Emek Yuksek[a*], Aysegul Okumus Ermis[a], H. Cuneyt Unlu[b], F. Elif Genceli Guner[a**]

a Istanbul Technical University, Chemical Engineering Department, b Istanbul Technical University, Chemistry Department, Ayazaga 34469 Maslak, Sariyer Istanbul, Turkey

* +90 (535) 053 8064 yuksek15@itu.edu.tr
** +90 (532) 341 4922 gencelie@itu.edu.tr

epf GRONINGEN 2025

Raw Lignin Modification and Waste Recovery for Tissue Adhesive Formulations

Motivation

Introduction

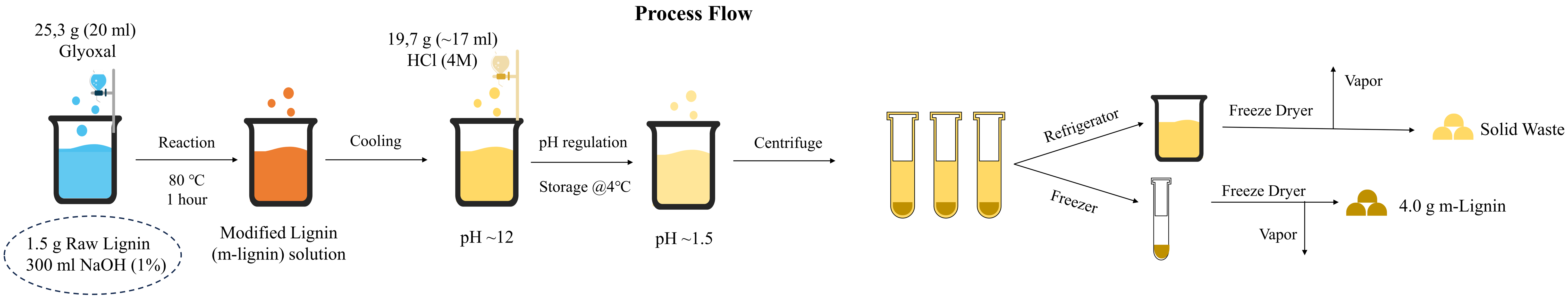
- Raw lignin has limited adhesive performance in its native form.
- Chemical modification is essential to improve its functionality.
- This study focuses on:
  - Improving lignin via glyoxal modification.
  - Reducing chemical use.
  - Exploring waste reuse strategies during precipitation.

Objective

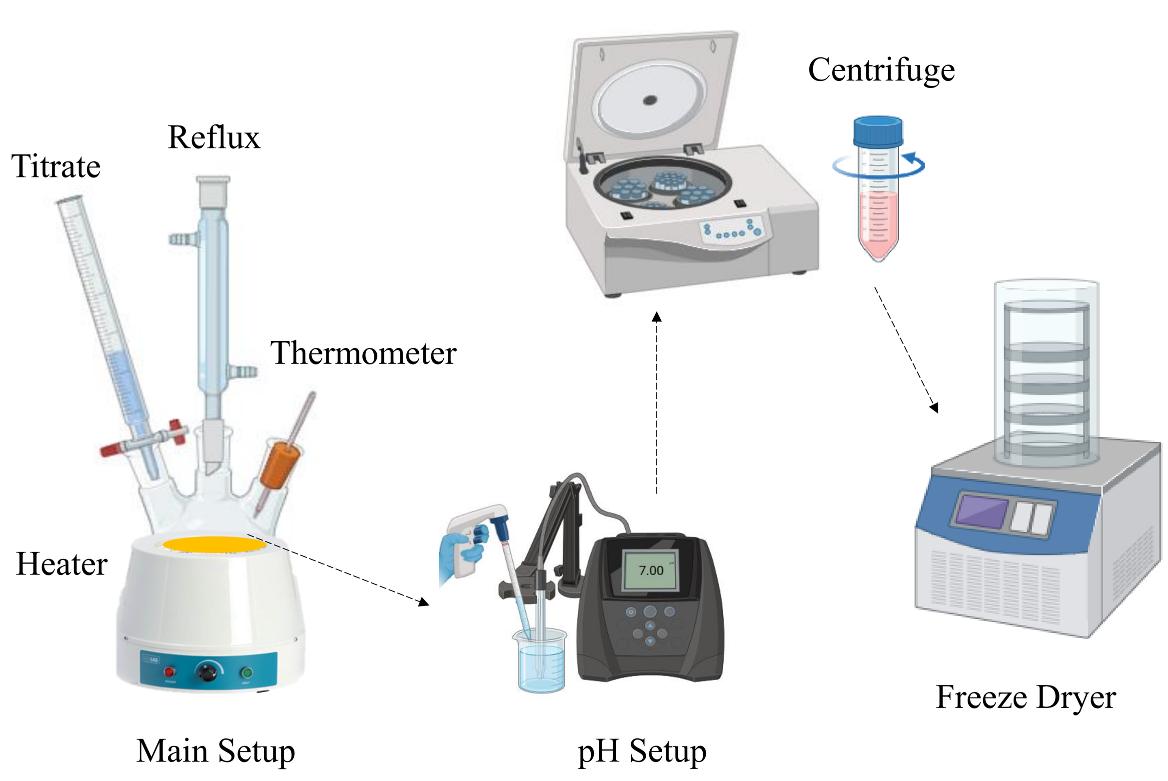
- Optimize glyoxal concentration in the modification process.
- Minimize consumption of chemicals.
- Reuse the acidic waste solution instead of fresh HCl.
- Evaluate the quality of lignin obtained from recycled systems.
- Establish a complete mass balance of the process.

Material & Methods

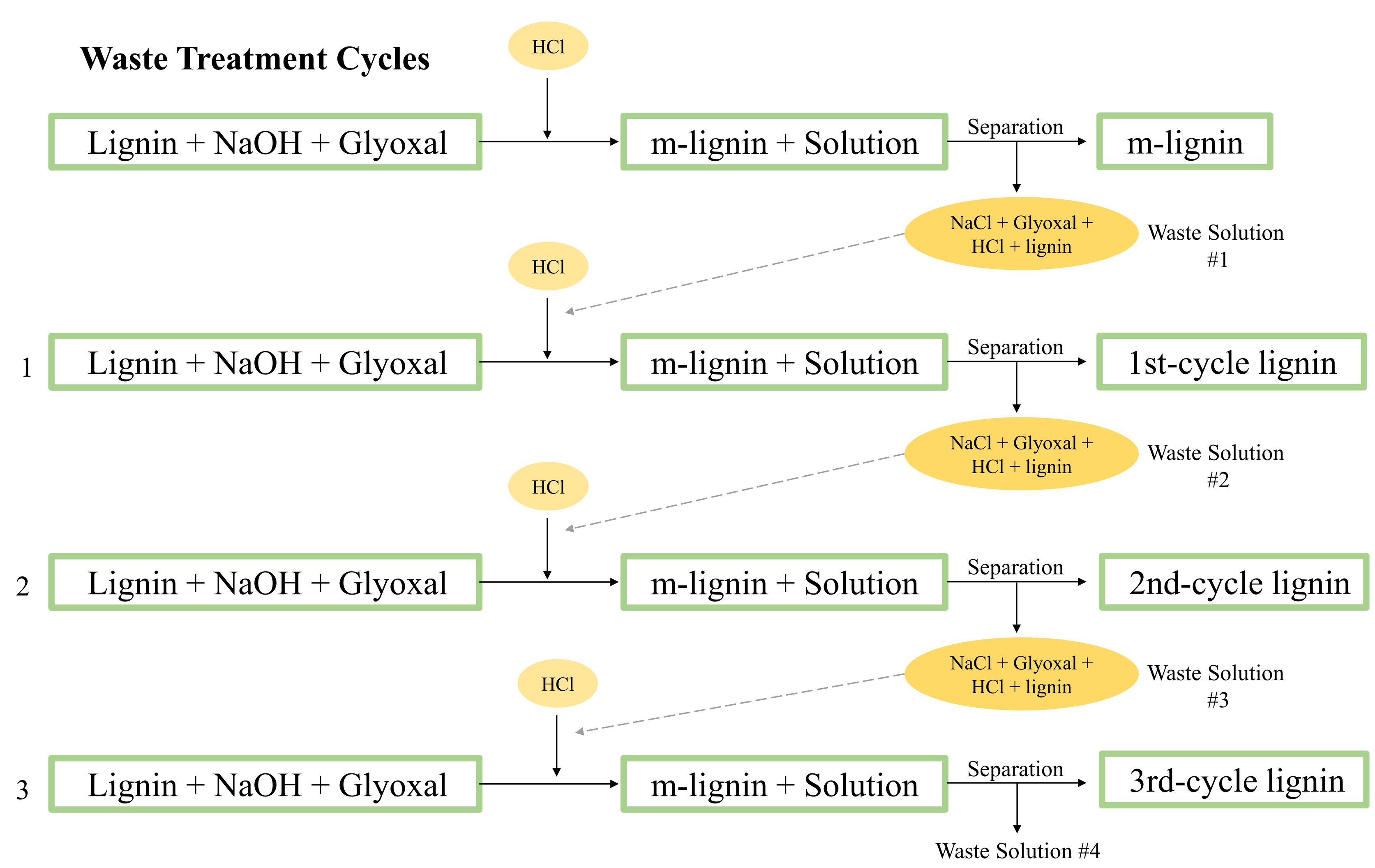
Process Flow



Experimental Setup

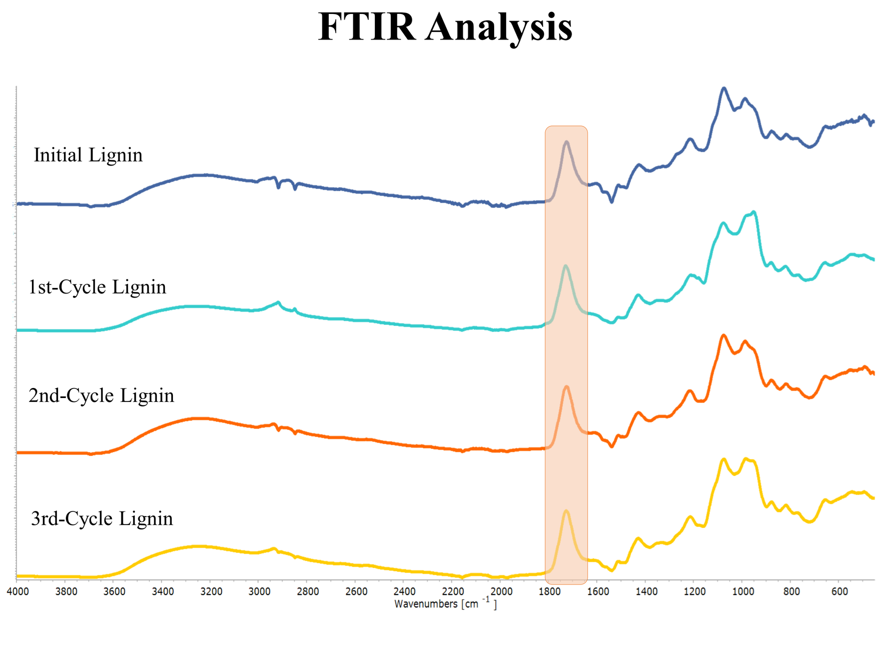


Waste Treatment Cycles

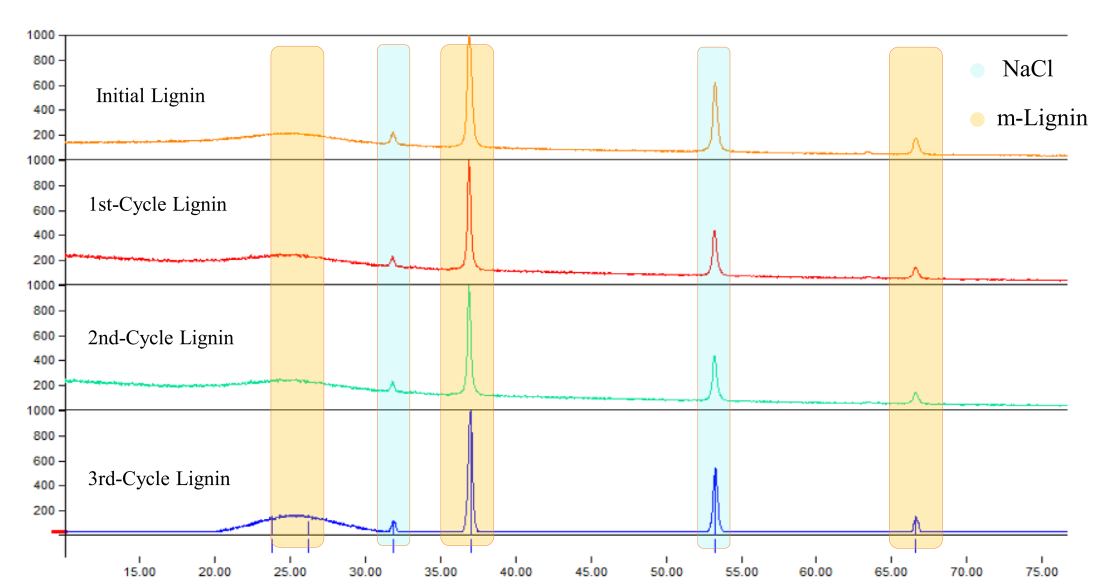


Results

FTIR Analysis



XRD Analysis



- Modified lignin quality was preserved across reuse cycles.
- Reuse of acidic waste successfully reduced fresh acid consumption.
- Process remained sustainable up to **24 cycles**, based on NaCl accumulation.
- **Total process loss <10%**, regaining of m-Lignin from waste is efficient.
- The approach supports environmental sustainability and cost reduction.

m-Lignin Regaining

Cycle #	% Regaining
1	22.5
2	30
3	60

Fresh Acid Usage Reducing

Cycle #	% HCl Reduction
1	46.1
2	64.9
3	70.5

Conclusion

Conclusion

- Lignin can be effectively modified using glyoxal with minimal fresh chemical input.
- Reuse of acidic waste solution is feasible and efficient.
- The process provides a scalable and eco-friendly route for biopolymer development.
- Mass balance and m-lignin recovery support industrial application potential.

Outlook

- Modified lignins obtained from each cycle will be used in tissue adhesive formulations. Adhesive performance will be evaluated through:
  - Tensile strength tests under dry and moist conditions, and
  - Rheological characterization of the formulations.
- To further reduce system accumulation, the waste stream will be treated by:
  - Eutectic Freeze Crystallization (EFC), enabling the simultaneous removal of water (as ice) and NaCl (as crystals) from the solution.