Catalytic Conversion of Lignin in Ionic Liquids *via* Catalysis and Biocatalysis

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Converting lignin into high value chemicals adds revenues for a bio-refinery and helps to improve the economic viability of biofuel production. Ionic liquids (ILs) have received increasing interest because of their potentials in fractionating and pretreating lignocellulosic biomass. ILs containing ions made of naturally occurring bases and acids from sugars, protein, and phenolic has recently emerged and proven more biocompatible and less costly compared to petroleum based ILs. We foresee a great opportunity to develop a new strategy for lignin fractionation and upgrading via catalysis and biocatalysis in aqueous ILs. In situ lignin conversion in IL will also tackle some of the challenges associated with IL recycle and recovery. In this work, a portfolio of ILs were synthesized, characterized, and screened for improved lignin solubility and selectivity on lignin depolymerization. The stability and activity of commercial fungal and plant laccases were evaluated in these ILs. Results suggest that certain ILs are fully compatible with laccases; while some appeared as non-competitive inhibitors to laccases. Immobilization of laccase on solid matrix, i.e. membrane surface helps to retain the enzyme activity and overcome the inhibition effects. We also explored catalytic oxidation route in ILs by screening a range of metal catalysts and oxidizing agents. Molecular weight distribution of lignin fraction was followed using gel permeation chromatography while the oxidation products such as vanillic acid, syringaldehyde, and syringic acid were identified and quantified using a GC-MS. Cleavage of the lignin inter-unit linkages were further investigated by NMR to understand the plausible oxidation mechanisms. Results from this study provide insights into the oxidative degradation pathway of lignin in the presence of IL and the selectivity of catalyst towards product formation.