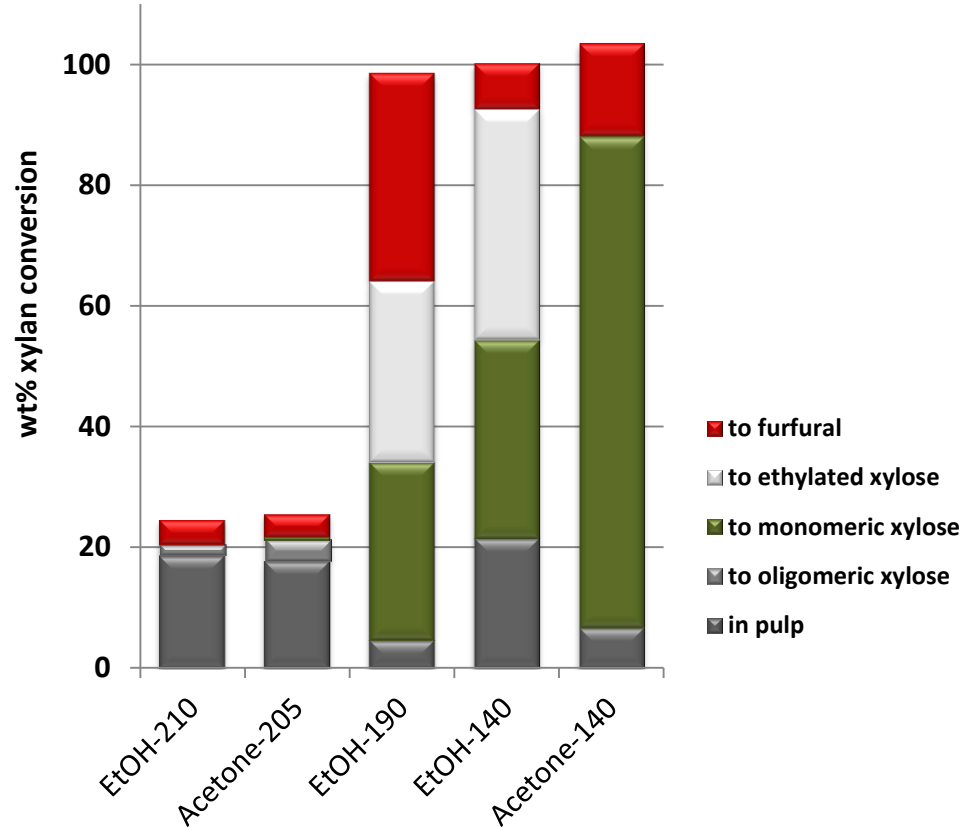
## Organosolv fractionation of wheat straw:

**Ethanol 210°C**  
**Acetone 205°C**  
 < 10% hemicellulose products




**Ethanol 190°C – 30mM H<sub>2</sub>SO<sub>4</sub>**  
 Roughly equal Xyl, Et-Xyl and furfural.

**Ethanol 140°C – 60mM H<sub>2</sub>SO<sub>4</sub>**  
 Reduction of furfural formation

**Acetone 140°C – 60mM H<sub>2</sub>SO<sub>4</sub>**  
 Yield monomeric xylose: 81%

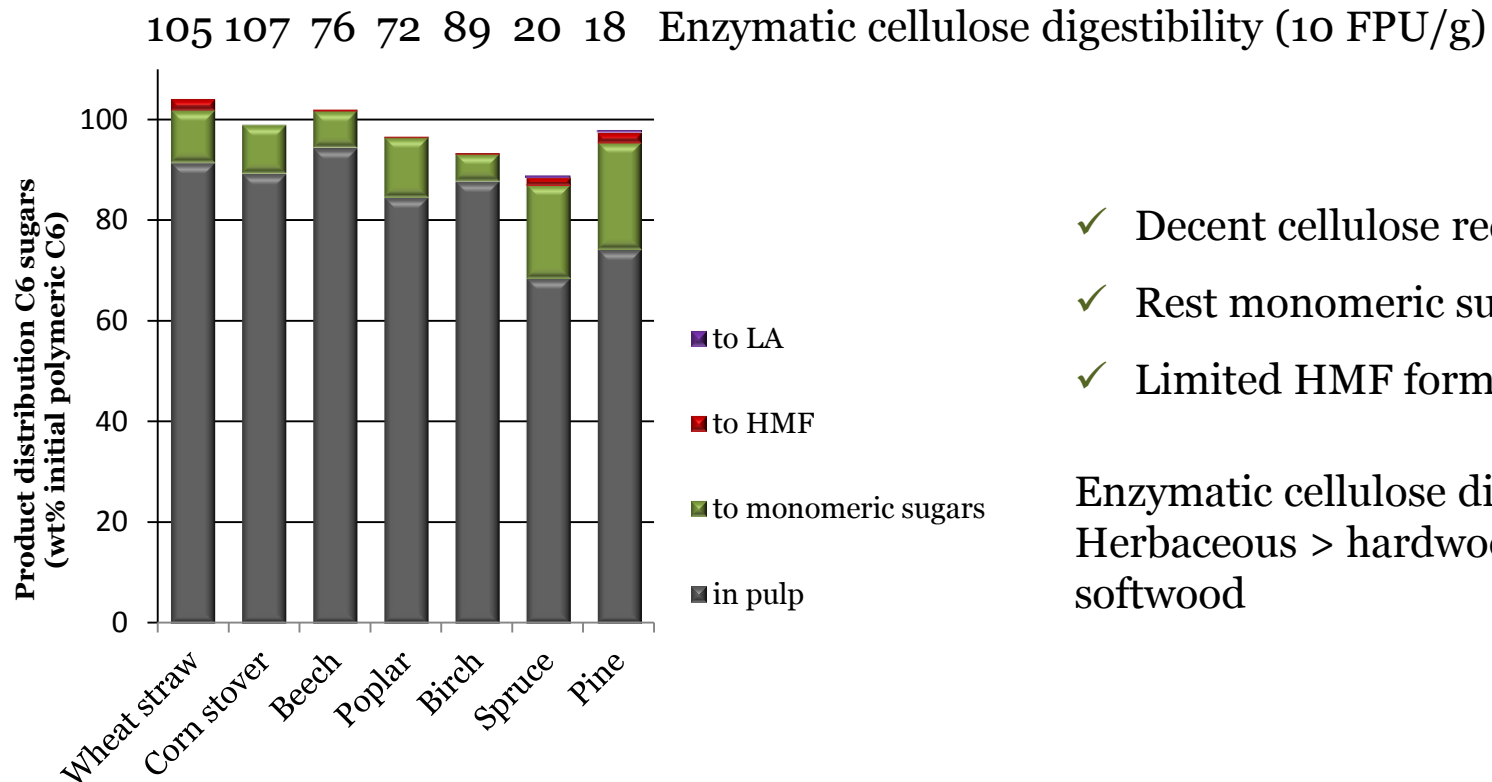


# Feedstock screening

	<i>Herbaceous</i> <i>Wheat straw, corn stover</i>	<i>Hardwood</i> <i>Beech, poplar, birch</i>	<i>Softwood</i> <i>Spruce, pine</i>
<i>Extractives</i>	8-9wt% 	2-5wt% 	4-5wt% 
<i>Ash</i>	10-14wt%	0.1-1wt%	0.3wt%
<i>Cellulose</i>	Polymeric glucose	Polymeric glucose	Polymeric glucose
<i>Main hemicellulose sugar polymer</i>	<u>Arabinoxylan</u> (C5)	<u>arabinoxylan</u> (C5)	<u>glucomannan</u> (C6)
<i>Main lignin building blocks</i>	Guaiacyl (G) Syringyl (S) p-Hydroxyphenyl (H)	Guaiacyl (G) Syringyl (S)	Guaiacyl (G)
<i>Fractionation conditions</i>	140°C, 120min, 50% w/w aqueous acetone, 40mM “Free” H <sub>2</sub> SO <sub>4</sub>		



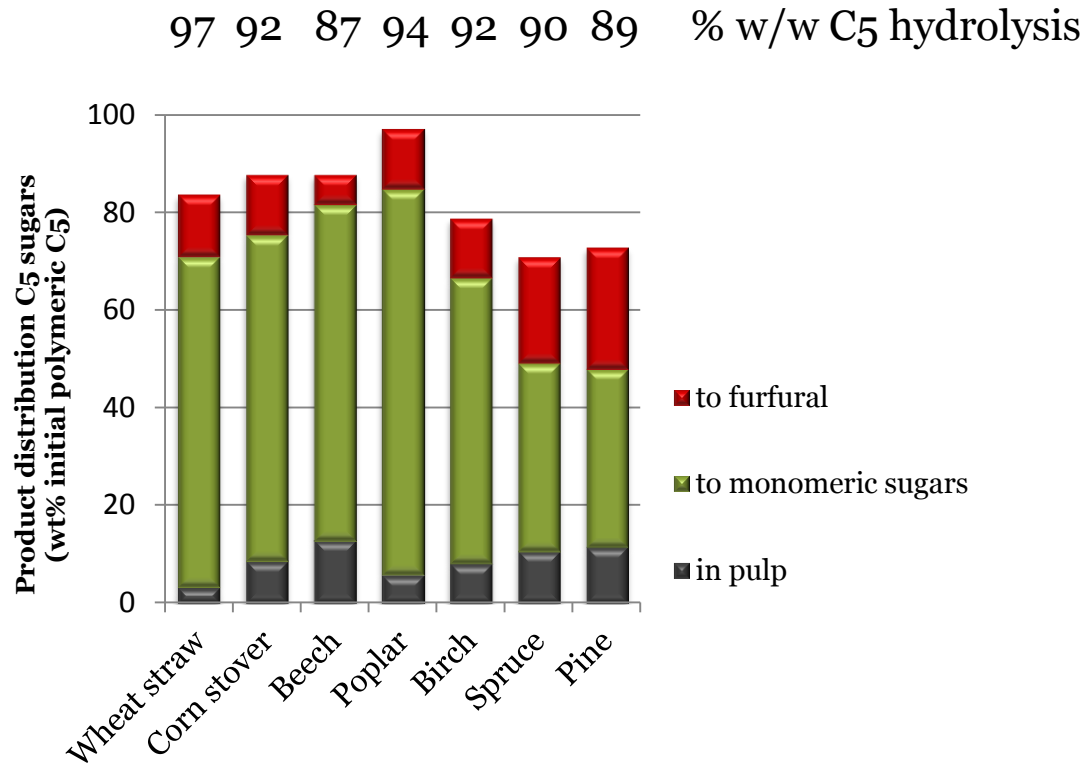
# Cellulose



- ✓ Decent cellulose recovery
- ✓ Rest monomeric sugars
- ✓ Limited HMF formation

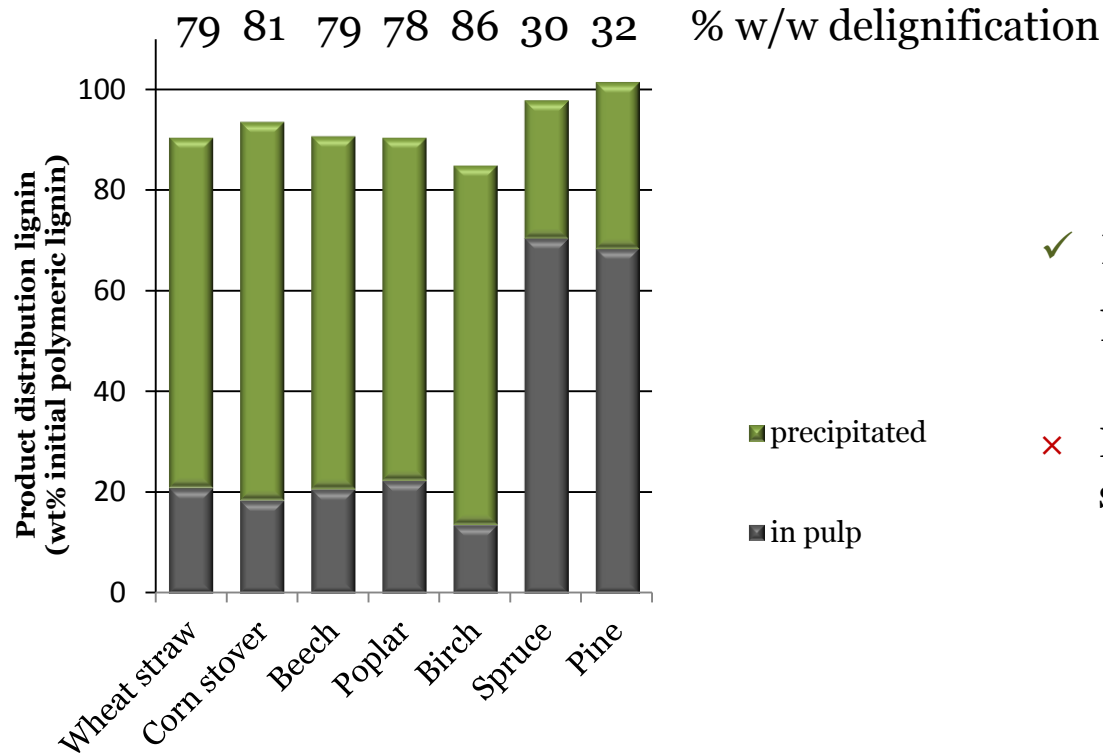
Enzymatic cellulose digestibility:  
Herbaceous > hardwood >>  
softwood

# Hemicellulose



- ✓ High C<sub>5</sub> hydrolysis
- ✓ High C<sub>5</sub> sugar yield except for softwood
- ✗ Gap in mass balance

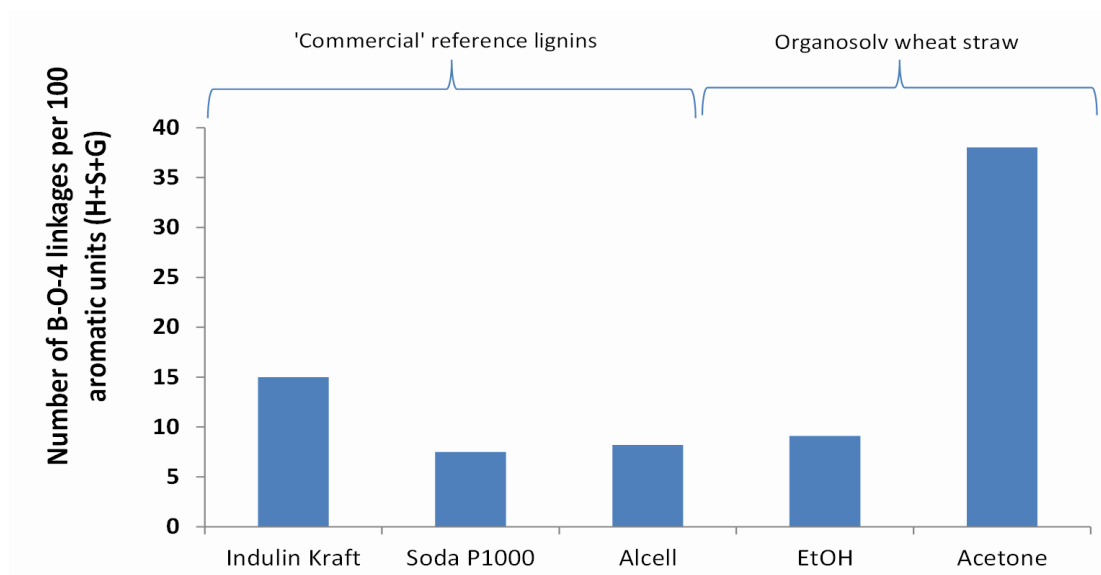
# Lignin



- ✓ High level of delignification for herbaceous and hardwood
- ✗ Low level of delignification for softwood

# Remarkable Lignin Characteristics

- **High number  $\beta$ -O-4 ether linkages.**
  - Suggests more native lignin.
  - Crucial for many chemocatalytic depolymerisation routes.



# Conclusion

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## **Herbaceous biomass and hardwood**

- Yield C<sub>5</sub> sugars
- Cellulose digestibility
- Lignin yield and characteristics



## **Softwood**

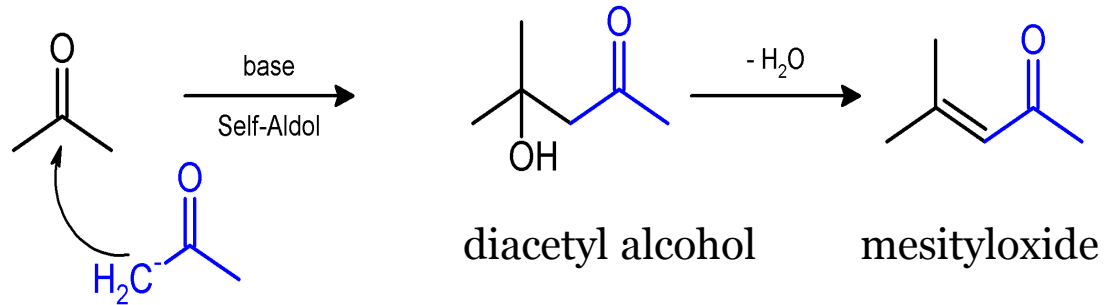
- Cellulose digestibility
- Lignin yield

# Acetone self-condensation



# Acetone self-condensation

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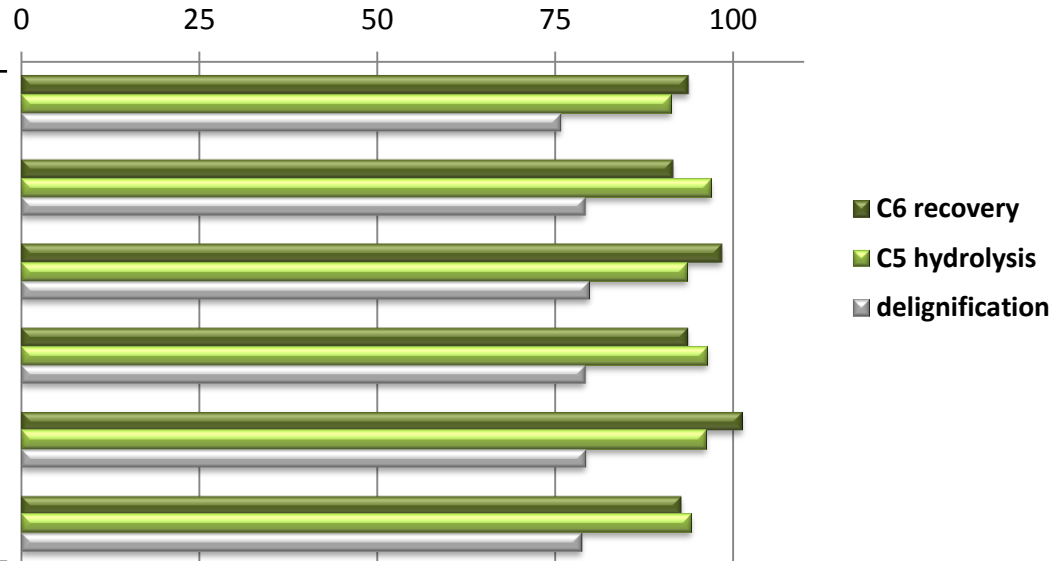
Organosolv experiments with and without wheat straw at varying conditions

# Acetone stability

## Fractionation conditions

Nr:	Temp (°C)	Time (min)	Free H <sub>2</sub> SO <sub>4</sub> (mM)
1	100	960	180
2	140	120	40
3	140	60	40
4	140	30	80
5	140	15	120
6	170	60	15

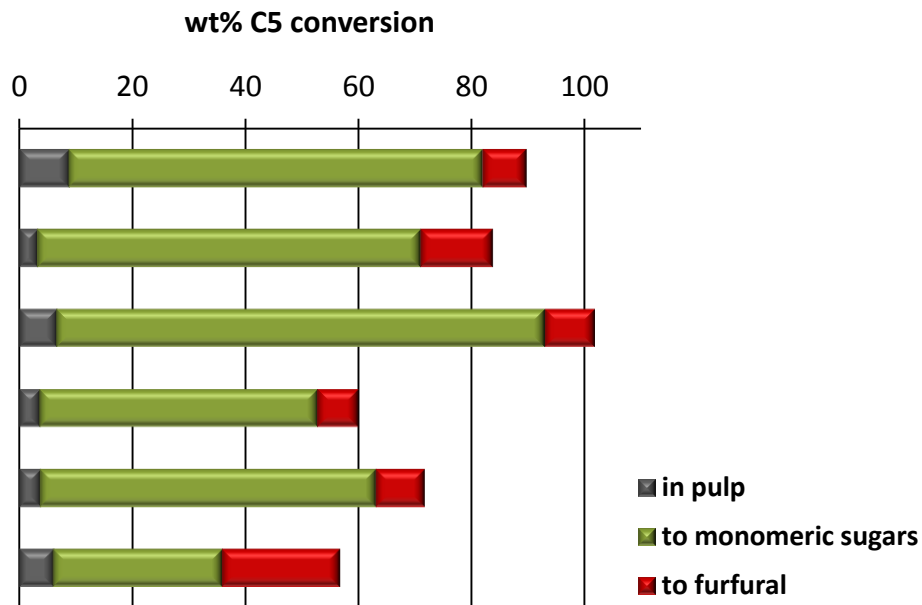
## General fractionation data



# Acetone stability

## Fractionation conditions

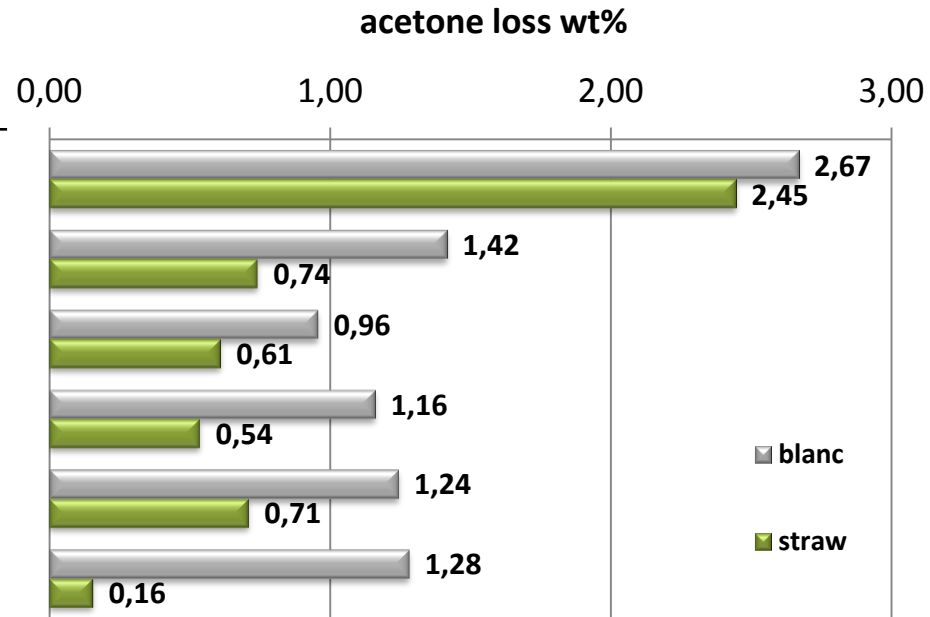
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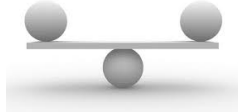

# Acetone stability

## Fractionation conditions

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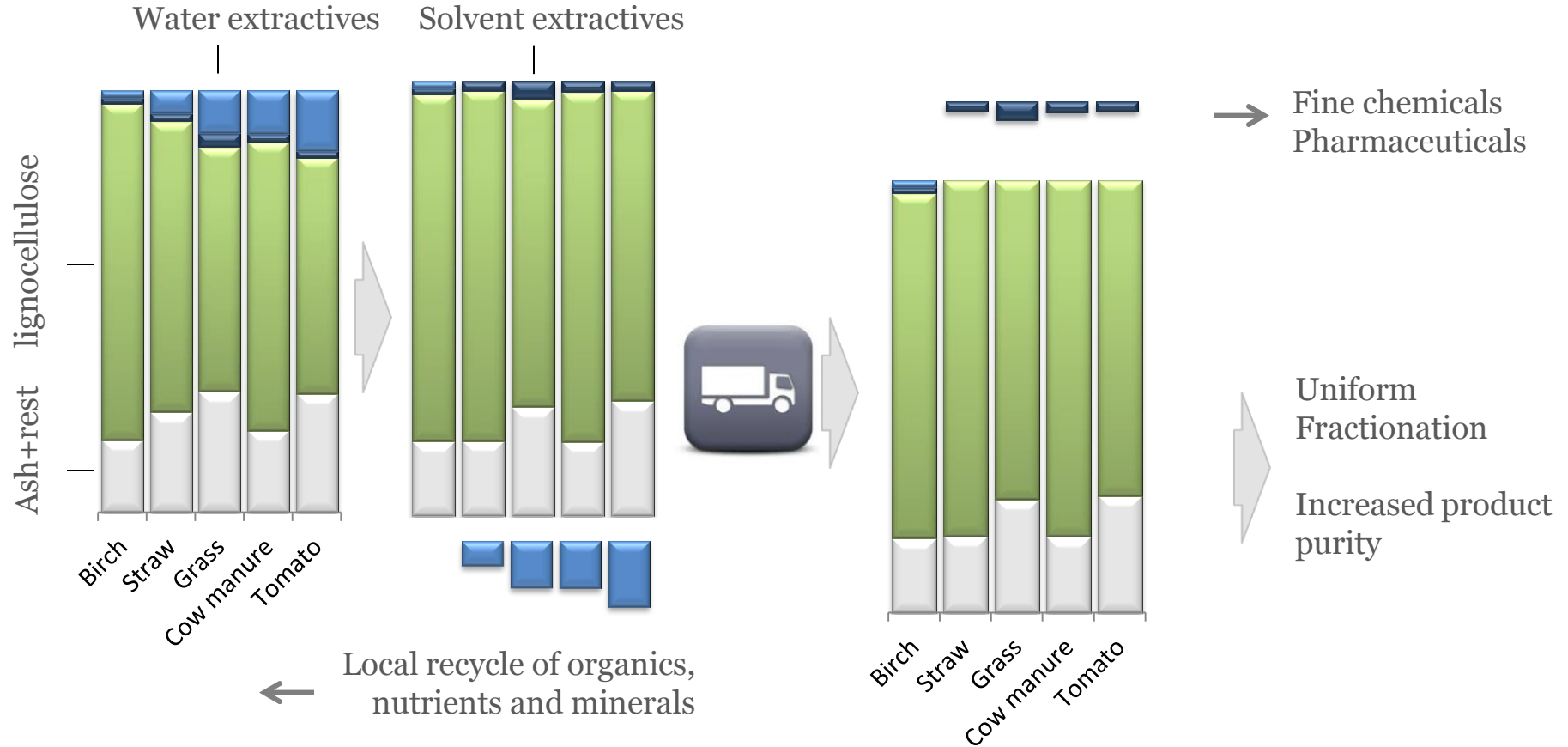
# Process Characteristics

	T	H <sub>2</sub> SO <sub>4</sub>				
Ethanol	210°C		<b>32 bar</b>		<b>?</b>	<b>All</b>
Acetone	205°C		↓	↓	↓	↓
Ethanol	190°C – 30mM					
Ethanol	140°C – 60mM					
Acetone	140°C – 60mM		<b>8 bar</b>	<b>-50%</b>	<b>±1%</b>	<b>Herbaceous Hardwood</b>

# New developments



# Feedstock Flexibility: Upgrading



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**Thank you for your attention!**

- For more information: [a.t.smit@ecn.nl](mailto:a.t.smit@ecn.nl)

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