Build back better: preserving and building on natural structures to make new biobased chemicals and materials

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The development of various renewable chemicals sustainable such as plastics or solvents from abundant renewable feedstocks has been limited by the complexity and efficiency of their production, as well as their lack of competitive properties. Here, I will discuss the direct integrated transformation of biomass into a functionalized lignin fraction that can be used as a surfactant, and a xylan-derived solvent or polyester precursor at high yields (>80%) by fractionation in the presence of multifunctional aldehydes. Using simple aldehydes such as formaldehyde can lead to diformylxylose production, which is an interesting polar aprotic solvent candidate that can be used for several commercially relevant reactions. Using glyoxylic acid as the aldehyde leads to a hydrophilic lignin fraction that can be used as a surfactant and a diacid from xylose that can be esterified and separated for use in polymer chemistry. Melt polycondensation of the resulting xylose-derived diester with a range of aliphatic diols or diamines led to high-molecular weight polyesters or polyamides, respectively. In both cases, materials with high performances were achieved (i.e. high glass transition temperatures with great strength and toughness) despite not using aromatic monomers. Instead, we suggest that the (often less toxic and more abundant) carbohydrate core, could serve as a replacement for aromatic moieties in many performance applications. The production of these useful and high performance chemicals by straightforward acid-catalyzed functionalization during biomass fractionation could drastically simplify the production of several biobased chemicals.