

An integrated lignin biorefinery: Scaling-up lignin depolymerization technology for biofuels and chemicals

Citation for published version (APA):

Kouris, P., Oevering, H., Boot, M. D., & Hensen, E. J. M. (2017). *An integrated lignin biorefinery: Scaling-up lignin depolymerization technology for biofuels and chemicals*. Poster session presented at NOVACAM Winter School, February 22-23, 2017, Padova, Italy, Padua, Italy.

Document status and date:

Published: 22/02/2017

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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An integrated lignin biorefinery: Scaling-up lignin depolymerization technology for biofuels and chemicals

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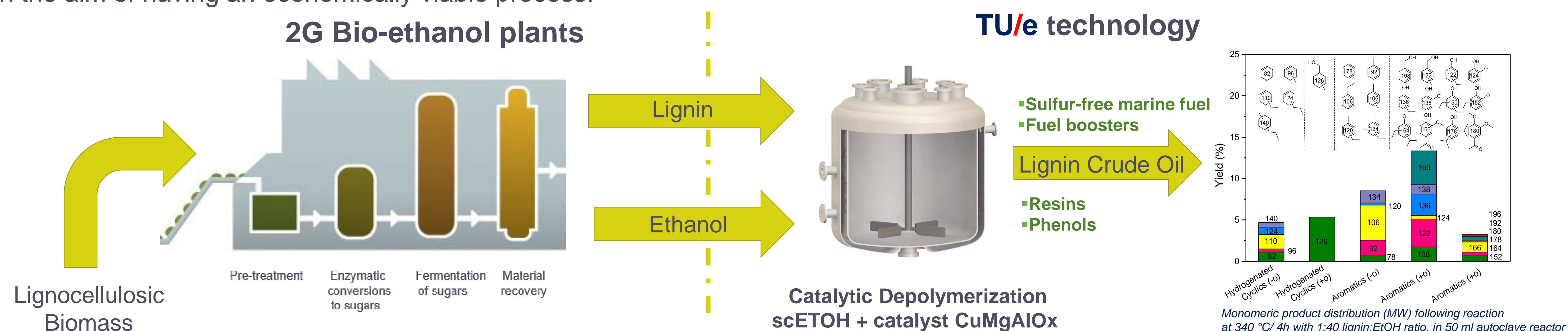
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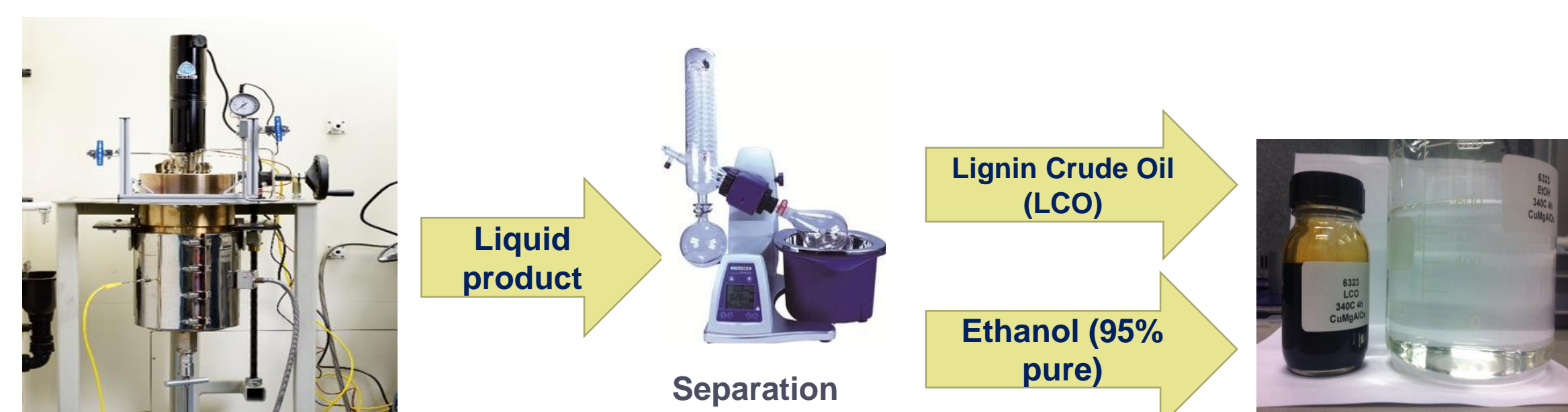
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Lignin RICHES (Resins Chemicals Fuels)

Lignin is one of the major components of lignocellulosic biomass, constituting 15-30 % of the weight and approximately 40 % of the energy content depending on the source. Currently the lignin produced in 2G bio-ethanol plants is mainly used for on-side energy production. At Eindhoven University of Technology a method was explored to depolymerize lignin in super critical ethanol with cheap non-noble catalysts to produce a mixture of monomeric aromatics. The product might be applied directly as a bio marine fuel, or as a source for chemical building blocks (Resins), octane boosters or biofuels when blended with gasolines. The primary goal for pilot activities is to produce Lignin Crude Oil (LCO) from lignin with a viscosity spec < 800 cSt at 40 °C, on a ton scale and to collect information for designing a demo plant with the aim of having an economically viable process.

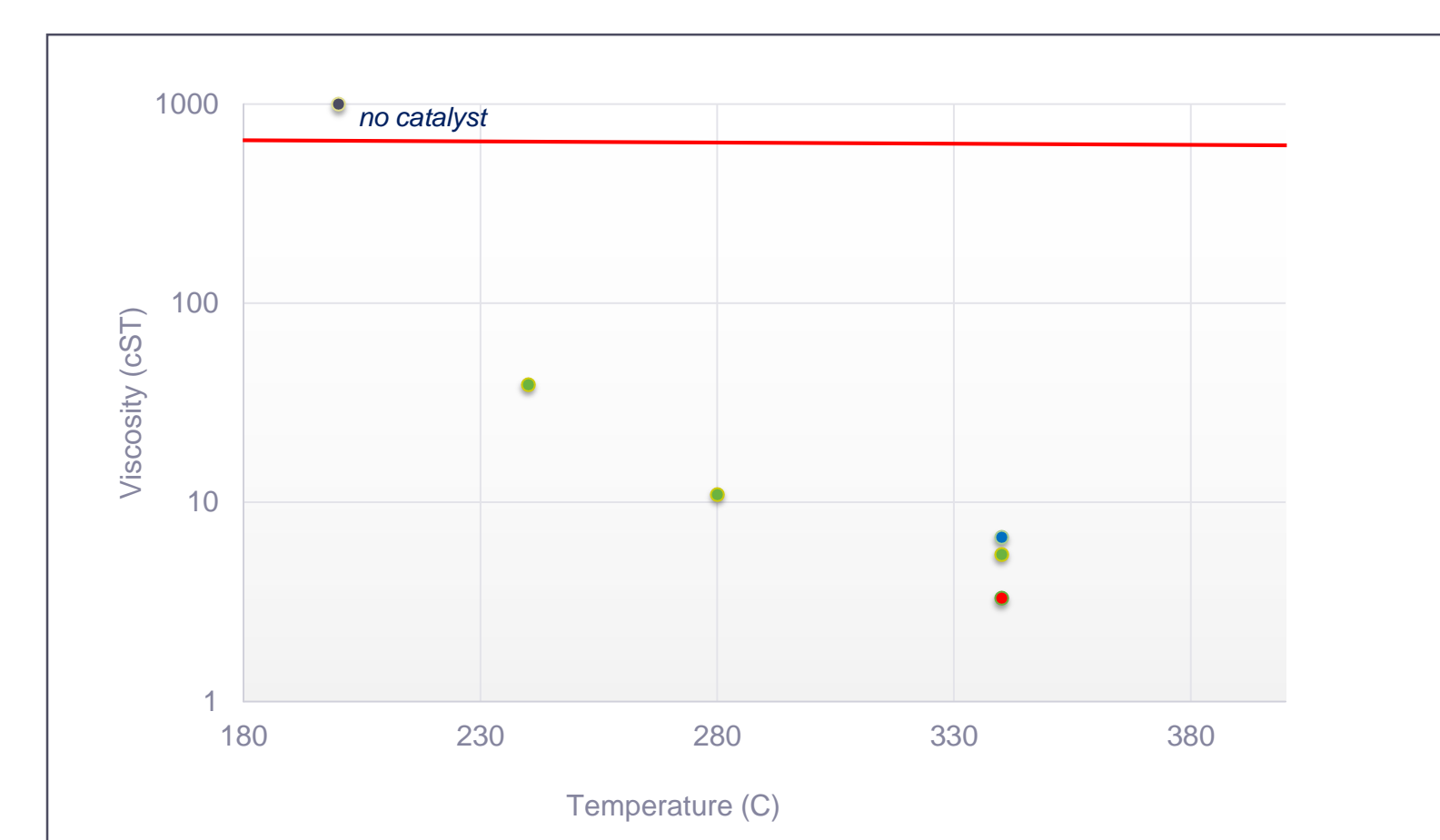
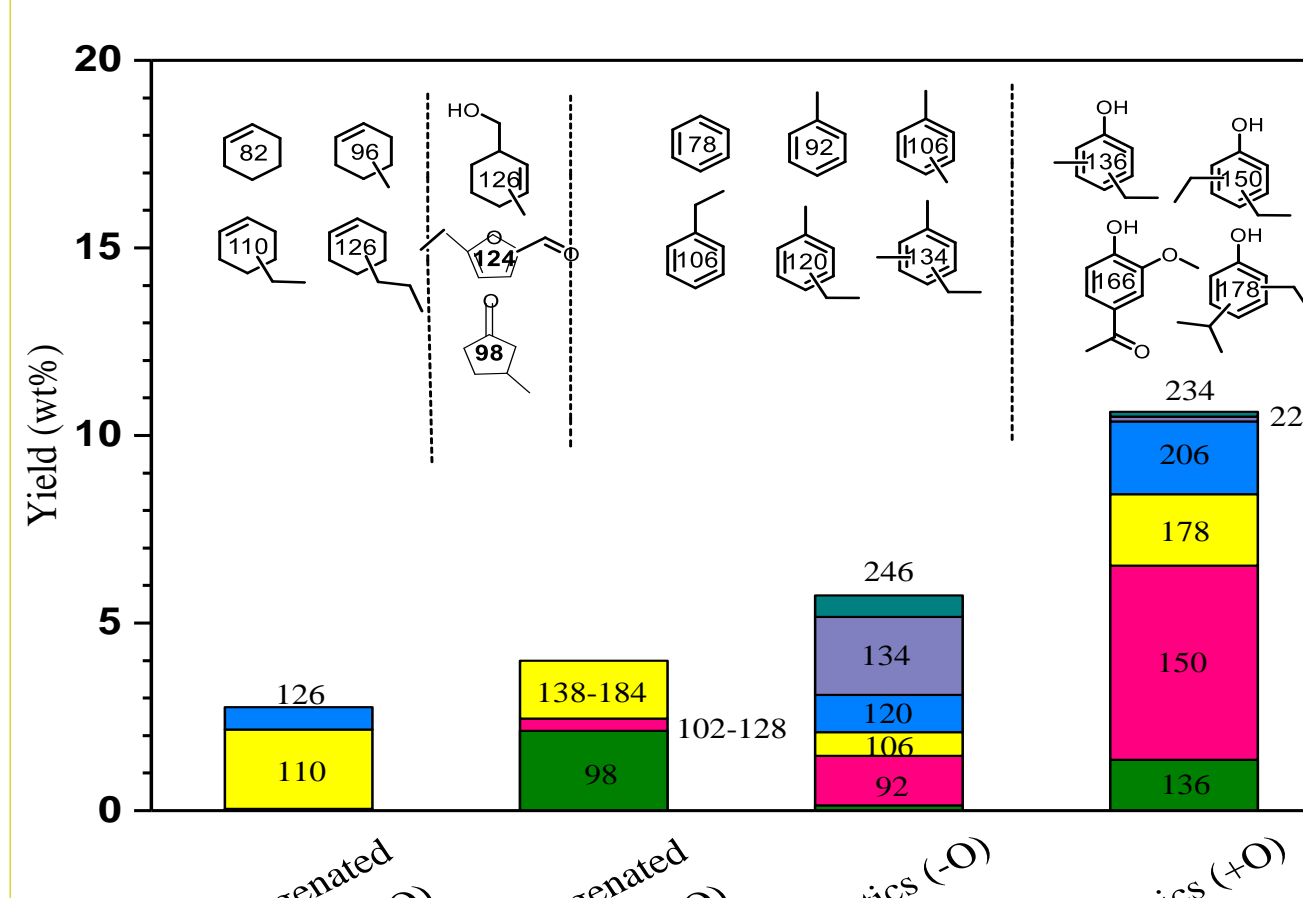


Scale-up reactions



Temp [°C]	Lignin:EtOH ratio (w/v)	Monomer Yield (wt%)	LCO viscosity @40°C (cST)	Ethanol conversion (wt%)
200 (no cat)	1:40	1	>1000	4
240	1:40	1	39	12
280	1:40	3	11	21
340	1:40	11	5,5	53
340	1:30	14	3,3	46
340	1:20	25	6,7	47

Conditions: Lignin (20-50 g), CuMgAlOx (10-25g), Ethanol (800-1200 ml), Lignin:EtOH ratio : 1:40 -1:10
4L Autoclave reactor, t=4h



Monomeric product distribution (MW) following reaction at 340 °C with 1:20 ratio, in a 4L reactor

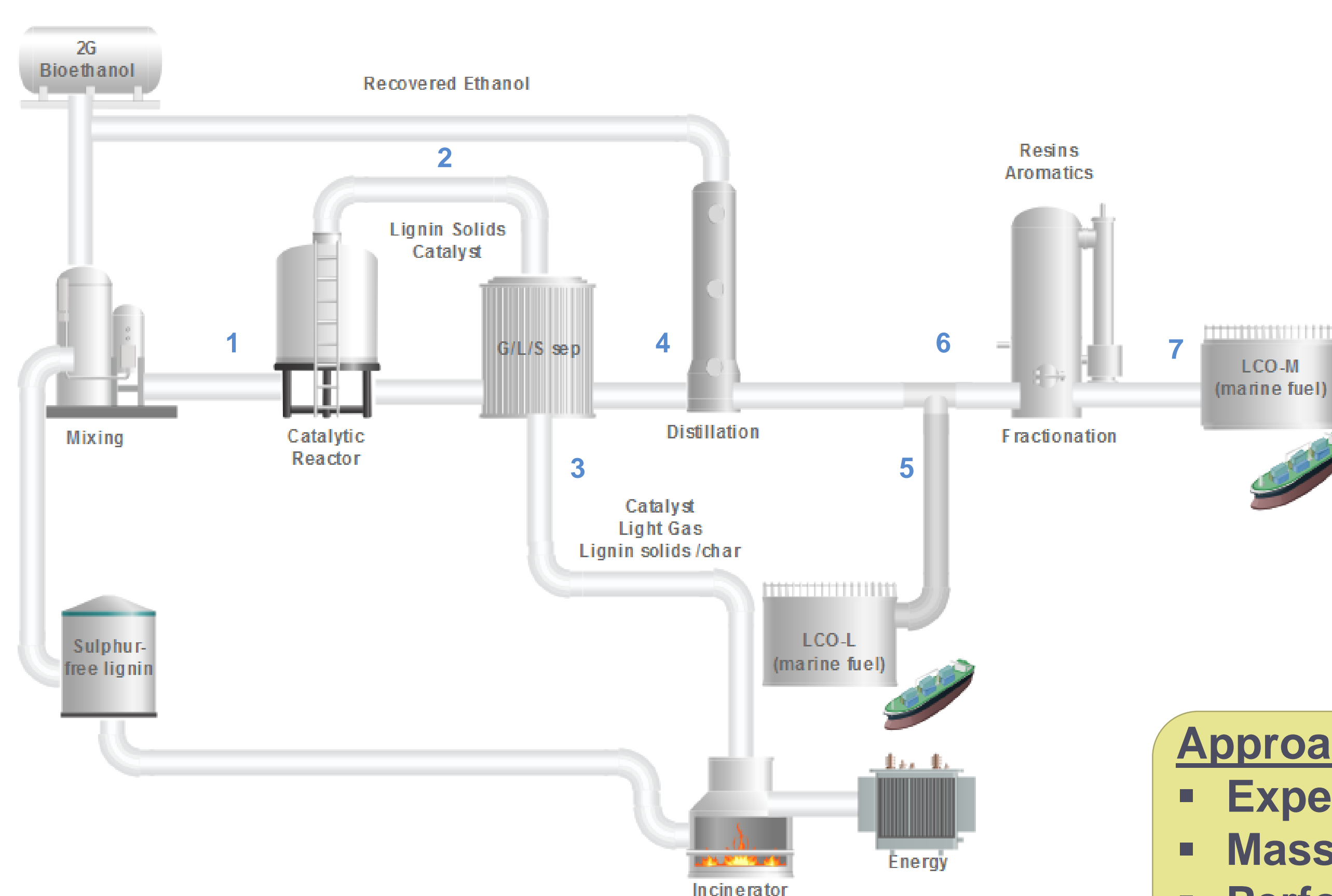
	Elemental analysis					GHV	Viscosity
	Oxygen(%)	Carbon(%)	Hydrogen(%)	Nitrogen(%)	Sulphur(%)	GJ/tn	cST
LCO 1:20	15,5	73,4	10,3	0,8	0	38,1	6,7

- High monomer yield is important for the LCO fractionation process (resins and phenols)
- Gross Heating Value (GHV) and viscosity specifications are crucial for marine fuel application
- Ethanol conversion products are contributing to decreasing the LCO viscosity to very low levels

Piloting

Process steps

1. Feed lignin / ethanol to catalytic reactor
2. Re-use catalyst / unconverted lignin
3. Burn catalyst / gas products / char for energy production
4. Liquid stream for separation process
5. Lignin Crude Oil production directly for low viscosity marine fuel (LCO-L)
6. Downstream process of LCO for resins application
7. More concentrated LCO for marine fuel application (LCO-M)



Design Challenges

- Process complexity
- Batch vs continuous
- Operating window
- Lignin / catalyst loading
- Ethanol conversion
- Reactor design
- Catalyst regeneration
- Separation steps
- Ethanol concentration in LCO
- Ethanol losses in the process

Approach

- Experimental data ↔ input for process design
- Mass & energy balances for all process streams
- Perform techno-economical study
- Optimize the most feasible process routes