Latent NHC and Amine Salt-based Catalysts for Vitrimeric Polyesters

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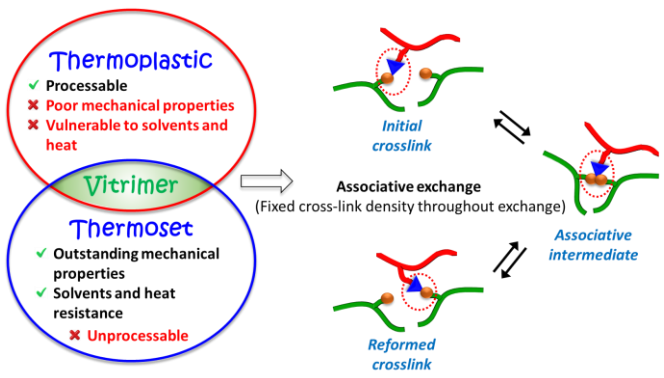
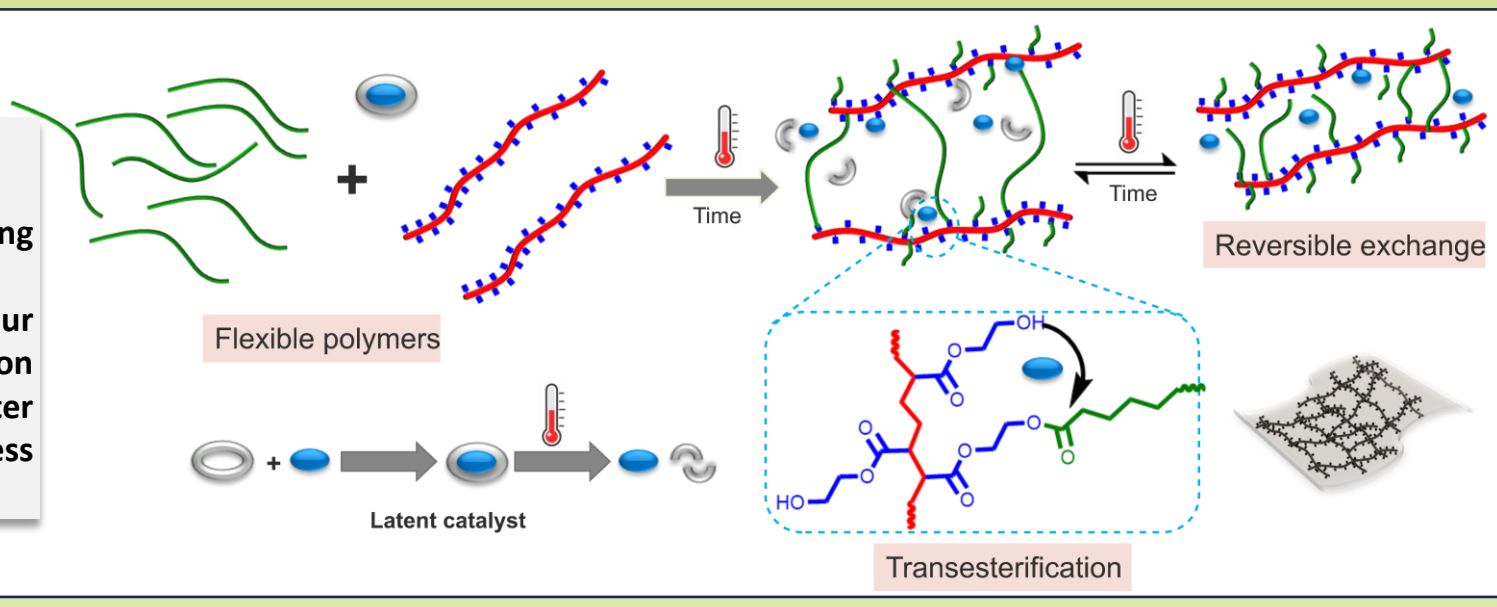
Motivation

Polyesters are widely used in industry, but their recyclability poses challenges—thermoplastics degrade during recycling, and thermosets are almost unrecyclable. Introducing vitrimeric properties offers a smart solution by enabling reprocessing without compromising mechanical performance. In this work, we develop latent catalysts based on amine salts and N-heterocyclic carbenes (NHC) that activate under heat to trigger transesterification. These catalysts allow tunable recycling conditions and improved sustainability for both thermoplastic and thermoset polyesters.



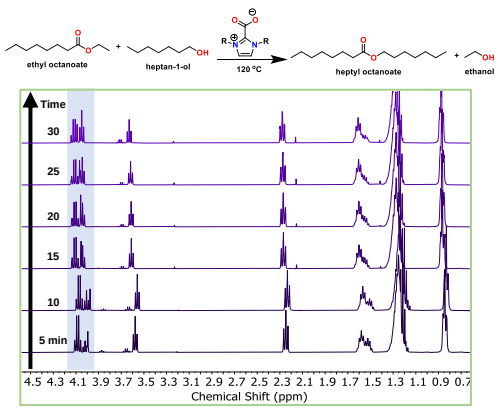
Concept

- ✓ Flexible polymers
- ✓ Polymers with low T_g
- ✓ Low topology freezing transition temperature (T_v)
- ✓ Exhibit vitrimeric behaviour by a transesterification reaction between the ester groups and the excess hydroxyl groups



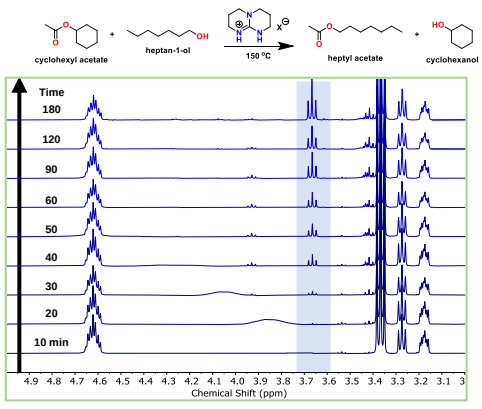
Model Compound

NHC Catalysts



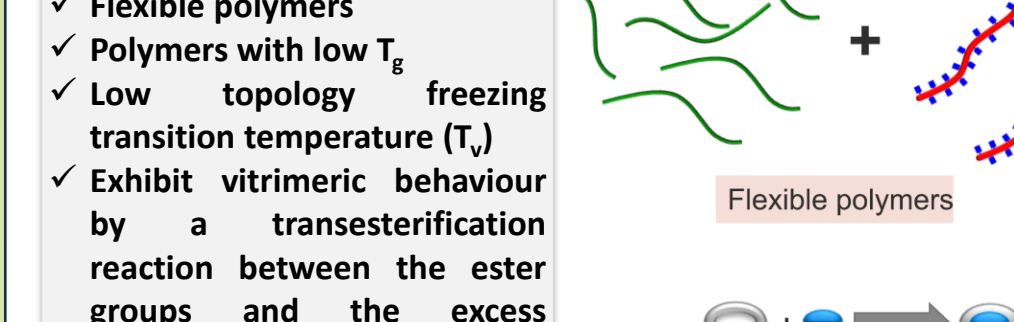
- ✓ Equimolar mixture; Solvent-free; 0.1 eq. catalyst
- ✓ Catalyst activation temp. 120 °C
- ✓ Conversion ~50% in 30 min

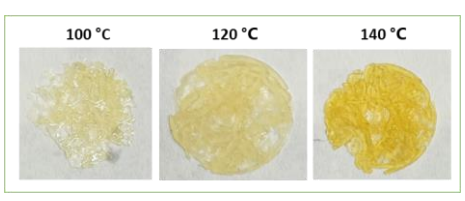
Amine Salt Catalysts



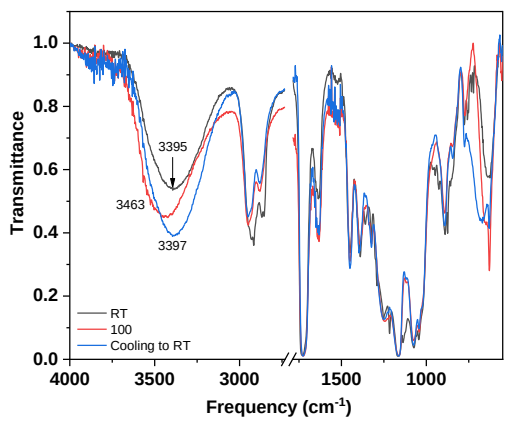
- ✓ Equimolar mixture; Solvent-free; 0.1 eq. catalyst
- ✓ Catalyst activation temp. 150 °C
- ✓ Conversion ~50% in 3 hours

Graphical representation of vitrimer synthesis

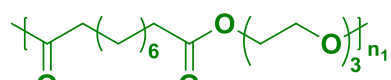


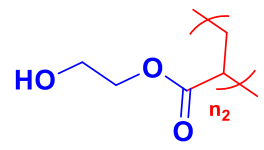


Temperature-dependent FTIR

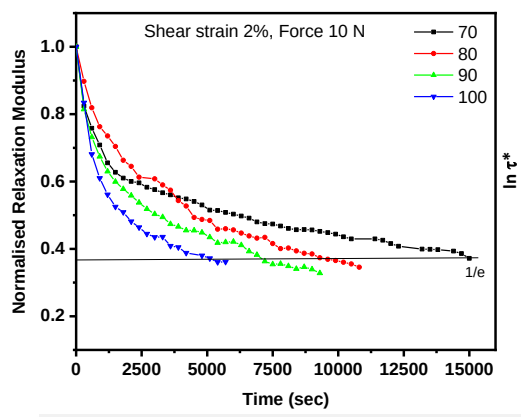


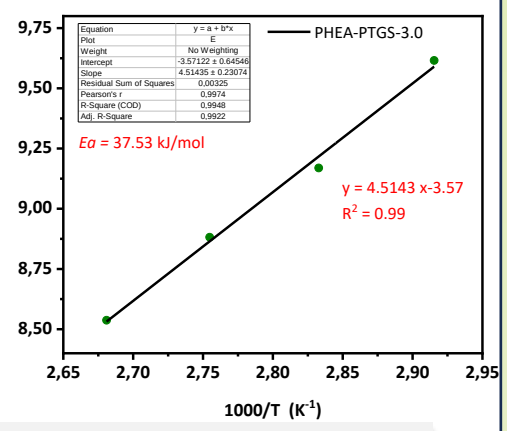
Even after cross-linking, a significant amount of OH groups are present in the network, which is important for transesterification





Relaxation studies





- ✓ The transesterification rate is very slow at a low temperature
- ✓ At a higher temperature, the vitrimers can rearrange their network topology by transesterification exchange reactions between the PHEA and PTGS

Conclusion

- ✓ NHC and Amine salt catalysts successfully synthesised and characterised
- ✓ Catalytic efficiency demonstrated via model transesterification
- ✓ Fabricated vitrimeric films using latent catalysts
- ✓ Verified bond exchange via stress relaxation and rheology

Acknowledgment

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References

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