

Hill Research Group

Organic Polymer Chemistry & Materials Science

est. 2022 @ Colorado State University

Research in the Hill group leverages organic polymer synthesis and physical organic chemistry to design high-performance materials with predictable and controllable properties. Our primary focus is on materials that will support a future of sustainability, including the use of reversible dynamic chemistries for enhanced recyclability and applications in catalysis and energy storage.

Hill Research Group 2023



Left to Right: Curtis Lake - undergraduate, Tyler Ryan - undergraduate, Alex Claiborne - 1st year grad, Ally Cunningham - 1st year grad, Zach Zimmerman - 1st year grad, Megan Hill - Principle Investigator
Not pictured: Gwen Wilsz - undergraduate & John Choinopoulos - Research Scientist

Current projects

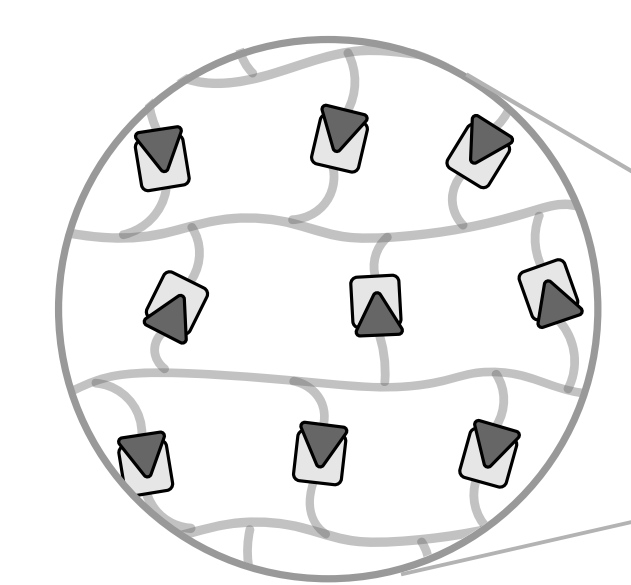
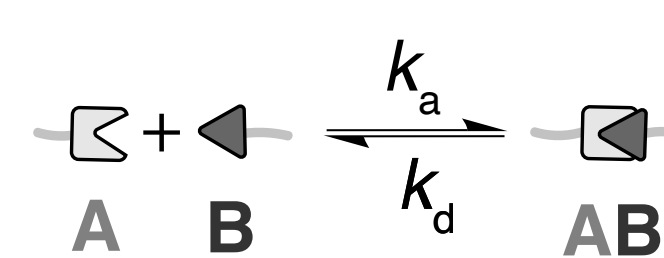
Property control in recyclable, soft materials

Supramolecular chemistry, chemical kinetics, material characterization

Goal: Access and predict range of properties in soft materials

Potential applications: Tissue engineering, drug-delivery, recyclable thermosets

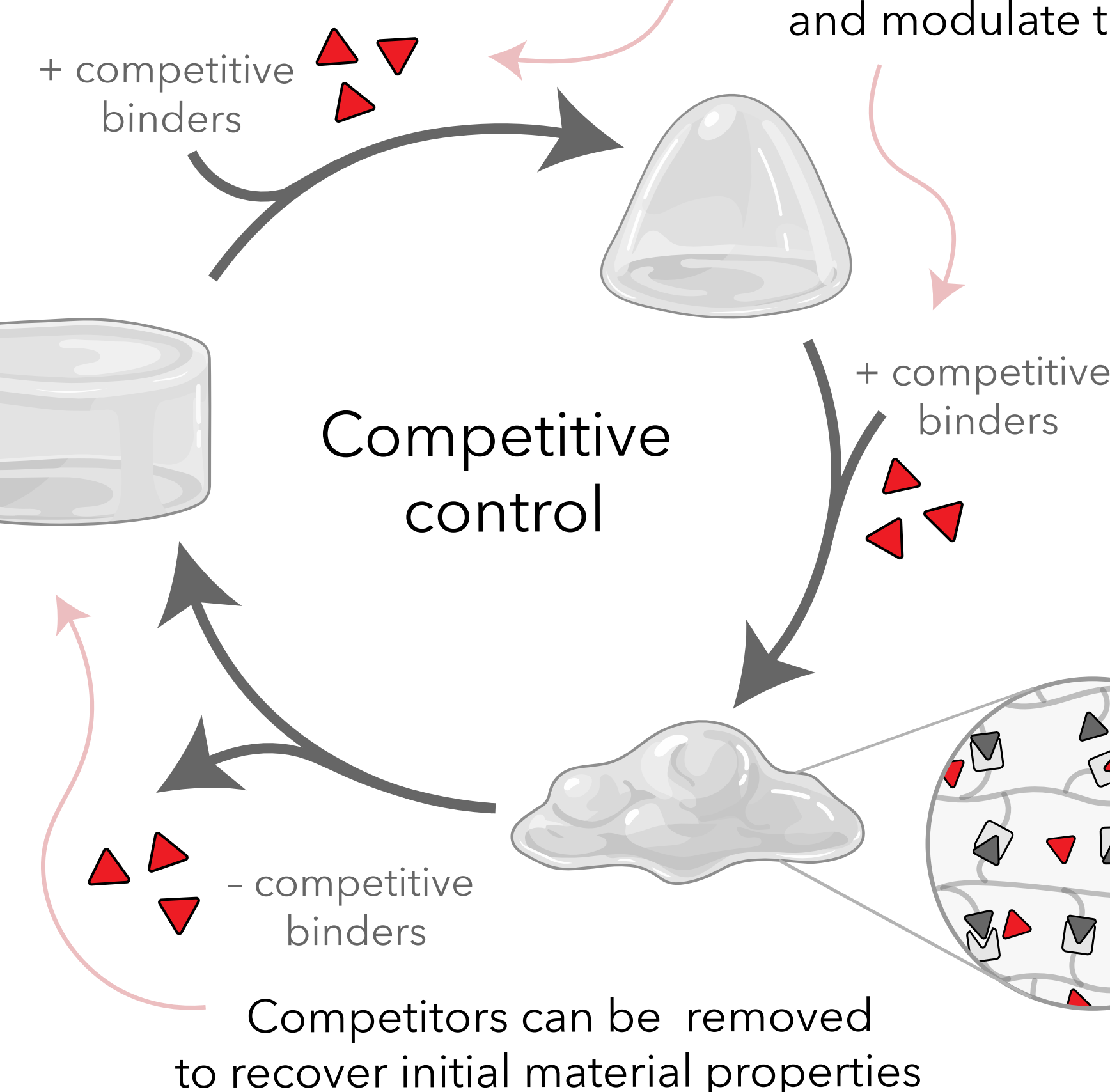
The problem:



$$K_{eq} = \frac{[AB]}{[A][B]} = \frac{k_a}{k_d}$$

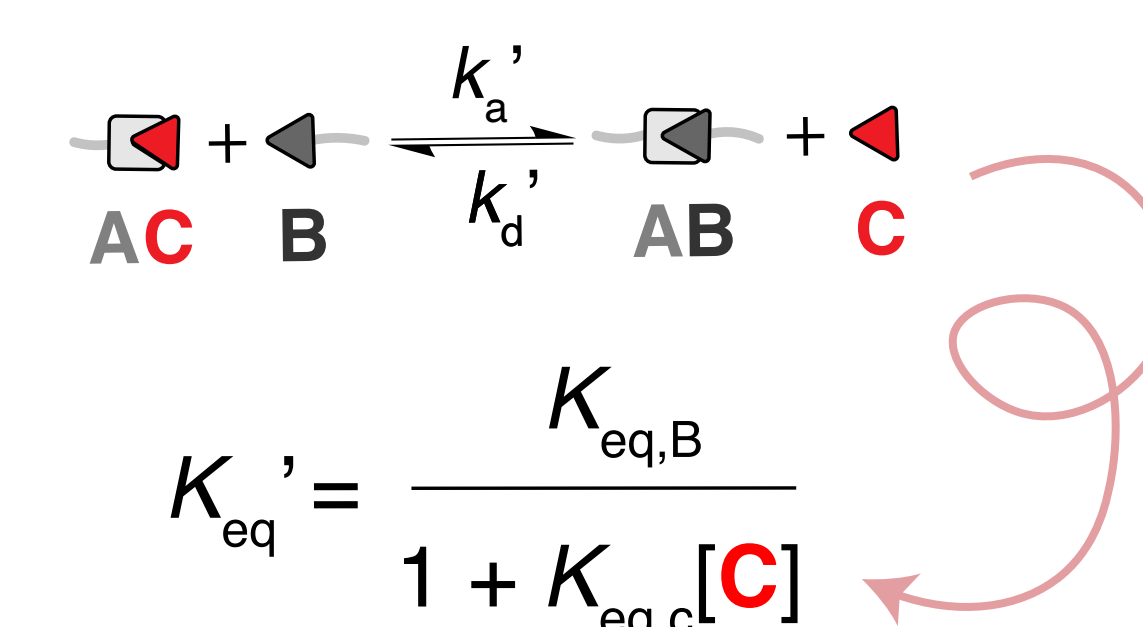
Material properties are heavily influenced by the dynamic bond, but they are difficult to predict prior to network synthesis.

Our strategy:



Monovalent molecules can compete with and modulate the strength of the crosslink.

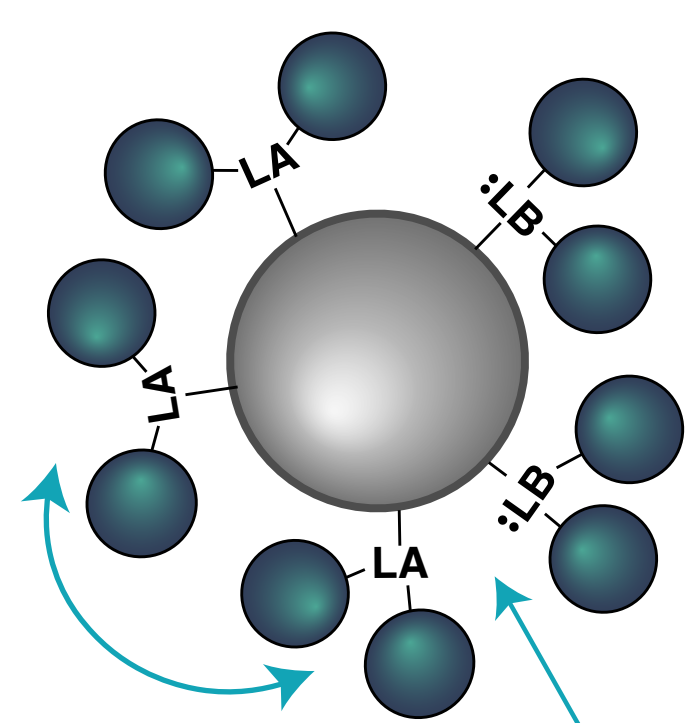
We can develop models that predict this change in crosslink strength based on concentrations and interaction strengths.



These predictions may enable greater understanding of how dynamic materials behave in complex environments, such as the body.

The problem:

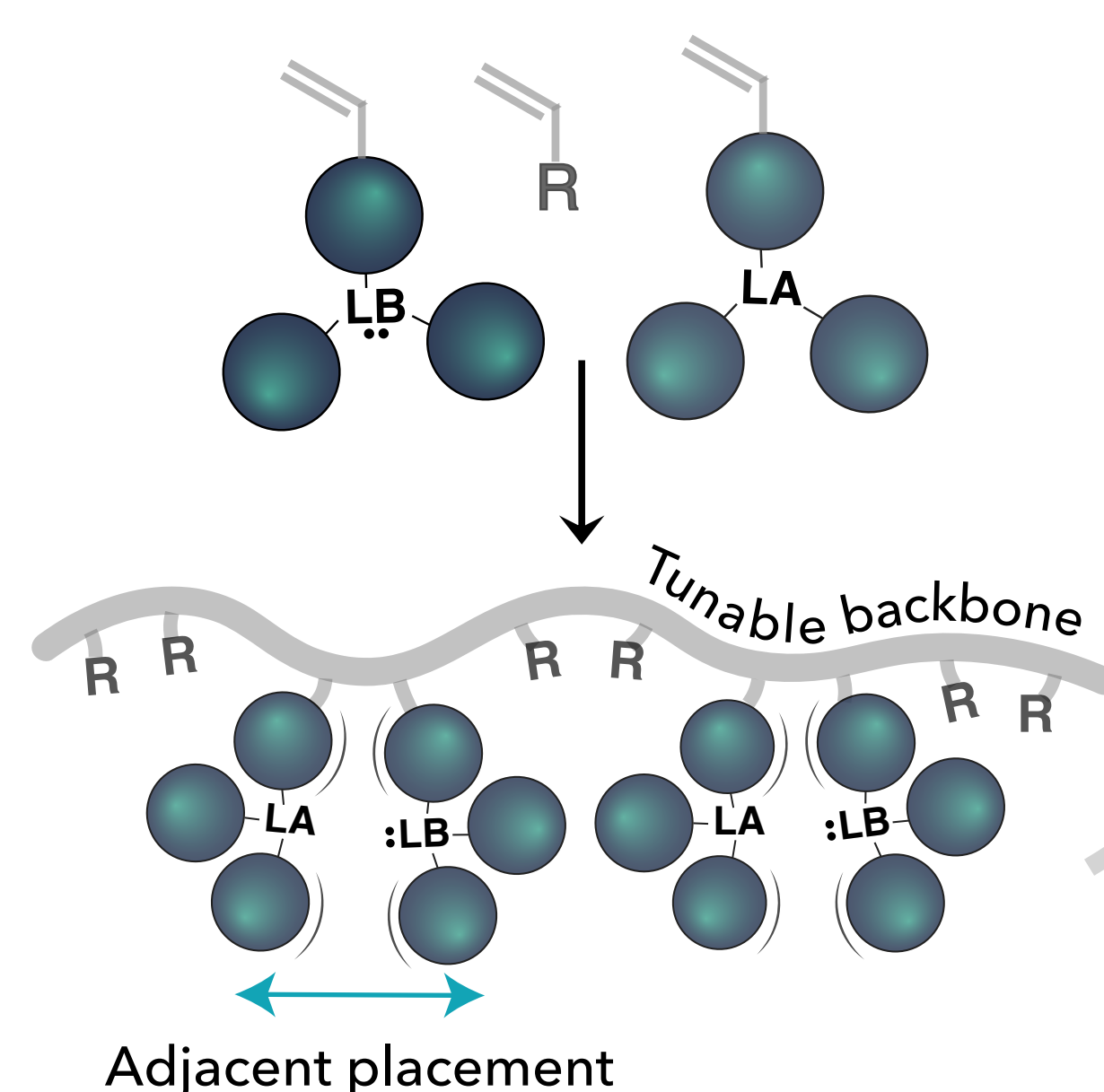
Heterogeneous catalysts enable recyclability & reuse, but...



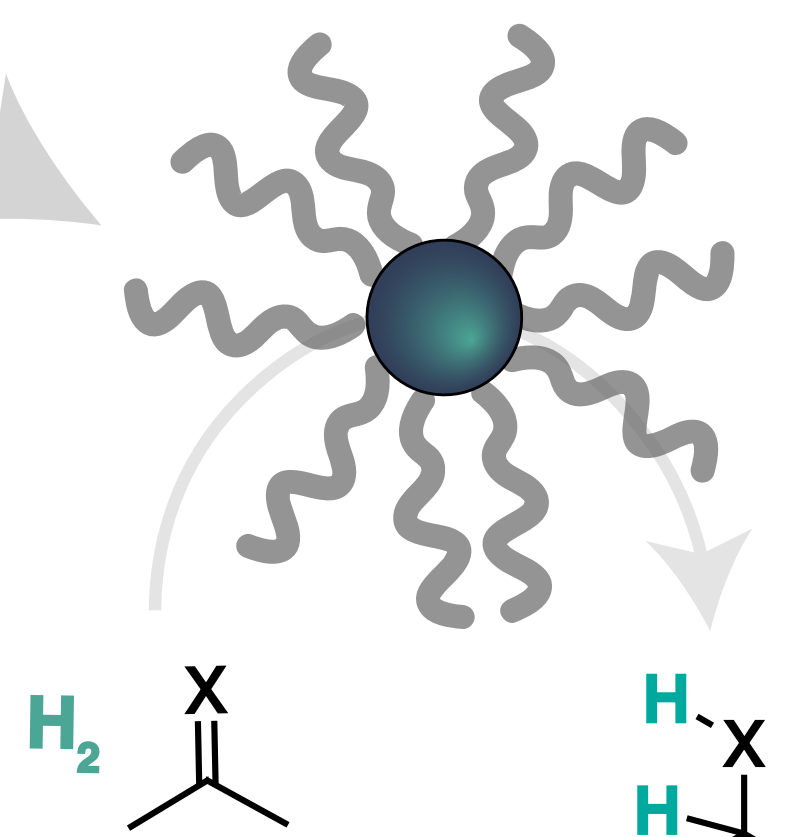
No control over catalyst placement
Support affects catalytic activity

Our strategy:

Controlled catalyst placement



Assemble into micelles, networks



Catalyze! Recycle! Reuse!

De-novo heterogeneous catalyst design

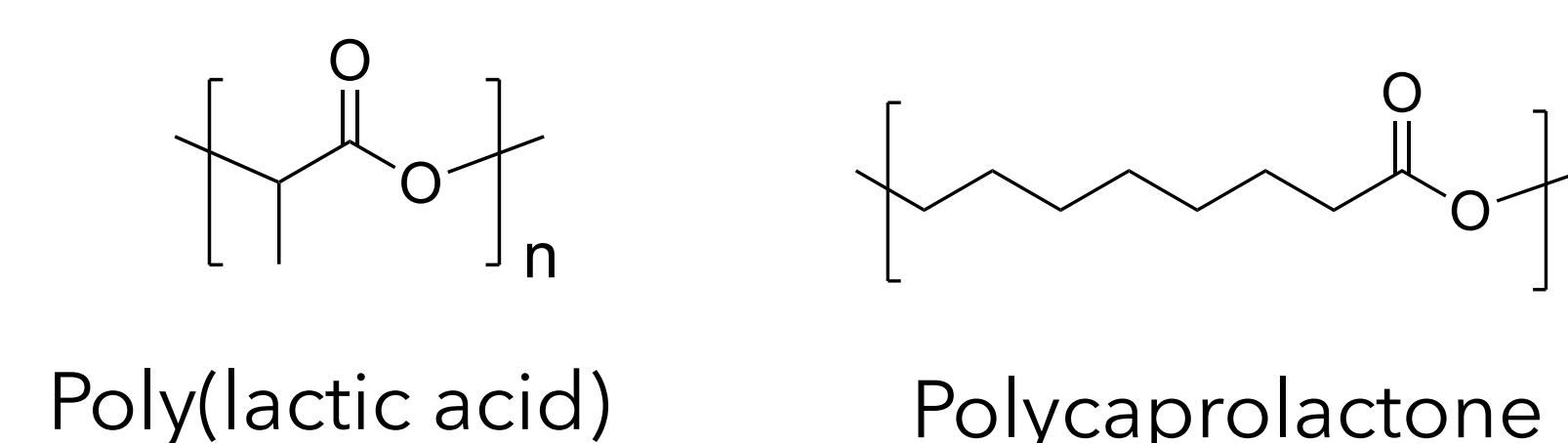
Organic synthesis, catalysis, polymer kinetics

Goal: Control placement of catalyst along polymer backbone

Potential applications: many areas of catalysis (LA-LB, photoredox), energy storage

The problem:

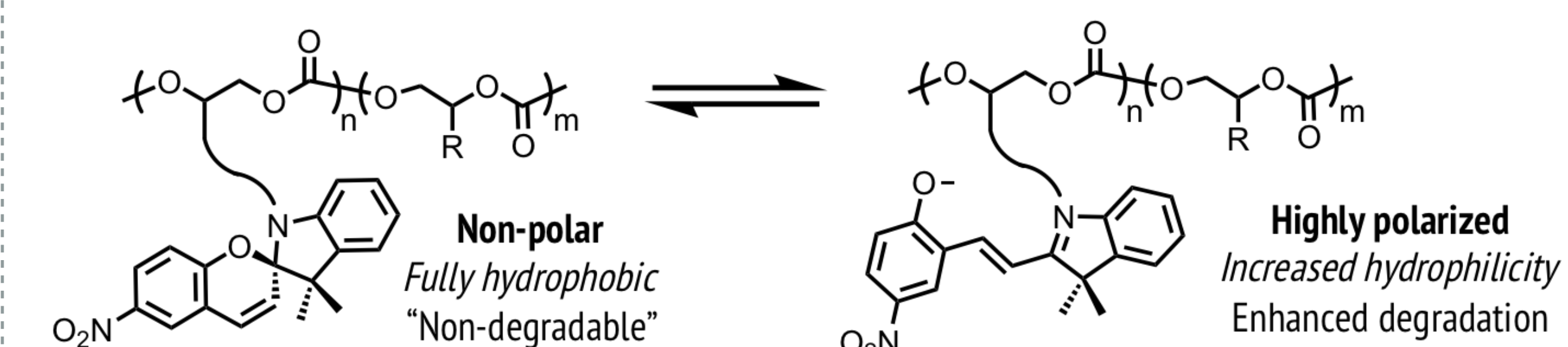
Hydrophobic, highly crystalline polymers are desirable for good mechanical properties, but prevent degradability under typical environmental conditions



Widely used polyesters not degradable in the environment

Our strategy:

Incorporate stimuli-responsive groups to "turn on" degradation after use



Increasing Degradation Potential



Degradation OFF



Degradation ON

On-demand polymer degradation

Polymerization, stimuli-response, degradation

Goal: Enhance degradability of polymer materials **after** use

Potential applications: replacement for current plastics, drug-delivery, biomedical applications