

Hydrothermal kraft lignin depolymerization with glycerol as a capping agent

Introduction

To make use of aromatic units from lignin as chemicals or fuel additives, the molecular structure of lignin needs to be broken down.

Hydrothermal liquefaction (HTL), where the lignin is depolymerized in hot pressurized water, is one way to break the lignin structure. However, the depolymerized material is reactive and suffers from repolymerization.

We here investigate one method to mitigate repolymerization by means of short residence times in the reactor and by adding glycerol as a capping agent.

Aim

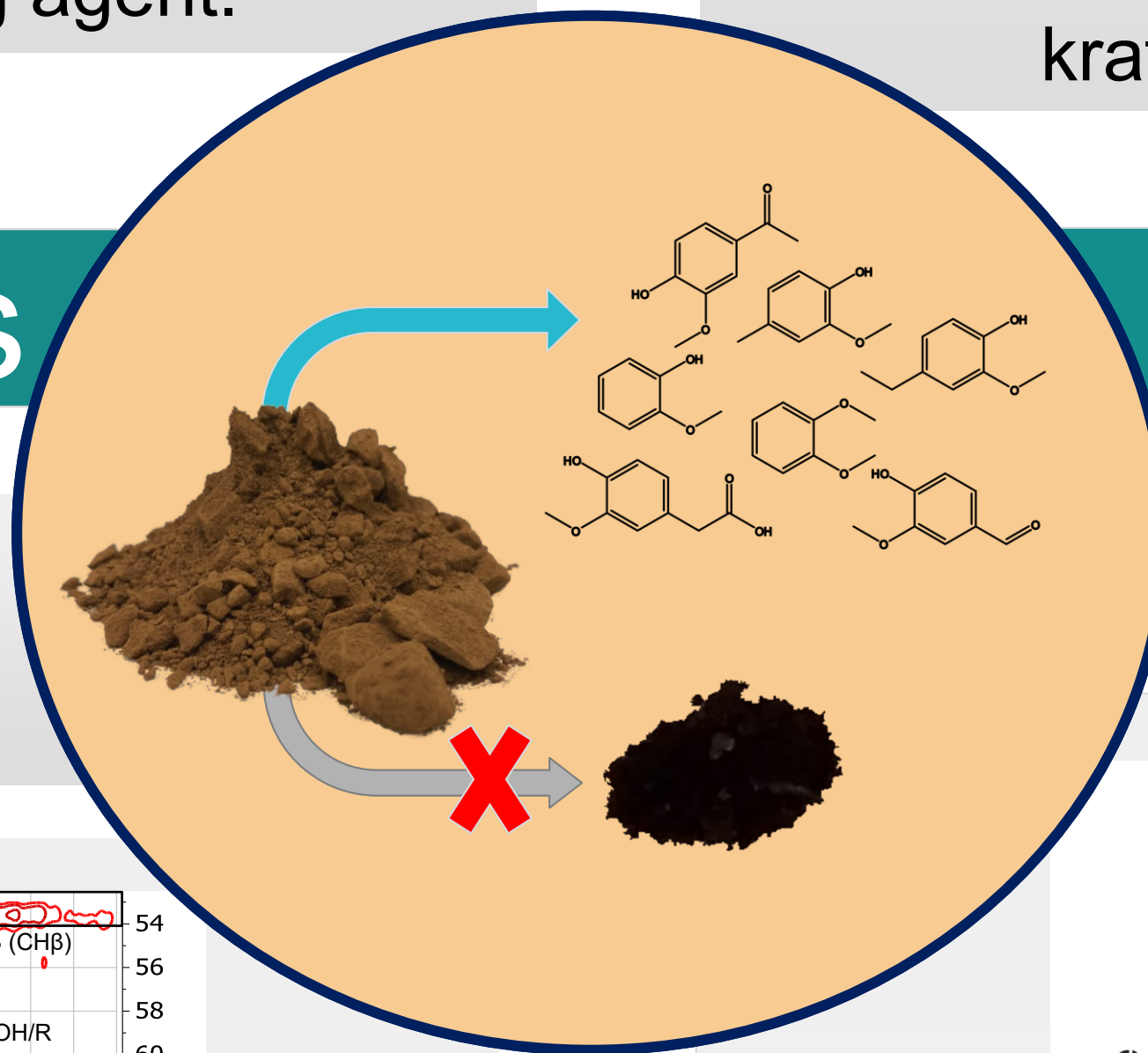
To investigate structural and molecular weight changes of kraft lignin in hydrothermal liquefaction at short residence times with glycerol as a capping agent to expand on previous work made with isopropanol as a capping agent at short residence times.^{1,2}

Conclusion

The depolymerization is quick, with molecular weight changes occurring within one minute. Also, inter-unit ether linkages are broken within the first minute of residence time in the reactor. This opens up for HTL processing of kraft lignin at short residence times.

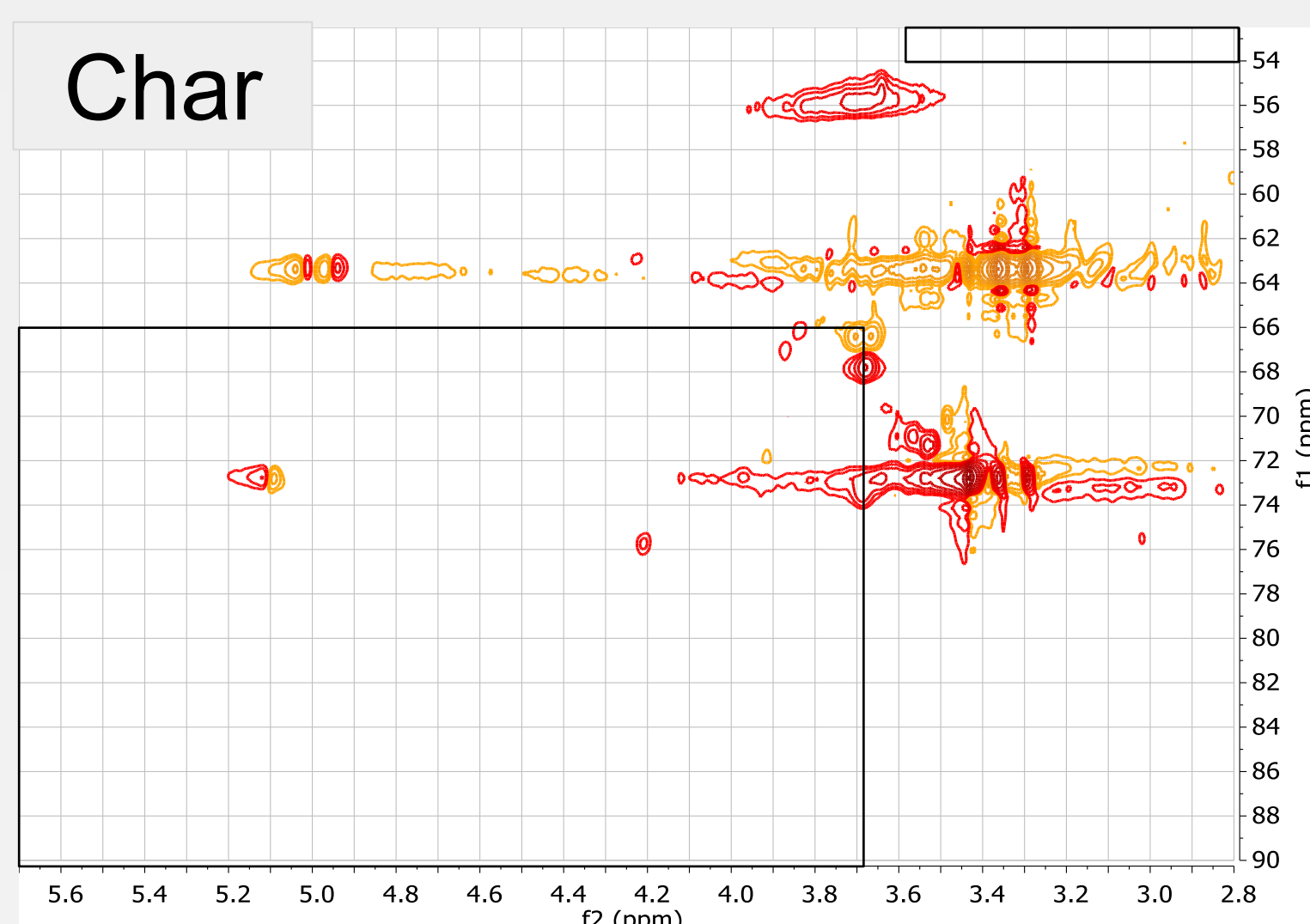
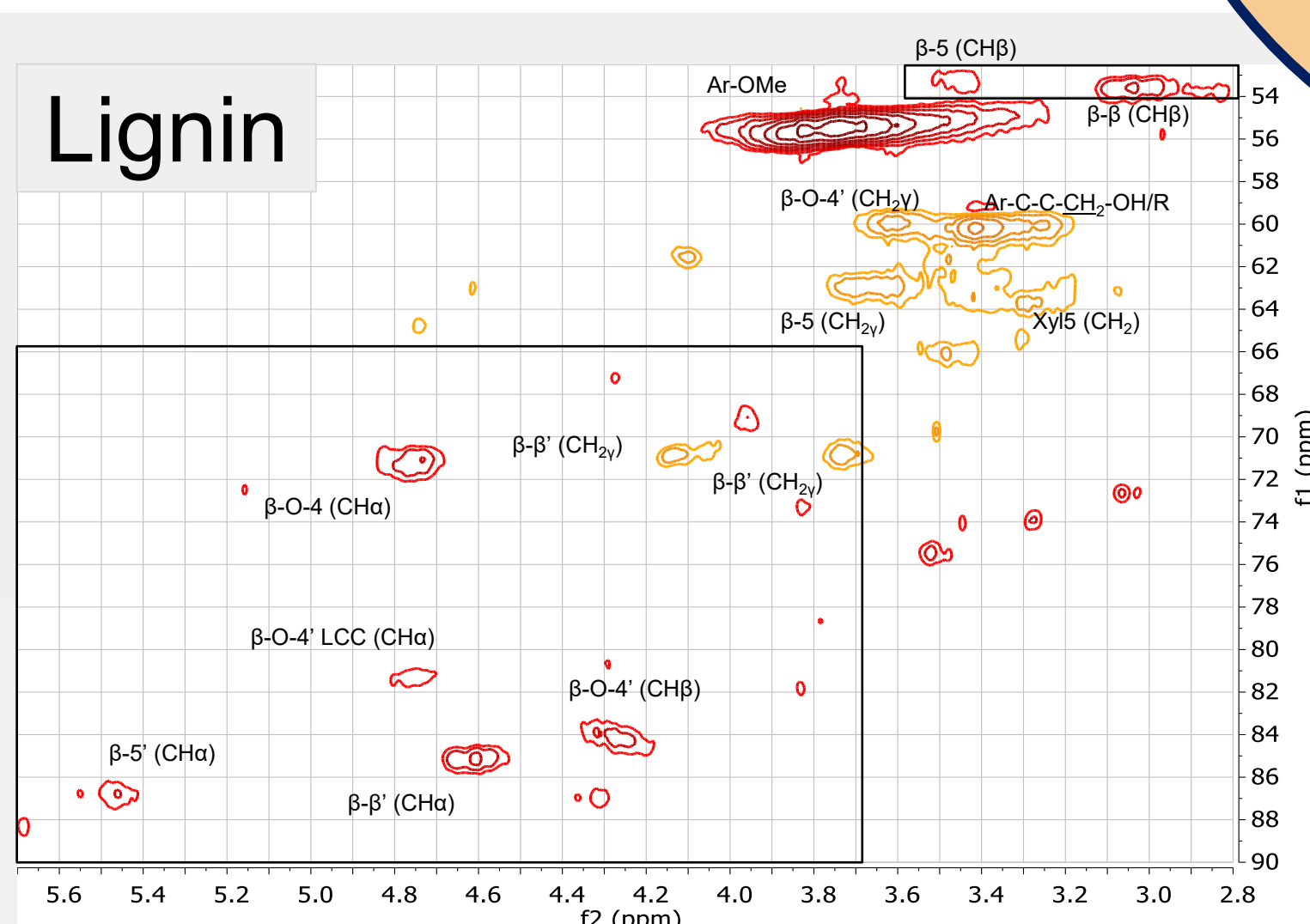
Structural changes

Typical inter-unit ether linkages in lignin are cut already after 1 min of residence time in the reactor.

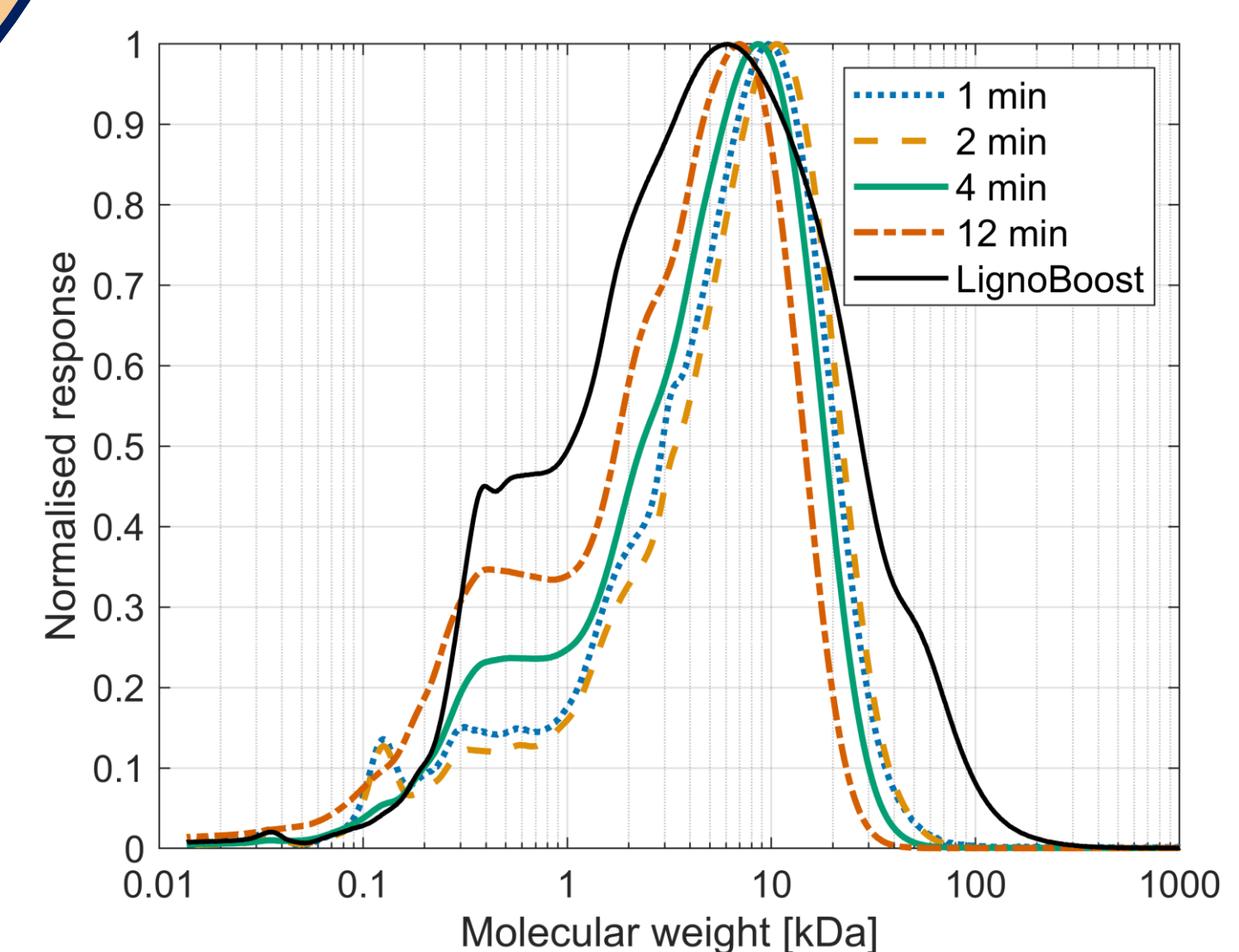


Molecular weight

Large molecular weight fractions are lost after only 1 min of residence time.



Inter-unit aliphatic region of 2D-NMR spectra of LignoBoost lignin and char. Annotations for lignin according to Mattsson et al.³



Molecular weights of the LignoBoost lignin and char fractions.

Method

Softwood kraft lignin, isolated with the LignoBoost process, was depolymerized using hydrothermal liquefaction at the following conditions

- 290°C
- 250 bar
- 1-12 min residence time
- 99 ml batch reactor
- 6 wt% lignin
- 1 wt% NaOH
- 16 wt% glycerol
- 1.6wt% Na₂CO₃

The reaction mixture was quickly heated in a custom-made batch reactor by pumping the lignin mixture into pre-heated material in the reactor. The reaction products were ejected after the specified residence time and quickly quenched in an ice-bath.

1. Ahlbom, A., Maschietti, M., Nielsen, R., Lyckeskog, H., Hasani, M. and Theliander, H., **Energies** 14, 932 (2021).
2. Ahlbom, A., Maschietti, M., Nielsen, R., Hasani, M. & Theliander, H., **Holzforschung** 76, 37–48 (2022).
3. Mattsson, C. et al., **Biomass and Bioenergy** 95, 364–377 (2016).