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Conversion of Lignin from Lignocellulosic Biomass into Biodegradable Plastic

Abstract.

Lignin, a heterogeneous network of cross-linked aromatics, makes the cell walls of plants rigid and impervious. Breaking down lignin from lignocellulosic biomass to utilize its energy content and release the associated sugars for the production of high-value products is therefore a persistent problem for the energy industry. Microorganisms used to convert the sugars into biofuel often cannot metabolize lignin breakdown products (LBPs), such as monolignols and hydroxycinnamic acids, and the current biomass pretreatment processes partially degrade the preferred polysaccharides. A process that deconstructs lignocellulosic biomass, preserves the polysaccharides, and utilizes LBPs for high-value products has yet to be realized. It is proposed that the photosynthetic and facultative anaerobe *Rhodopseudomonas palustris* CGA009 (hereafter *R. palustris*) can be engineered to produce biodegradable plastics from carbon dioxide and LBPs. The microbe's natural storage product, polyhydroxybutyrate (PHB), will be the first biodegradable plastic optimized through this methodology. LBPs would be generated through a novel pretreatment method for lignocellulosic biomass that preserves the sugars for biofuel production, while the carbon dioxide could be derived from industrial sources, acting as a sink for the greenhouse gas. In anaerobic conditions, wild-type *R. palustris* fixes carbon dioxide to maintain redox balance, consumes multiple LBPs from corn stover hydrolysate, and makes PHB when nutrients are limited; however, *R. palustris* has yet to be forward engineered to take advantage of these traits. Advances in systems and synthetic biology tools and biomass pretreatment provide the means from which a methodology that converts lignin into PHB can be developed. The conversion of two waste streams, lignin and carbon dioxide, into PHB would boost biofuel profitability. Engineering *R. palustris* to maximize the production of PHB from lignocellulosic biomass co-products would help establish the metabolically versatile bacterium as a biotechnology platform that produces a number of renewable products, all from problematic, low-value lignin.