Enzymes Can Redesign Hemicelluloses for Use in Tailored Biomaterials

Background/Objective

- Hemicelluloses are structurally diverse plant polysaccharides with untapped potential for biobased materials, but their structural variability, influenced by botanical sources and extraction methods, presents challenges for tailored biomaterial applications.

Approach

This review compiles advances in enzymatic strategies for modifying hemicellulose including:

- Enzymes to control structural heterogeneity by selective removal of side groups
- Selective synthesis of hemicellulose using glycosyltransferases
- Polymerization of defined oligosaccharides using glycosynthases and transglycosylases
- Functionalization via enzymatic addition of functional groups for customized applications

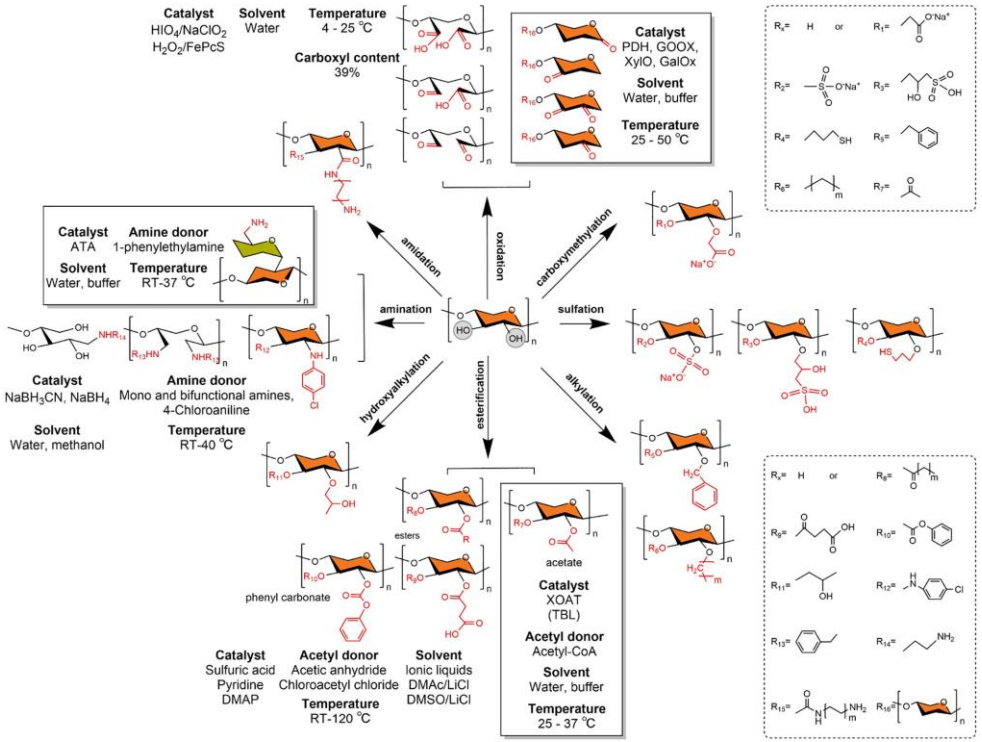
Results

- We highlight case studies demonstrating improved material properties post-enzymatic modification and review industrially relevant enzyme systems enabling scalable and sustainable processes.
- We emphasize how functionalization expands application potential; oxidation and amination reactions can be used to introduce novel chemical handles, enabling new bio-based materials.
- We describe how enzymatic approaches reduce structural heterogeneity, overcoming extraction challenges and improving downstream utilization.

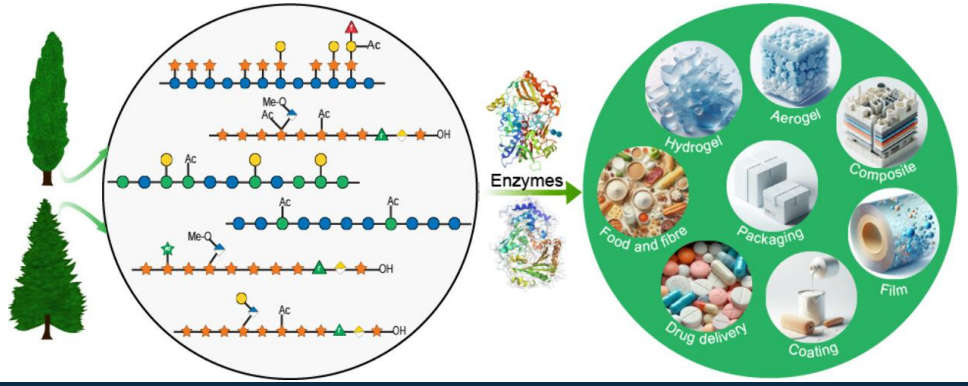
Significance/Impacts

- Plant cell wall biosynthetic enzymes are valuable biocatalysts for producing designer glycans, with application-focused screening efforts driving functional advancements. Collaboration between enzymologists and material scientists will enable tailored screening strategies for diverse feedstocks and end-uses, expanding the industrial potential of these enzymes in material and biomanufacturing applications.

Enzymatic and chemical strategies for hemicellulose modification



Application of hemicelluloses in bio-based materials



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