Designing CO_2-responsive and degradable polymers for coating applications

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1. Introduction

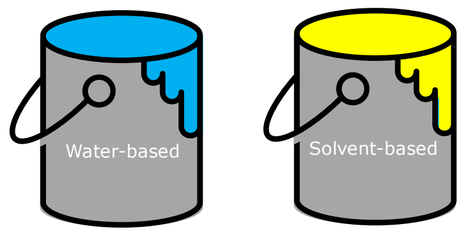
Use of disposable plastic and coatings

- 9 billion tons of plastic manufactured globally in 2023
- ~50% of manufactured plastic is used for single-use purposes

- Polymeric coatings have a significant presence in the commercial and industrial sectors
- Global coatings market volume estimated to be 26.5 billion liters worth in 2009

Related concerns of plastic and coating use

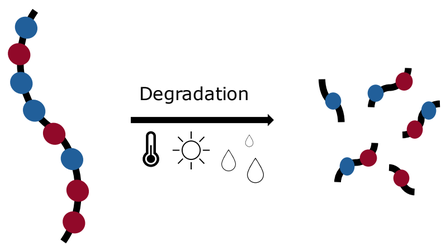
- Persistent particles known as microplastics end up in the environment
- Microplastics cause harm to aquatic life and humans



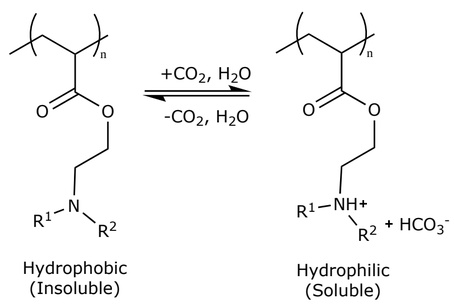
- Coatings currently available are often lacking in performance (water-based) or use organic solvents as the bulk solvent (solvent-based)
- Both coating types also result in persistent particles in the environment

Addressing the concerns related to plastics and coatings

- The use of polymers that can degrade under specific conditions can offset microplastic contribution
- Hydrolysis is an example of chemical degradation that can facilitate polymer breakdown



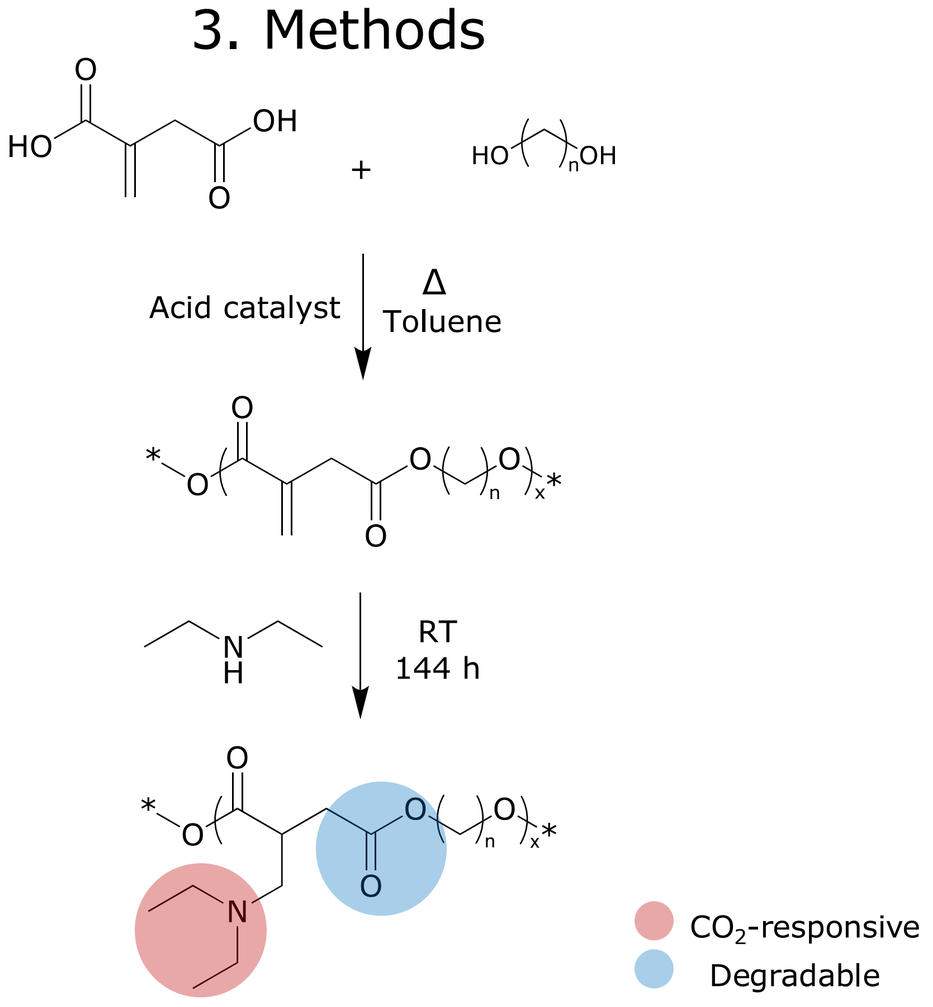
- The use of CO_2-responsive polymers allows carbonated water to be used as the bulk solvent
- Hydrophobic nature of the polymer in a neutral state offers superior coating performance



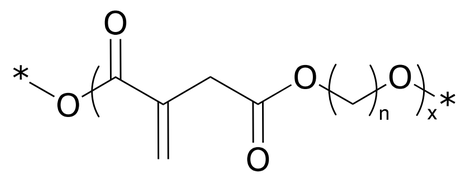
2. Goals of Research

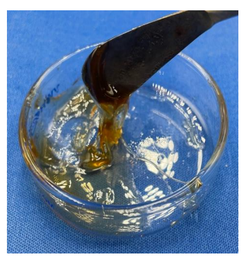
Polymerize monomers into CO_2-responsive polymers with degradable properties → Perform degradation and CO_2-responsiveness tests for qualitative and quantitative analysis → Tailor polymer properties for intended application

3. Methods

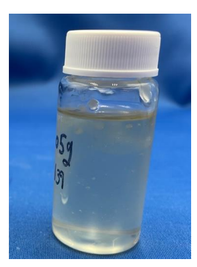


4. Results



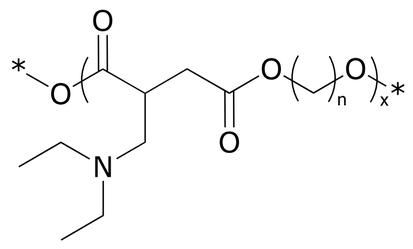


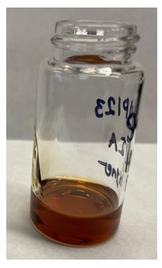
2.00 g scale



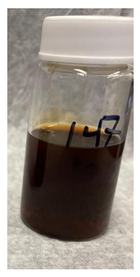
20.00 g scale

Reaction Scale	Mn	Mw	Polydispersity (Đ)
2.00 g	6409	8770	1.368
20.0 g	425	501	1.178





2.00 g scale

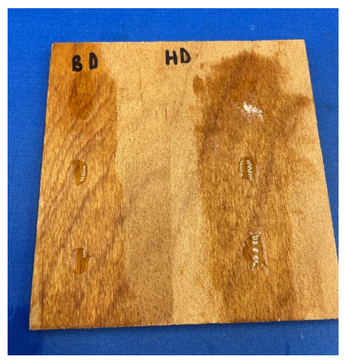


20.00 g scale

Reaction Scale	Mn	Mw	Polydispersity (Đ)
2.00 g	2498	2723	1.090
20.0 g	523	638	1.221

+ CO_2

- 2 coats
- 24 h drying time



- Droplet tests with DI water

- 24 h after droplet test

- Whitening can be seen on wood after applying water droplets to a wood surface coated with polymer solution from 20.0 g scale batch
- Molecular weight of the polymer is likely too low to achieve a hydrophobic coating upon surface application

5. Conclusions

- Condensation polymers bearing esters and tertiary amines can be synthesized using proposed method
- Scaling up the reaction results in a decrease in molecular weight up to ten-fold
- Coating performance was poor, but may be improved by increasing molecular weight of the polymer

6. Future Work

- Adjust experimental set-up to achieve a higher molecular weight polymer
  - Use a mechanical stirrer to improve reaction kinetics
  - Monitor reaction temperature throughout the reaction to ensure reflux is maintained
  - Monitor progress of polymerization via acid value

7. Acknowledgements

- Dr. Philip Jessop
- Dr. Michael Cunningham
- Dr. Tobias Robert
- Jessop Group members
- Cunningham Group members

8. References

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