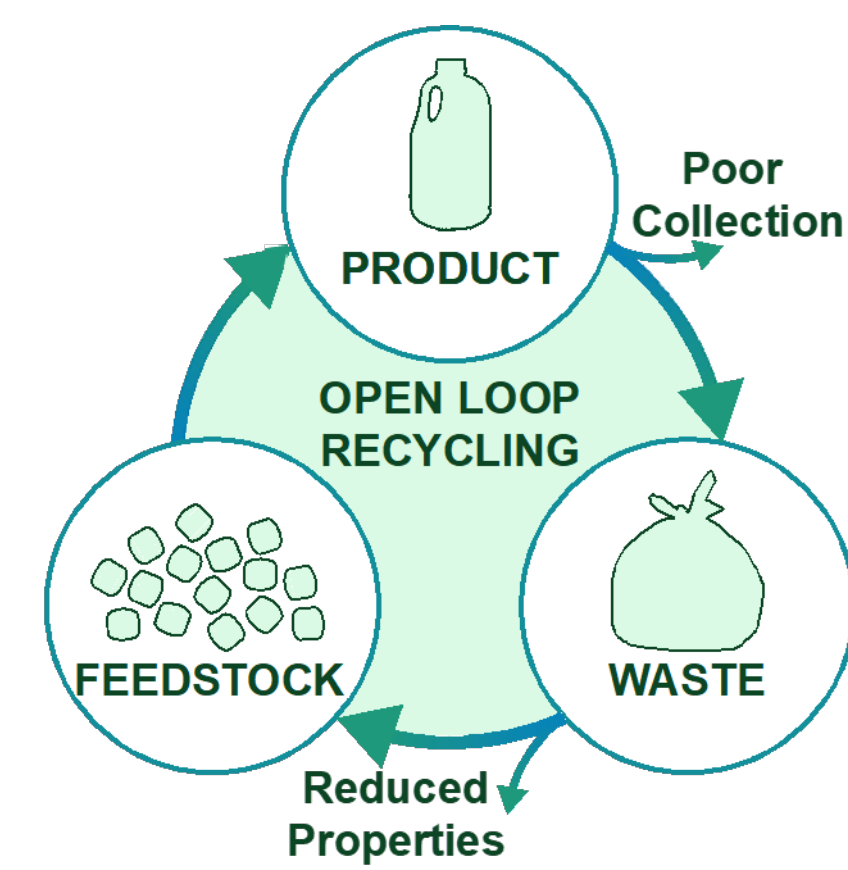


Synthesis and Study of Circular -by-Design High-Density Polyethylene -Like Materials for a Circular Economy

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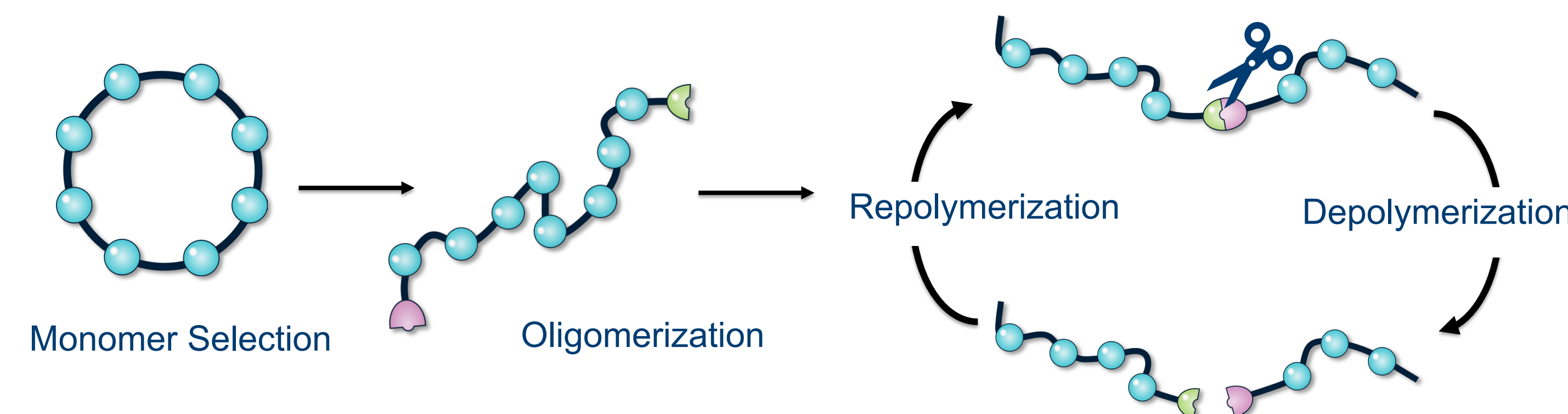
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Plastics & Open Loop Recycling

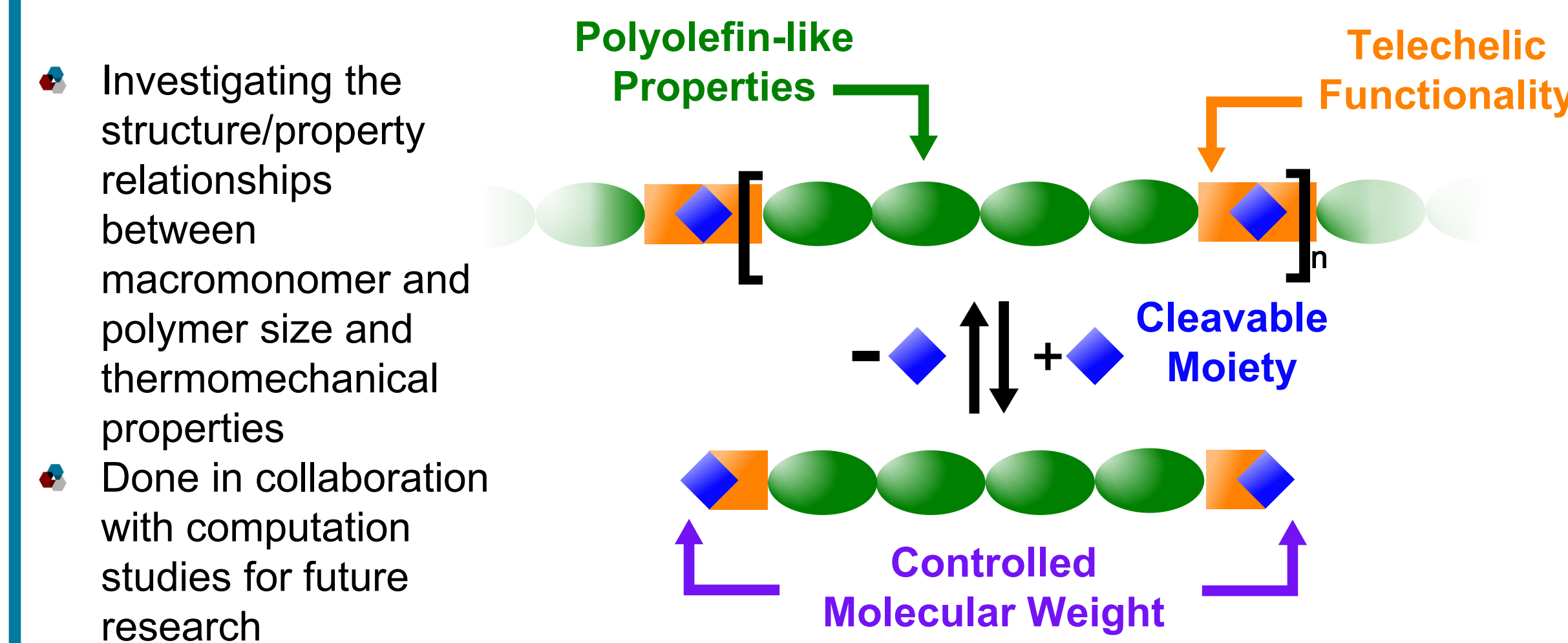
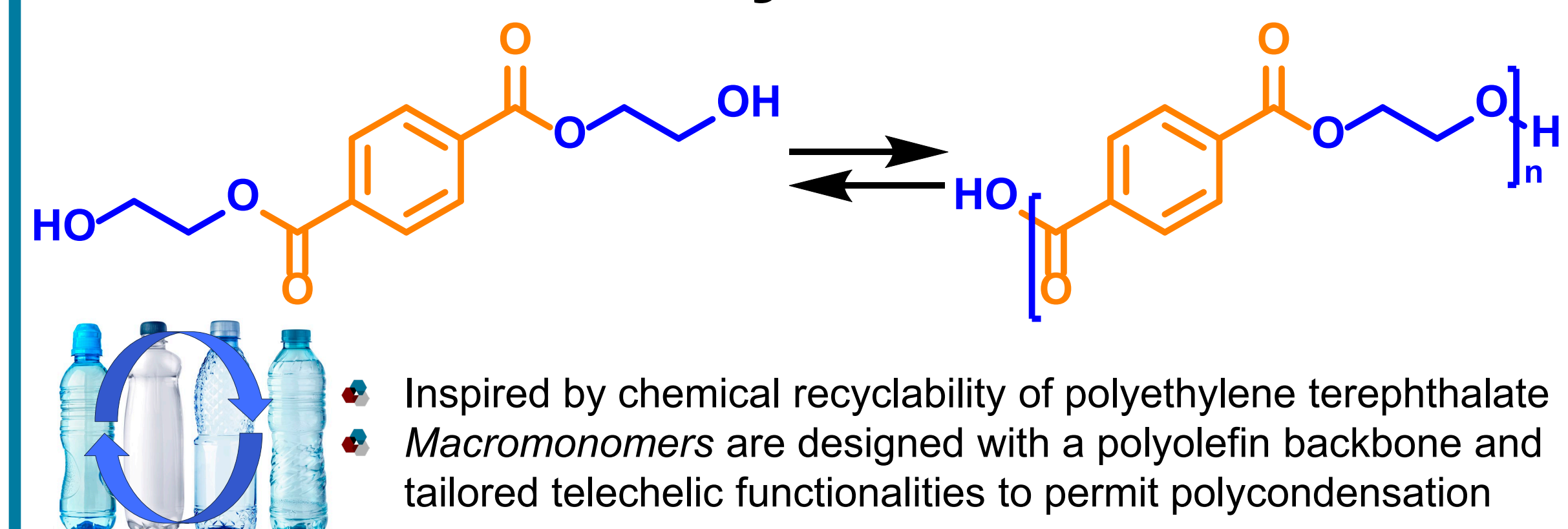
Current recycling of commercial plastics is done using processes that result in incomplete depolymerization and reduced performance properties in the second generation of plastic products.



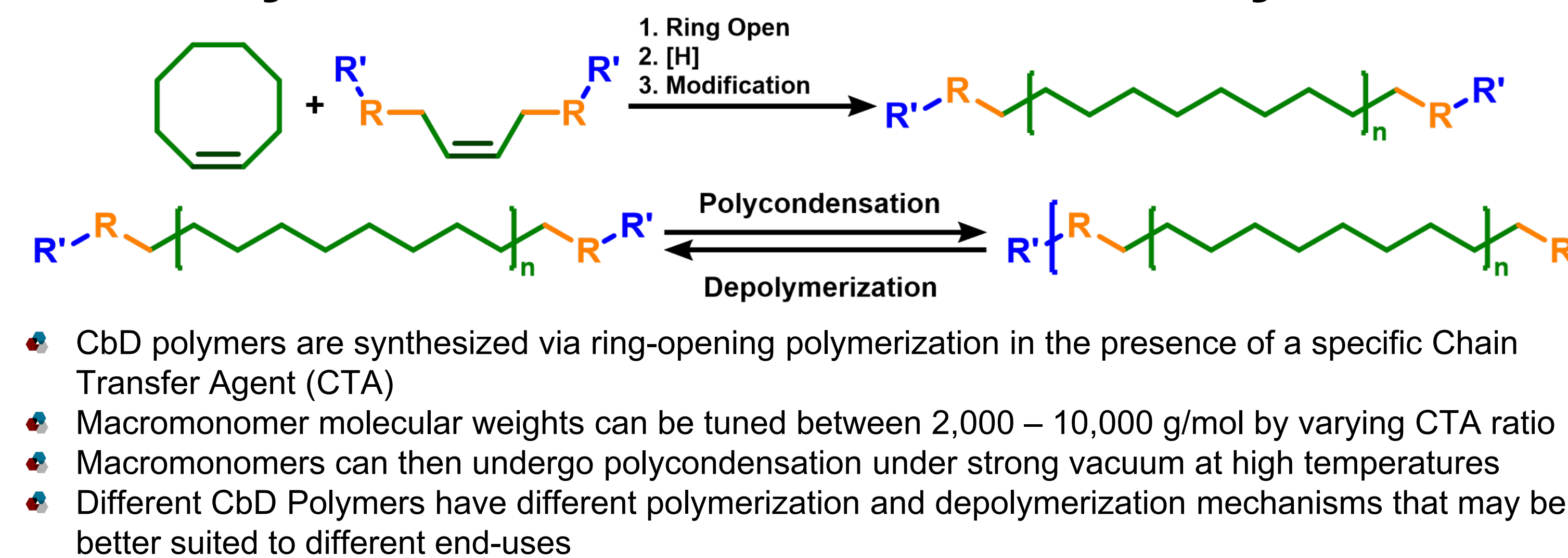
Closing the Loop & Maintaining Performance

Through mindful chemical design and with input from multiscale computational models, new, truly circular polymers are being designed with little cycle-to-cycle property fade and expanded end-of-life optionality.

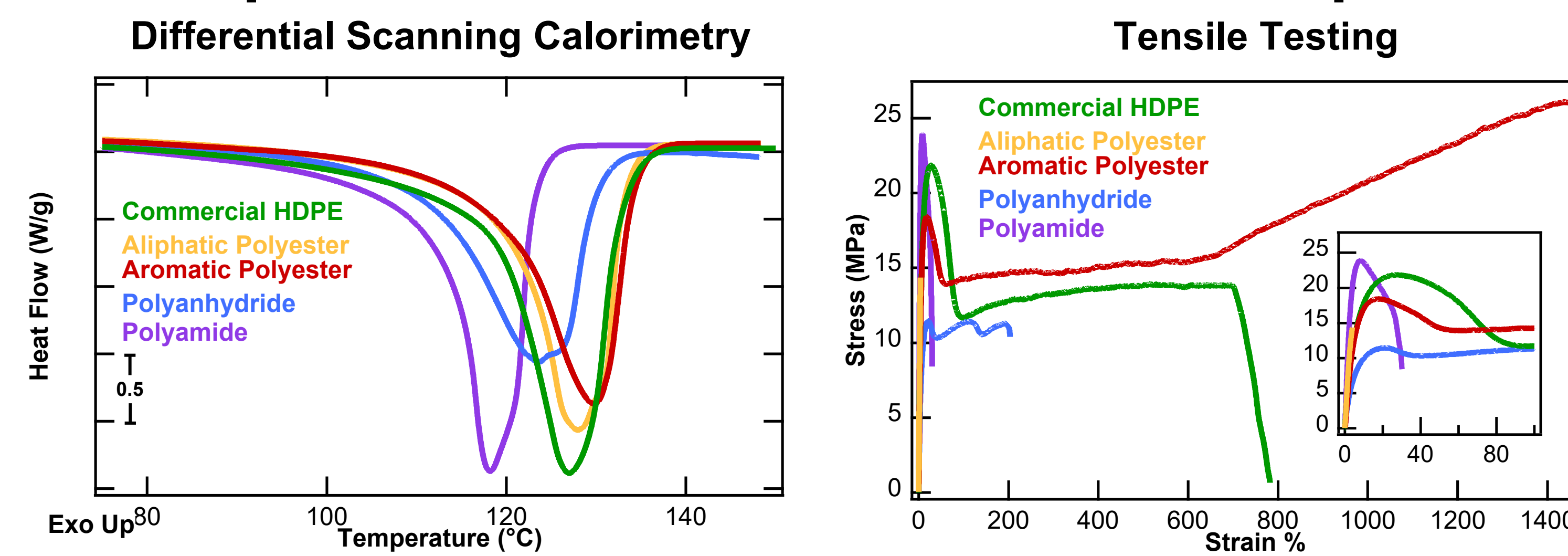
Circular Polyolefin Blocks



Synthesis of HDPE-Like CbD Polymers

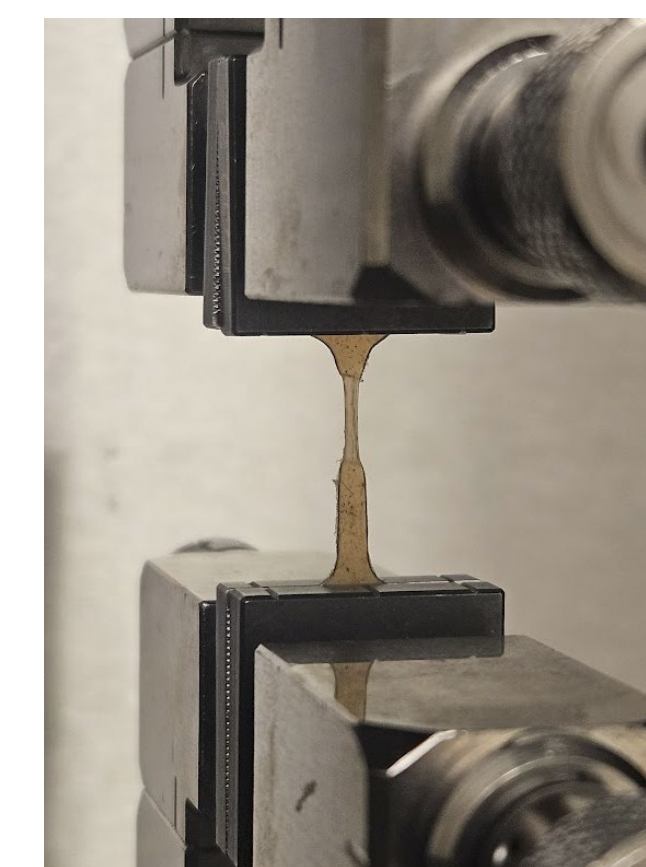


Comparison of Thermomechanical Properties



- CbD polymers typically have melting points slightly below that of HDPE
- By introducing a new functional group into the backbone, the structure of the polymer is disrupted resulting in lowered crystallinities

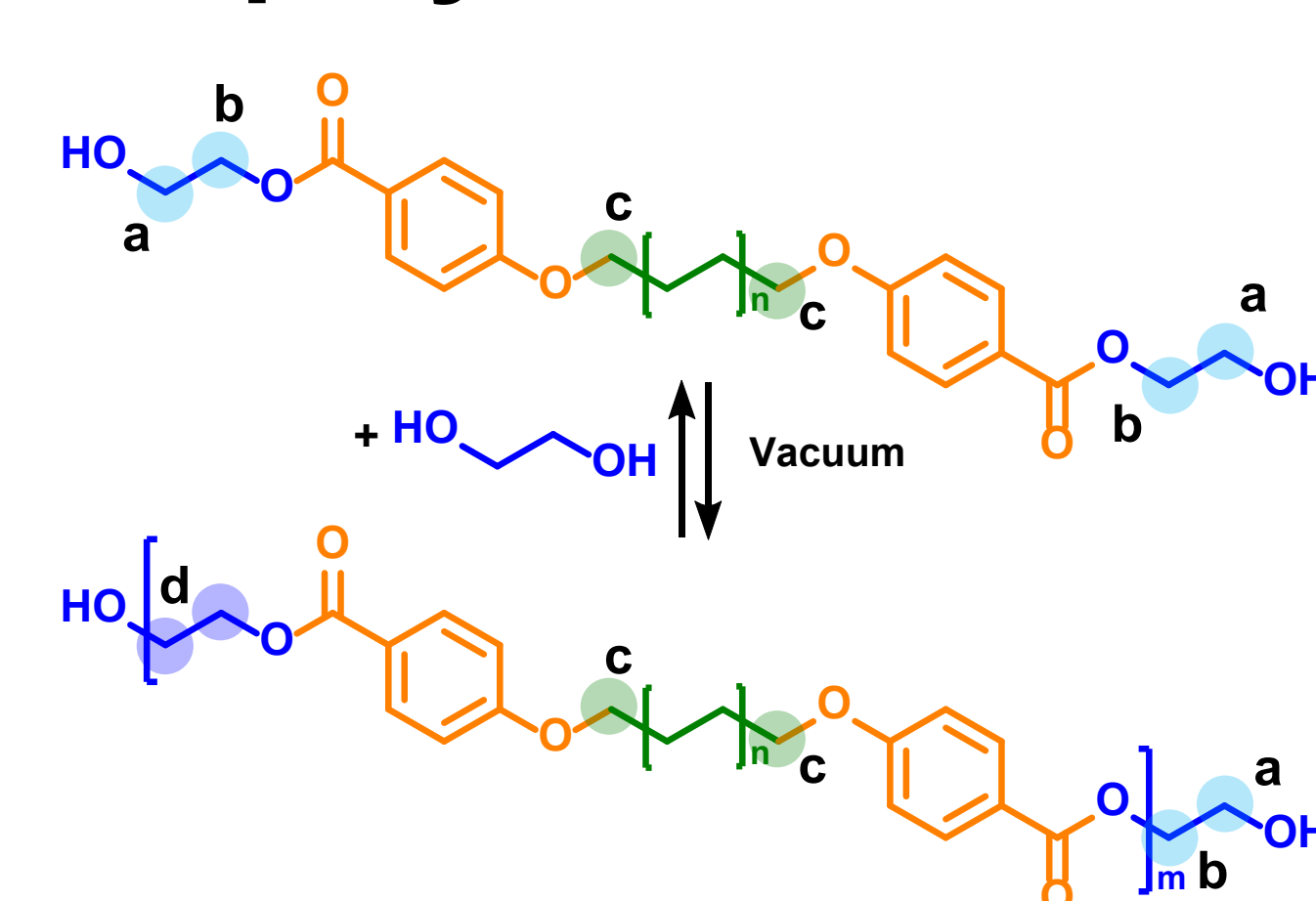
Polymer	Crystallinity	T_m	Strain at Break
HDPE	~60 %	~130 °C	500-1200 %
Aliphatic Polyester	54 %	127 °C	5 %
Aromatic Polyester	52 %	129 °C	1480 %
Polyanhydride	49 %	123 °C	200 %
Polyamide	49 %	118 °C	47 %



Example Tensile Test

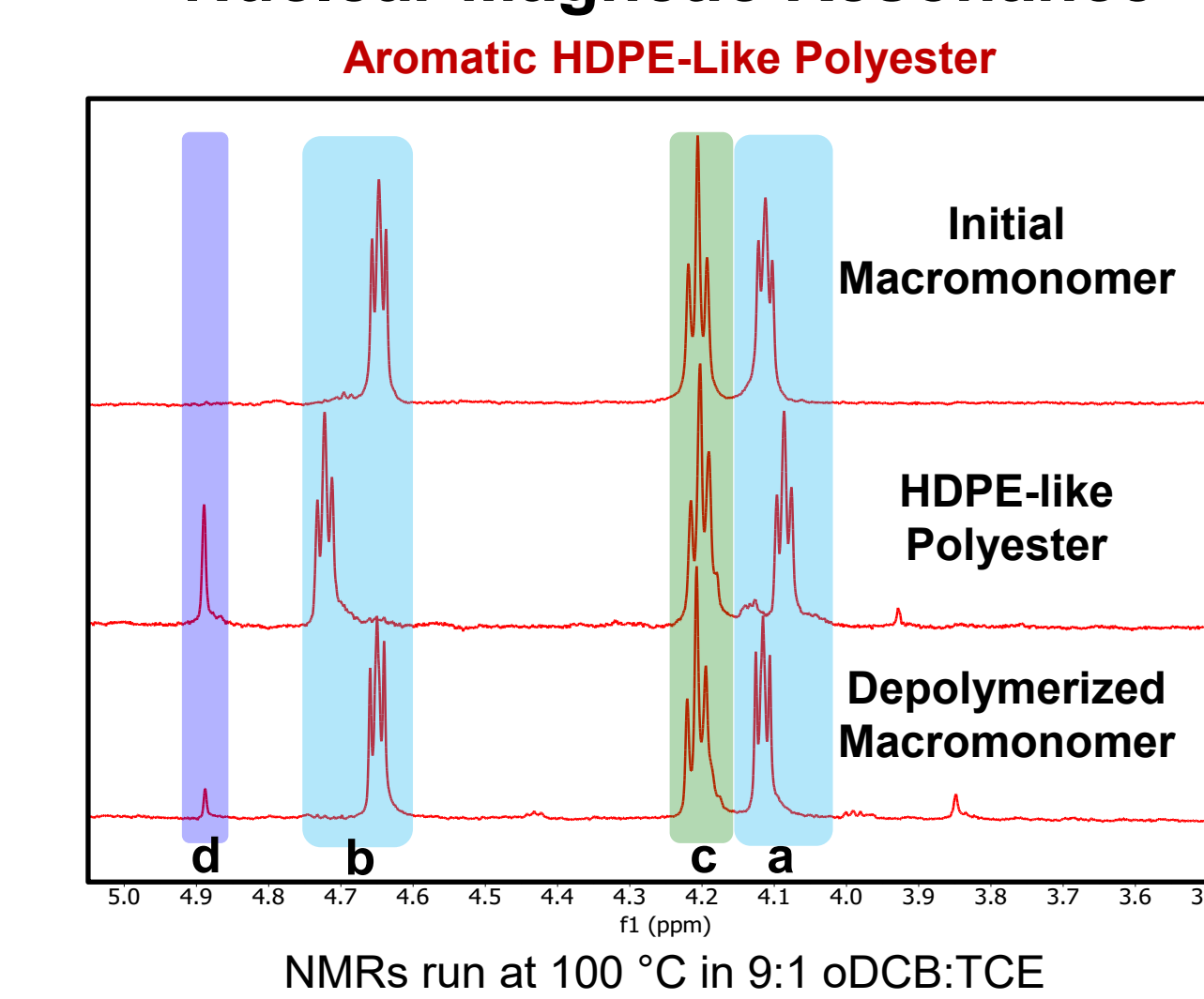
- Higher molecular weight macromonomers tend to exhibit properties closer to those of HDPE, however that may also come with added difficulty to polymerize and depolymerize

Depolymerization and Circularity of Polyesters

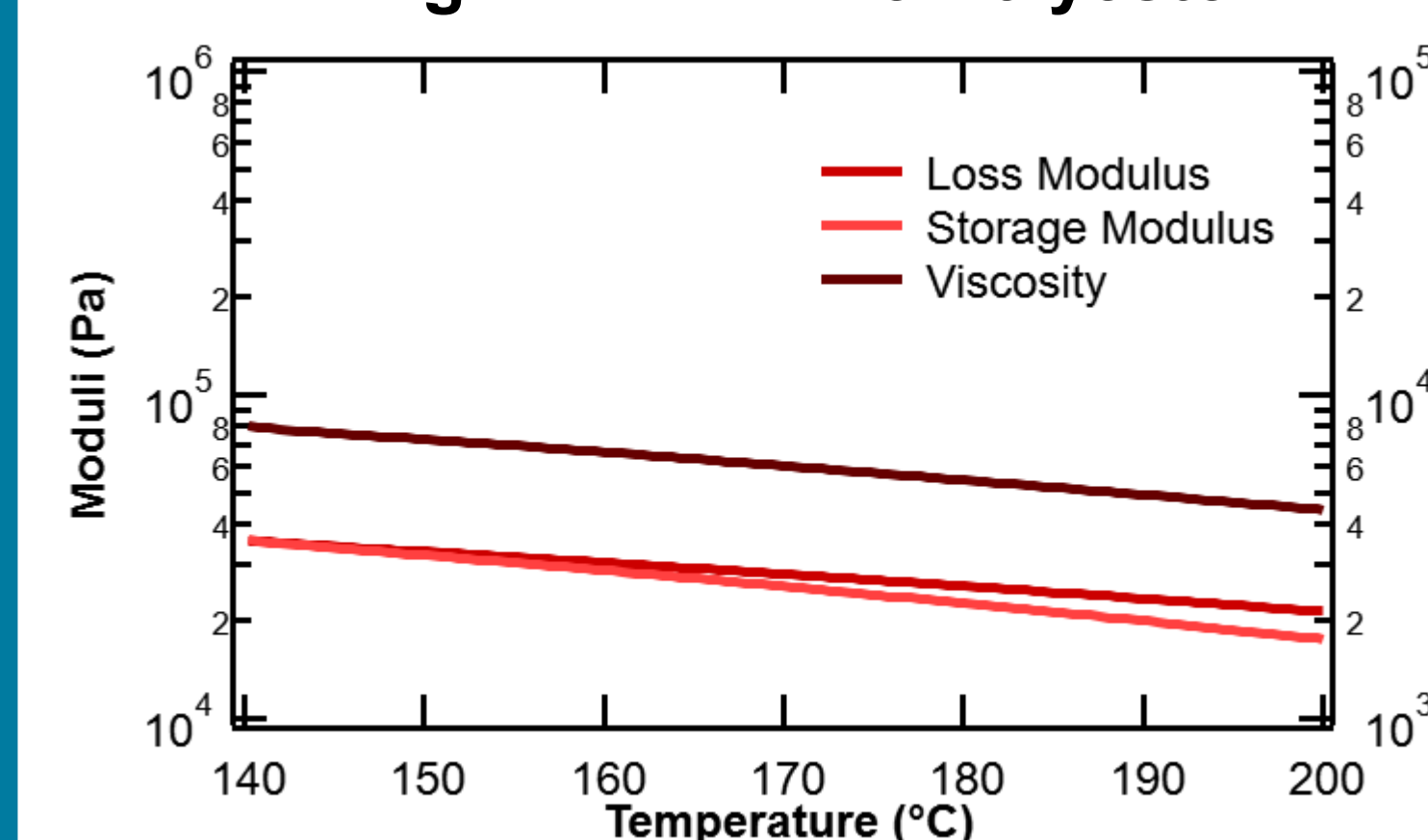


- Depolymerization has been demonstrated in the Aromatic HDPE-like Polyester system via base-catalyzed glycolysis reactions run in solution over several days

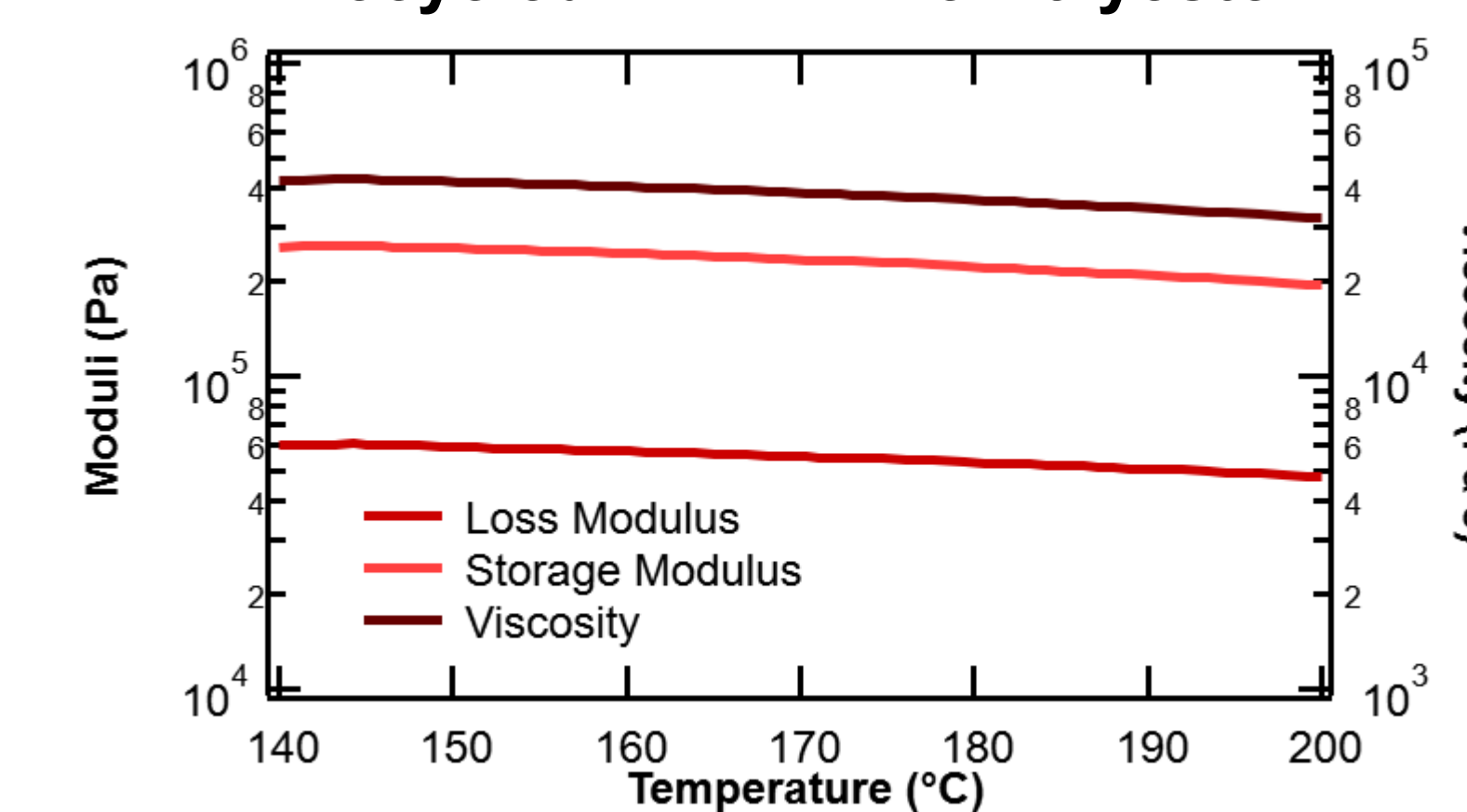
Nuclear Magnetic Resonance



Virgin HDPE-Like Polyester

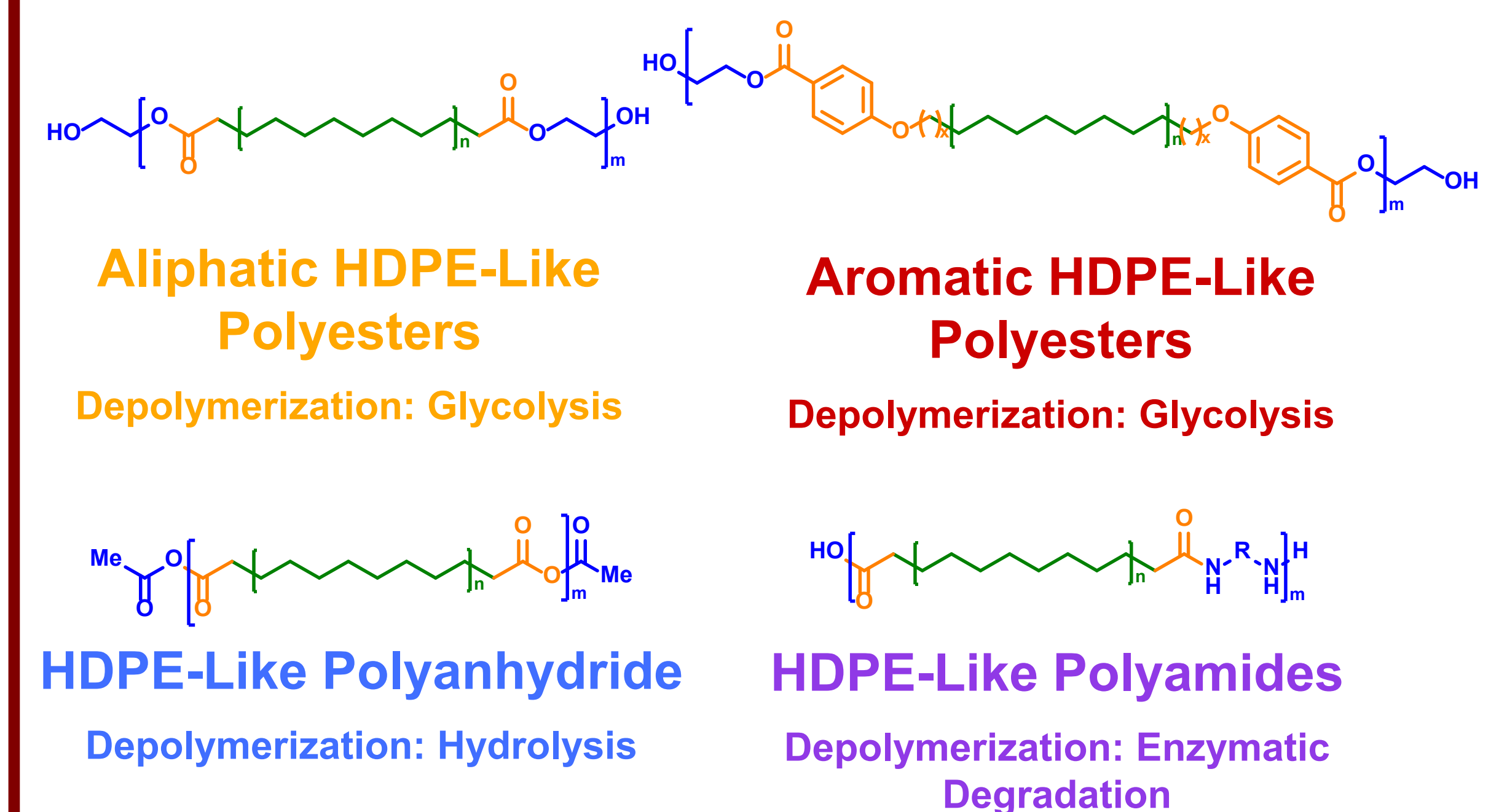


Recycled HDPE-Like Polyester



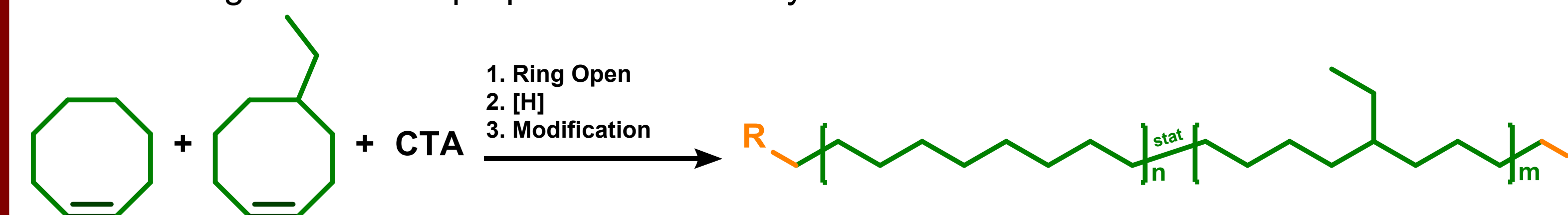
- Upon repolymerization of an Aromatic HDPE-like macromonomer the resulting polyester is significantly stiffer and more brittle, indicating some impurity that needs to be worked out

High Density Polyethylene-Like Circular-by-Design (CbD) Polymer Suite



Future Work

- Optimize the polymerization conditions for our polyanhydride and polyamide synthesis
- Modify post-depolymerization conditioning and subsequent polymerization in order to improve recyclability
- Implement additives such as antioxidants to improve chemical stability for recyclability
- Copolymerization with ethyl-branched cyclooctene monomers to tune crystallinity, achieving LLDPE-like properties which may exhibit more facile characterization



Acknowledgements



The work was supported as part of the Center for Plastics Innovation, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, under Award # DE-SC0021166.

References

- [1] Geyer, Jambeck, Law. *Sci. Adv.* **2017**
- [2] Worch, Dove. *ACS Macro Lett.* **2020**