

## HIGH TERPENE PINES: TRANSFORMING EXISTING AND ENABLING NEW FOREST BIOREFINERIES

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Forest biorefineries are one of the oldest and still the best examples of processing lignocellulose rich biomass to a wide array of renewable chemical and biomaterial products. For example in the US south, Kraft linerboard facilities breakdown wood from southern pine and hardwoods into fibrous pulp which is used to make base and top ply sheets for cardboard boxes, and the extracted liquor containing lignin, carbohydrates, fatty acids, and terpenes, are concentrated and separated prior to recovery of the inorganic pulping chemicals. While the lignin and carbohydrates are currently burned for energy, the hydrocarbon rich monoterpenes are recovered from the top of the digester as crude sulfated turpentine (CST) and fatty acids, diterpenes, and unsaponifiables are recovered from the spent pulping liquor as crude tall oil (CTO) soaps. CST and CTO co-products are sold to pine oleochemical refiners for separation and upgrading into a diverse set of products. Globally, pine oleochemicals are a >\$3 billion annual market, that is limited by CST and CTO supply. CST and CTO yields are limited primarily by the extractive content of pine wood, which averages 3-5% of the dry weight. We are developing high terpene southern pine trees to dramatically boost recovery of CST and CTO for the existing pine oleochemical industry as well as to supply advanced drop-in biofuels suitable for jets, ships and cars. Justification for development of high terpene pines and the potential impact on Kraft linerboard mill production and economics as a case study will be presented together with other possible alternative configurations of forest biorefineries that could maximize production of pine oleochemicals and value from pine lignocellulose.