

Sustainable Conversion of Biomass: Cooking or Art or Science?

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Sustainable development was poorly defined in the 1980s,¹ since the key requisite to accurately predict the needs of future generations has been impossible to meet due to the extremely fast rate of scientific and technical advances. Consequently, sustainability was replaced with suitability by many stake holders, as they had vested interests to call suitable developments sustainable, e. g. to make profits for businesses, get funding for NGOs, or to be elected/re-elected by politicians and political organizations. In order to overcome the vested and sometimes conflict of interests, we suggested a measurable definition of sustainability: *Nature's resources, including energy, should be used at a rate at which they can be replaced and the generation of waste cannot be faster than the rate of their remediation.*² We have defined the *real ethanol equivalents (EE_x)*² of carbon based chemicals and fuels, the *sustainability values of resource replacement (SV_{rep})*³ and *fate of waste (SV_{waste})*,³ which were used to establish a *sustainability indicator (SUS_{ind})*³ to assess the sustainability of fossil and biomass based chemicals and fuels.

Dimers, oligomers, and polymers of monosaccharides (sugar, cellulose, hemicellulose, starch, chitin, etc.) are the largest constituents of biomass, which could be used for the production of carbon-based chemicals and fuels in a lesser extent. We have identified several intermediates and different reaction paths for the sulfuric acid catalyzed conversion of fructose and glucose to 5-(hydroxymethyl)-2-furaldehyde (HMF) in different solvents.^{4,5} The acid catalyzed hydration of HMF leads to the formation of levulinic acid (LA) and formic acid (FA),⁵ which can be converted to gamma-valerolactone (GVL)^{6,7} the presence of the Shvo-catalyst.^{8,9}



Currently we are focusing on the valorization¹⁰ of agricultural residues and food wastes to produce platform chemicals including HMF, LA, FA, acetic acid (AA), GVL, and furfural (FF) under mild conditions.^{11,12} It should be noted, that the hydrogenation of FF resulted in furfuryl alcohol (FFA) which was converted to LA by hydro-isomerization. In the case of chitin, its acid catalyzed conversion to HMF is accompanied by the formation of AA and ammonium salts. In order to secure facile separation we have now immobilized the Shvo-catalyst to silica coated magnetite nanoparticles. *In situ* IR and NMR spectroscopic methods have been used to provide molecular level insights to many of the reactions involved.⁴⁻⁹

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