The Catalytic Depolymerization of Kraft Lignin (Valorization of Industrial Byproduct) via a Clamshell-Derived Calcium Oxide Catalyst for the Synthesis of High-Value Aromatic Monomers

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Abstract.
This study investigates the synthesis and application of a calcium oxide (CaO) catalyst, derived from clamshell, for the depolymerization of Kraft lignin obtained from black liquor, a by-product in pulp mills. The research explores various process parameters, about reaction solvents, temperature, and duration. The optimal conditions resulted in a peak bio-oil yield of 35.8 wt% at 340 °C using water as the solvent. However, the introduction of an alcoholic solvent, specifically methanol, significantly enhanced lignin depolymerization. The maximum bio-oil yield of 72.4 wt% was achieved utilizing a 10 wt% CaO catalyst in methanol solvent at 340 °C during a 4-hour reaction. Bio-oil analysis revealed that the non-catalytic reaction yielded bio-oil with a low total area percentage of phenolic compounds, predominantly comprising alkyl phenols with a minor presence of methoxy phenols. Interestingly, the CaO catalyst facilitated the promotion of lignin macromolecule depolymerization, resulting in an increased selectivity (58.7%) toward catechol compounds. Fourier transform infrared (FT-IR) spectroscopy analysis demonstrated a higher functionality of aromatic and methoxy compounds in catalytic bio-oils compared to non-catalytic counterparts. These findings underscore the efficacy of the clamshell-derived CaO catalyst in augmenting lignin depolymerization, thereby enhancing bio-oil yield and influencing the bio-oil composition. The study contributes valuable insights into sustainable practices by repurposing industrial by-products and advancing catalytic processes for lignin conversion.