Chemical Engineering Thesis Defense

Leveraging the Power of Ligninolytic Enzymes to Valorize Lignin to Polyvinyl Phenol

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Abstract

Phenolic polymers like polyphenols and polyphenylenes have several industrial applications including electrical insulation, specialty membranes, and packings but are typically synthesized under harsh reaction conditions and require hazardous chemicals like formaldehyde. Hydroxycinnamic acids, such as p-coumaric acid (p-CA), are aromatic derivatives of lignin hydrolysates, an underutilized and promising renewable feedstock for production of phenolics and phenolic polymers. Recently a strain of Corynebacterium glutamicum has been created by the Joint BioEnergy Institute (JBEI) which expresses phenolic acid decarboxylase (PAD), an enzyme which catalyzes the reaction of p-CA to 4-vinylphenol (4-VP). Further, a deletion of the phdA gene prevents assimilation of p-CA, thereby increasing 4-VP yield. 4-VP is a substituted phenol which can be polymerized to poly(4-vinylphenol) (PVP) in the presence of ligninolytic enzymes like laccases or peroxidases. This work explores in situ polymerization of 4-VP to PVP by supplementing ligninolytic enzymes during fermentation. Cultured in the presence of p-CA, the engineered C. glutamicum strain achieved a maximum 4-VP yield of 45.2%, 57.9%, and 34.7% when fed 2, 5, or 10 g/L p-CA, respectively. To further investigate carbon utilization in the cell, the engineered strain was plasmid cured thus removing the PAD enzyme and 13C pathway analysis was performed. Polymerization experiments were performed and the polymer was characterized using NMR and GPC.

April 11, 2024; 2:45 PM; BDC.CL1-21

Zoom Link: https://asu.zoom.us/j/6571387500

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