4ac Sustainable Technologies for Biomaterials from Renewable Resources

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We obtain high value-added chemicals and materials from biomass, specifically forest products, utilizing state-of-the-art extraction, separation, and chemical conversion techniques. The specialty chemicals industry is continually evolving, by which new chemistry trends, discoveries and innovations are implemented for technological advancement with environmental and economic benefit. Gas-expanded liquids are tunable solvents which offer significant opportunities for improving both operating economics and environmental sustainability for the production of bio-based value-added chemicals, with applications ranging from natural products to pharmaceutical and polymer precursors. They show excellent solvent strength and transport properties, enabling the penetration of solid matrices, while the tunability renders them ideal for separations and the tailoring of chemistry to facilitate desired reactions.

Specific advantages of tunable solvents include:

• Environmentally benign - low cost, low toxicity, low waste, energy efficient, carbon-neutral.

• Opportunities to use "natural acids" via formation of alkylcarbonic acids from CO_2 expanded alcohols. Their formation is reversible; thus eliminating neutralization/waste disposal.

• Opportunities to perform oxidation without catalysts, using nearcritical water or supercritical methanol.

• Enhanced extraction, selective fractionation and product purification.

• Ease of scaling and implementation – many similar processes are now in use.

The project focuses on two major pathways:

1) Obtaining value-added chemicals from industrial biomass waste streams; eg. black liquor stream from paper mills. We have demonstrated the value of these methods by extracting vanillin ($5/lb.), syringol ($15/lb.), and syringaldehyde ($25/lb.) from a lignin mixture (black liquor side stream, 2-3¢/lb.). The result of industrial application to a working paper mill would entail economic and processing benefits with no process disruption.

2) Using waste forest products to produce high value added chemicals. Currently, an industrial facility is near completion in Caserta, Italy that will use dilute mineral acids to hydrolyze and break down biomass containing lignocelluloses into furfural, levulinic acid, and lignin. Our approach is similar – following the extraction of desired specialty chemicals, the biomass will be processed with reversible acids, as opposed to mineral acids, providing benefits in waste reduction and product isolation. Product markets beyond specialty and commodity chemicals, including advanced materials / composites and a clean source of hydrogen and carbon feedstocks.

There is potential for interdisciplinary collaboration including: industrial partners for technology transfer, material science for the production of natural fiber based materials, and bio-engineering / genetic modification of trees for desired products. Application of these new technologies for the conversion of low-value forest biomass into high-value chemical compounds has the potential to provide a sustainable alternative to oil based industries that is economically competitive, environmentally attractive, and carbon-neutral.