

# Towards Biorefinery Piloting with Isobutanol as the Platform Molecule

Results of the IsoButanol Rotterdam platform project

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## Towards Biorefinery Piloting with Isobutanol as the Platform Molecule

Results of the IsoButanol Rotterdam platform project

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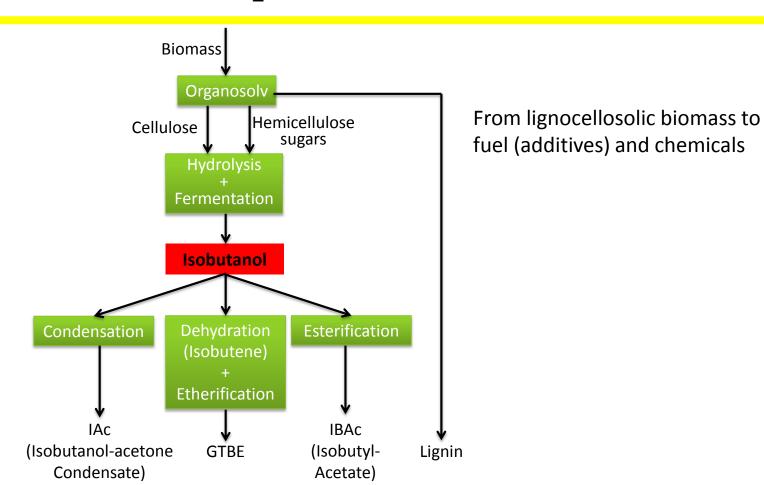
Wouter Wermink Procede

Andrea Ramírez Utrecht University

Jaap W. van Hal ECN EUBCE, Amsterdam, 8<sup>th</sup> June 2016



#### Isobutanol as a platform molecule





#### IBPR Consortium,

























#### The IsoButanol Platform Rotterdam (IBPR) consortium has:

- Demonstrated all steps in a biorefinery process experimentally
- Assessed the technical, economic and life cycle potential
- Is now ready for scale-up to pilot (~100 kg/hr feed)



### Organosolv fractionation



Successful fractionation producing multi-kg scale batches from spruce and poplar wood



Cellulose pulp



Hemicellulosic sugars



High-quality lignin



## Organosolv can fractionate all types of lignocellulosic biomass

















#### Cellulose

## Lignin



ECN PULP FROM BIRCH













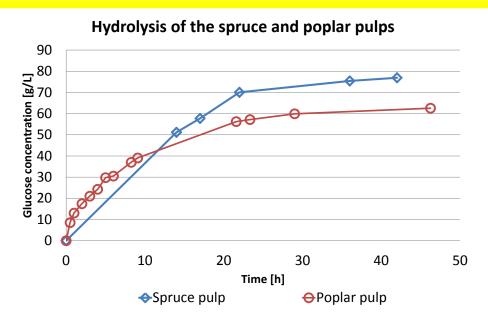








### Hydrolysis

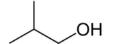


- Organosolv pulp hydrolysed using commercial cellulase cocktails
- Yield: up to 90 g/L glucose for spruce and 60 g/L glucose for poplar wood.





#### Production of isobutanol



 Successful fermentation using hydrolysates from organosolv-pretreated spruce and poplar wood



 Upgrading: successful dewatering using hybrid silica (HybSi®) pervaporation membranes (Pervatech)



Isobutanol from wood

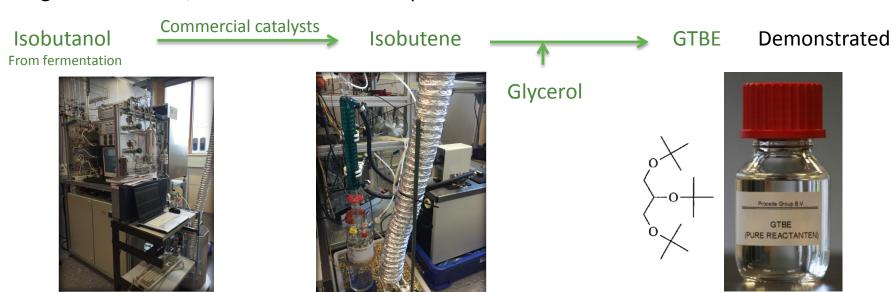






#### GTBE production

**GTBE** = Glycerol tert-butyl ether high value biofuel/additive for diesel with proven emission reduction



Preparations for introduction of GTBE (REACH, immersion experiments)







#### IAc and IBAc production

 IAc = isobutanol acetone condensate C11 and C15 fraction: Green precursor for fuel blend (diesel, gasoline, jet, bio-naphta)

Isobutanol + acetone



IAc + water

Demonstrated

IBAc= Isobutyl acetate Versatile colorless renewable solvent

Isobutanol + acetic acid \_\_\_\_\_\_ IBAc + water



Demonstrated

Alternatives: transesterification with methyl-acetate and combination of both

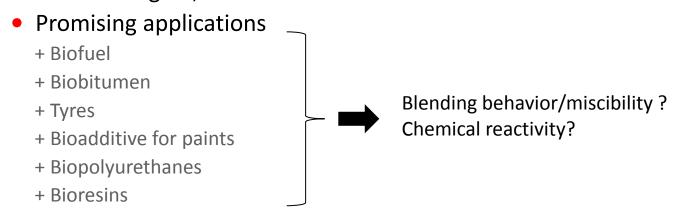
- Overcoming the equilibrium limitation
- → High potential of pervaporation membranes, 80-100% conversion reached





#### Lignin applications screening

#### Near-native lignin, low sulfur content



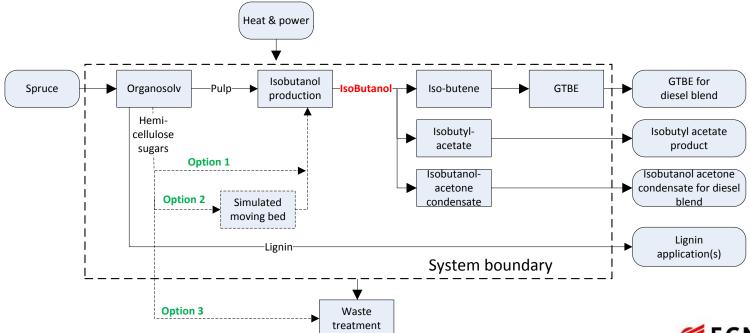
- Lignin as a solid fuel
  - + Pulverization
  - + Little by-products
  - ! Dust explosion risk





#### Techno-economic evaluation

- Detailed Aspen Plus modeling of all sections of the process
- Full size and pilot plant design (1 Mton/yr biomass feed)
- Equipment sizing and economic evaluation

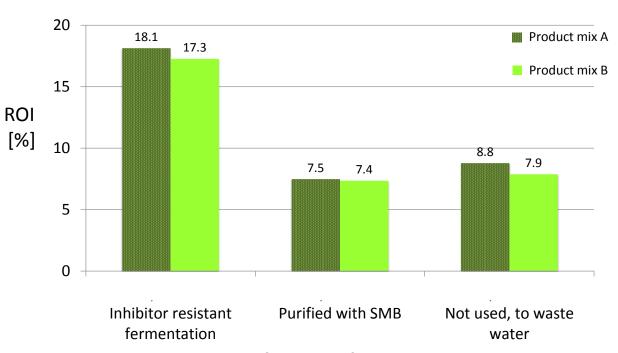








#### Economic assessment



Best case:

ROI = 18 %

POT = 6 years



Option for use of hemicellulose stream

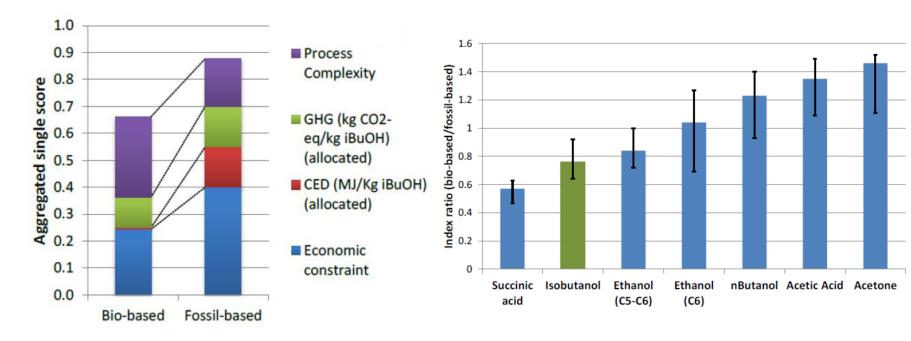




### Sustainability assessment

Index ratio = combining scores on economics, energy/GHG impacts and process complexity

→ lower is better







### Life cycle assessment

Cradle-to-gate analysis results

Category	Result
Agricultural land occupation (ALO)	~ 45 m <sup>2</sup> a/kg isobutanol
Non-renewable energy use (NREU)	-/- 45%
Greenhouse gas emissions (GHG)	-/- 25%
Water depletion (WD)	-/- 58%





#### Conclusions and Outlook

- Process presented for bio-based chemicals and fuel (additives) via the platform molecule isobutanol
- Experimental proof of the full chain of process steps at lab-scale
- Detailed techno-economic and LCA analysis show promising results
- Next is scale-up to pilot (100 kg/hr)
  - Setting up a consortium with provincial government support
- Opportunities to join the consortium for parties throughout the value chain
  - Product end-users
  - Process operators
  - Equipment manufacturers and OEM's



#### Acknowledgements





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