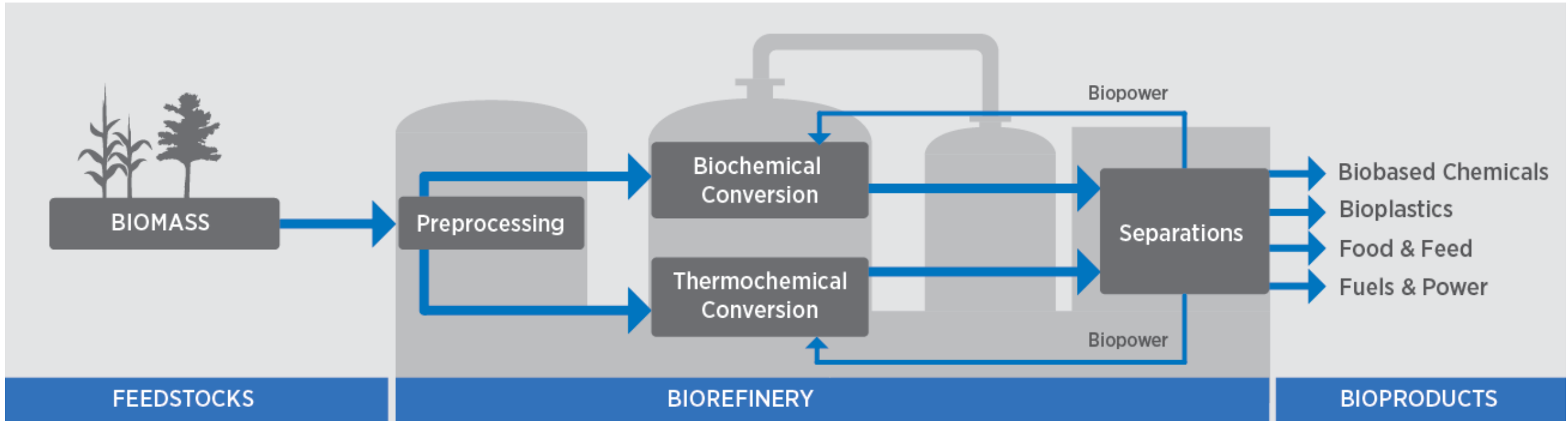
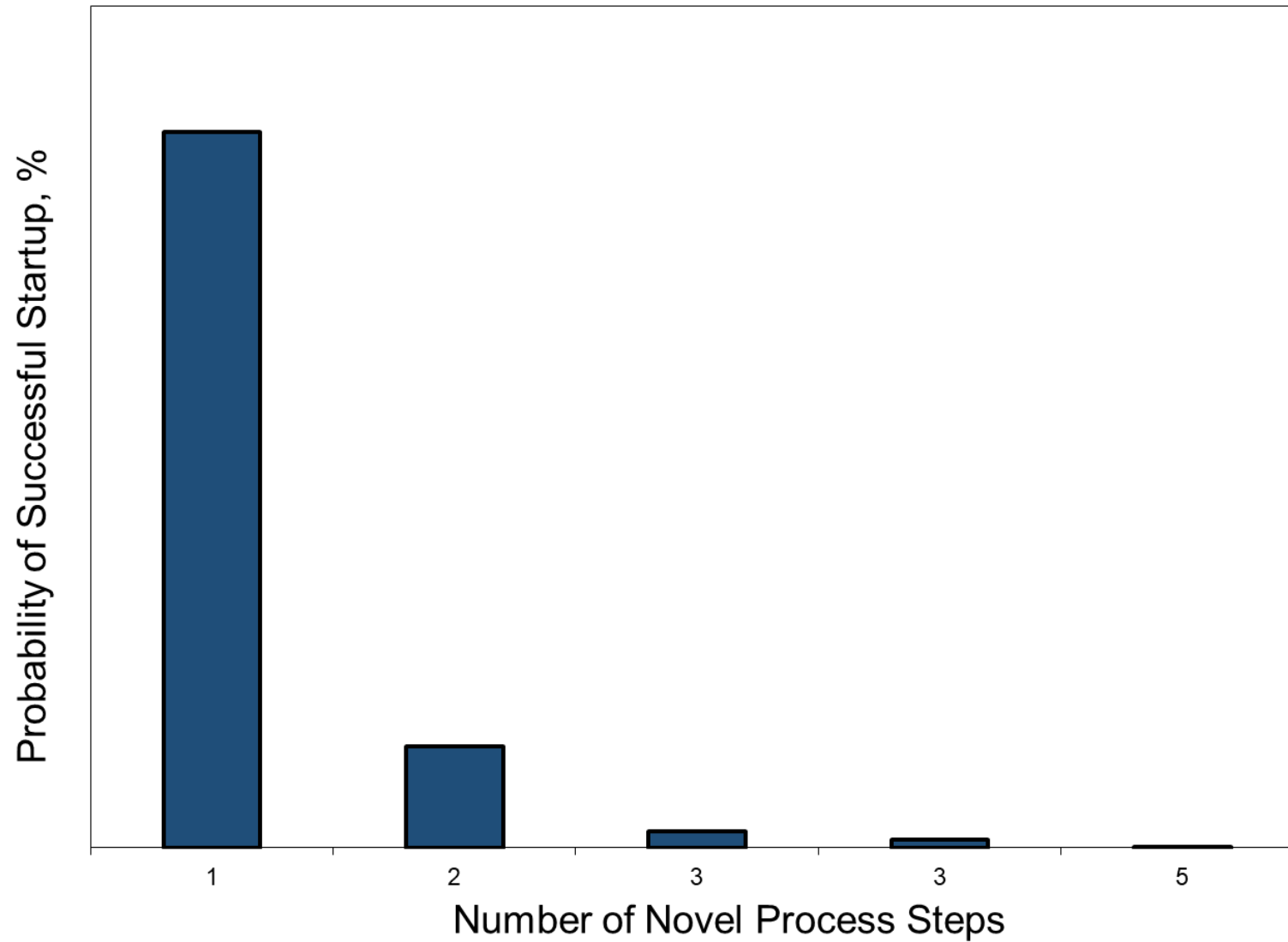


Utilizing 1st Generation Biofuel Production Facilities to Develop Enabling Biorefinery Technology

Biorefinery Vision



New Process Technology Reality



Process Leveraging Opportunities

- Process improvements
 - Microbe design for water utilization
- Technology integration demonstration
 - Furfural using γ -valerolactone solvent
- Product demonstration
 - Muconic acid as a bioprivileged molecules

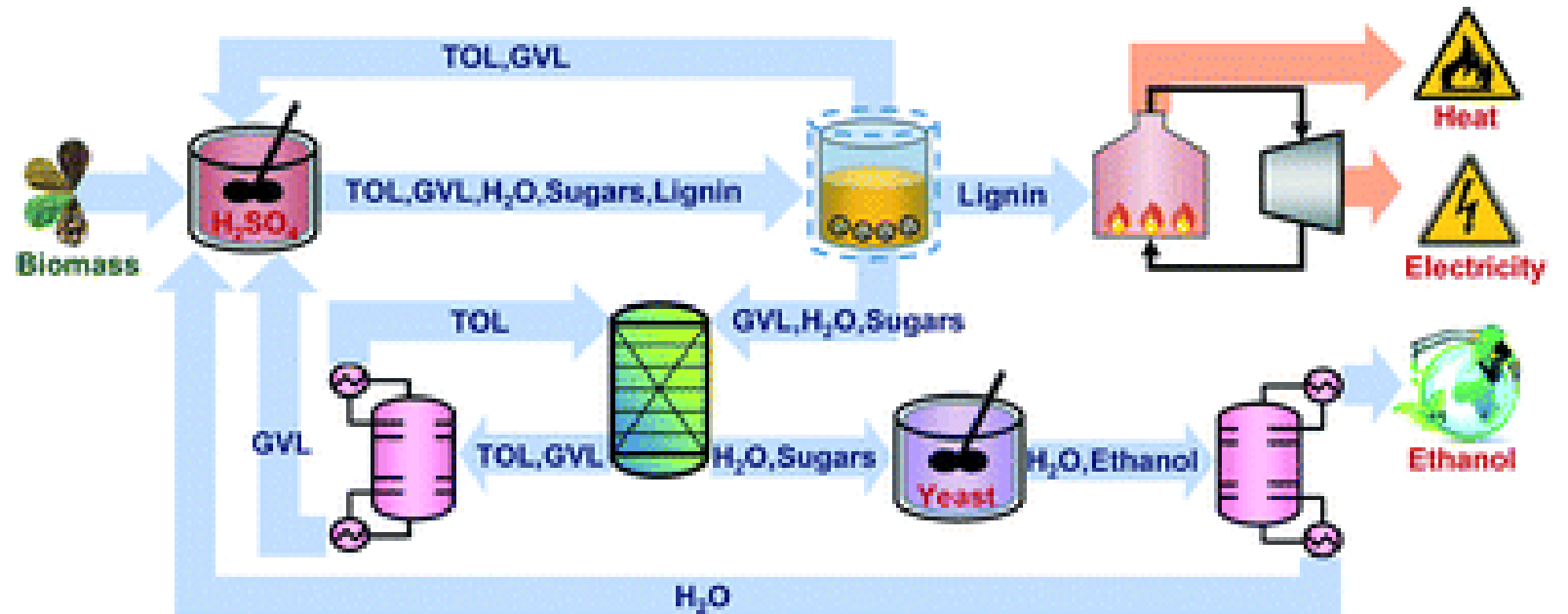
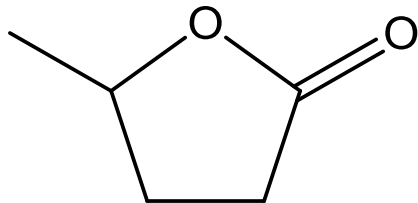
Process Improvements

- High water use rate
 - Estimated minimum of 2.85 gal water/gal ethanol*
- Areas of water usage
 - Cooling
 - Limited water recycling
- Microbial metabolic engineering targeted at water utilization
 - Higher temperature fermentation
 - Biogenic impurity tolerance

GVL Solvent Pretreatment - Biofuels

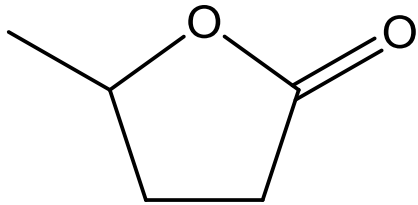


GREAT LAKES BIOENERGY
RESEARCH CENTER

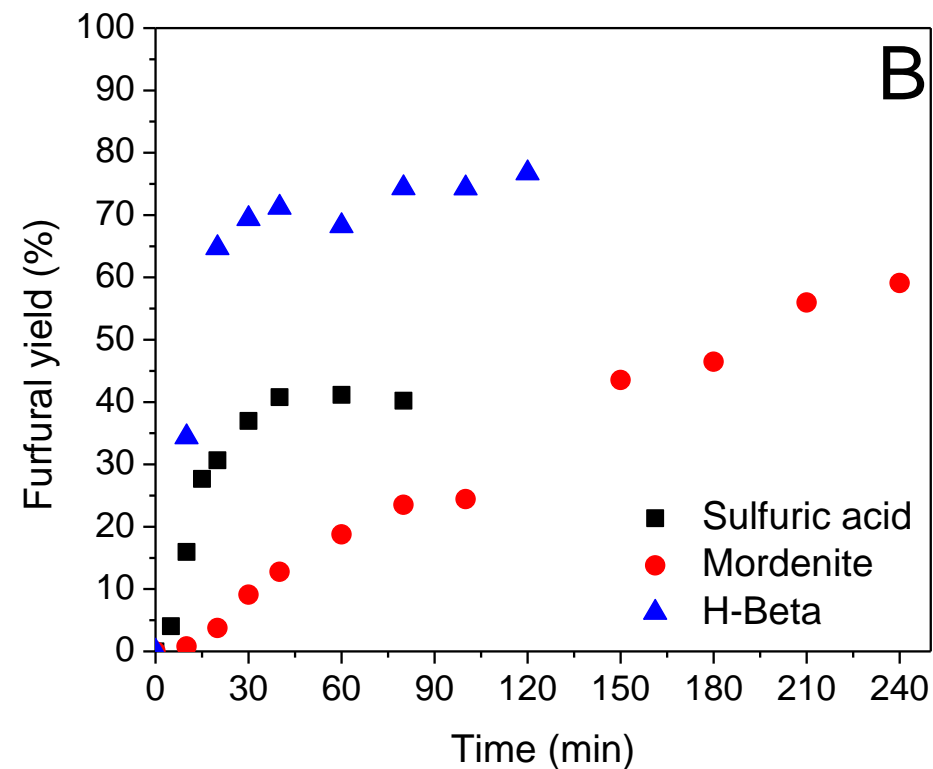
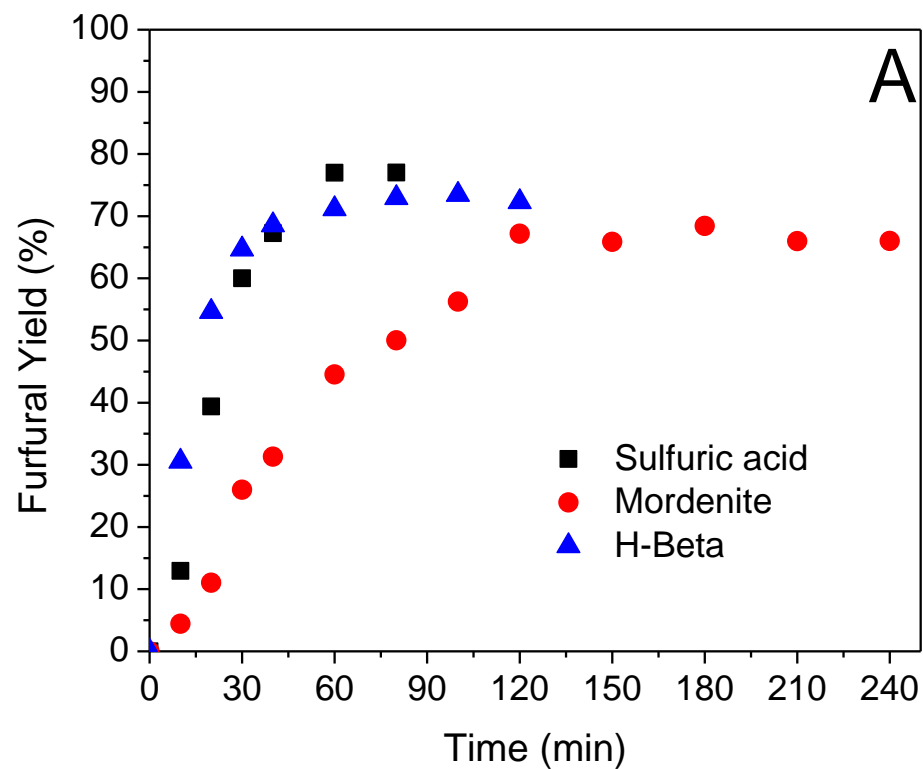


TOL: toluene, GVL: γ -valerolactone

GVL Solvent Utilization



C5 Dehydration in GVL



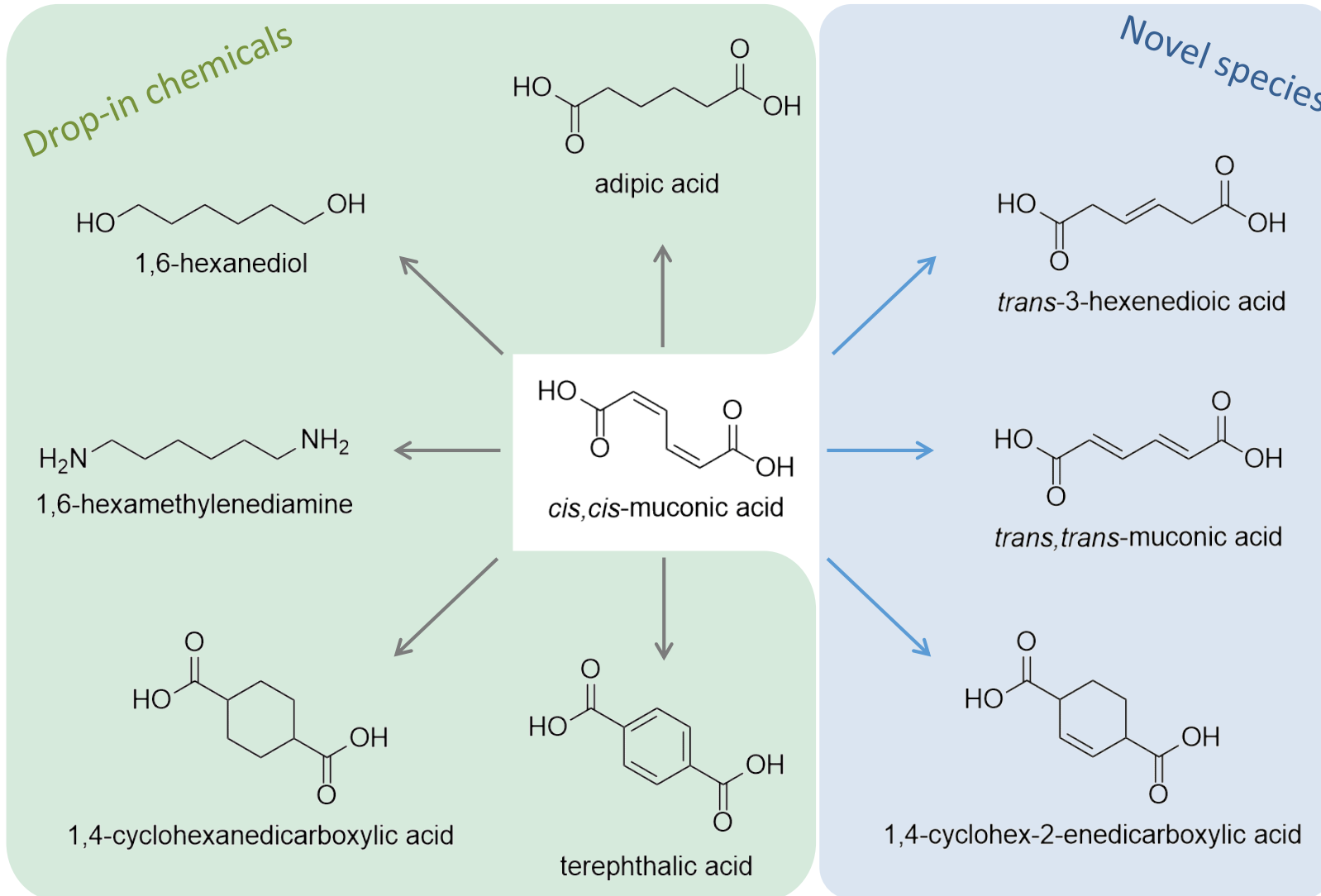
Dehydration of (A) xylose and (B) arabinose at 160°C using 0.05 M sulfuric acid and GVL containing 10 wt% water as solvent

Product Demonstration

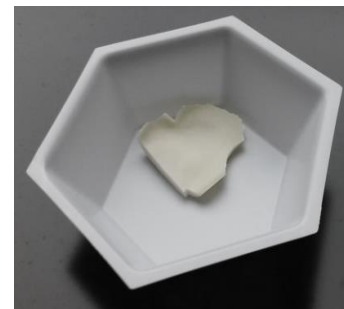
Bioprivileged molecules are defined as biology-derived chemical species that can be readily converted to a diversity of chemical products including both novel molecules and drop-in replacements.



Muconic Acid Platform



Bioadvantaged Nylon

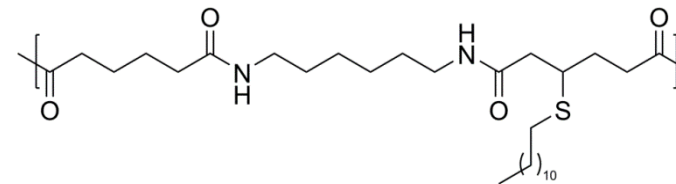
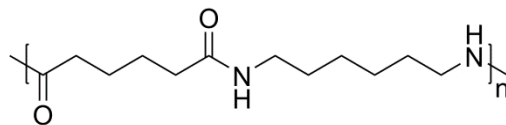


Polymer:

Nylon 6,6

Bioadvantaged Nylon 6,6 (2.5 wt% HDA)

Structure:



Water absorption:

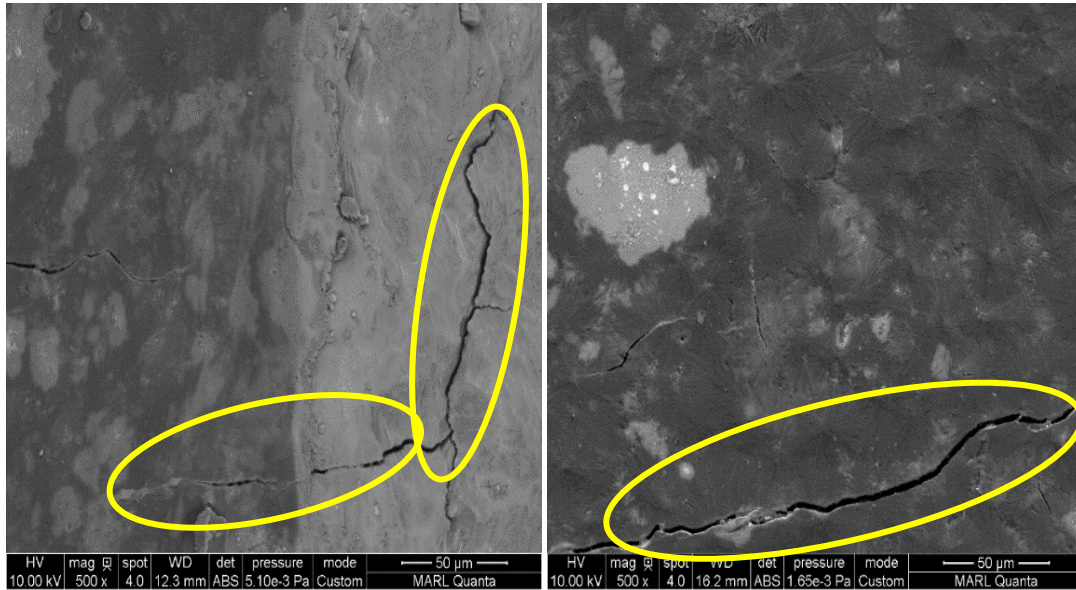
4.12 wt% increase

0.58 wt% increase

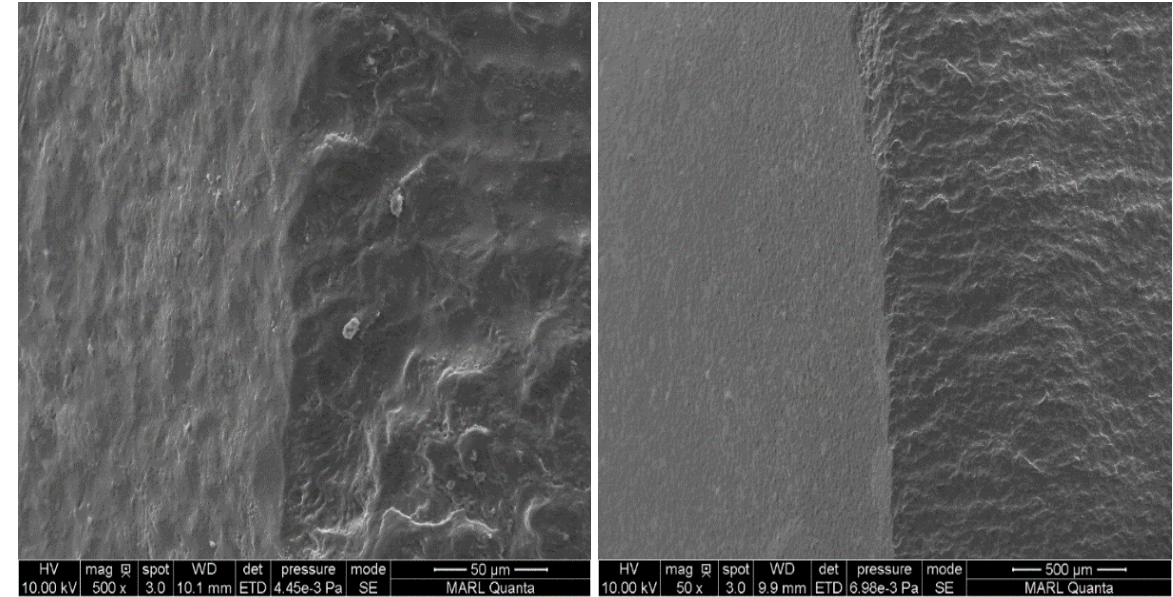
The mechanical properties of conventional Nylon 6,6 drop by 40% with the absorption of 2% moisture

Halide Resistance Test

Conventional Nylon



Bioadvantaged Nylon



Leveraging 1st Bioethanol Production

- Envision path to future biorefineries
- Establish **commercial** relevant steps (staged introduction)
- Target ongoing value creation!

Thank You