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Sustainable Biomass-to-Energy Transformation: Choline Chloride Based Deep Eutectic Solvent for Lignin Extraction and Liquefaction

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Biomass is often renowned as one of the inexpensive and largest sources of non-depleting energy in the world, attributed to its great potential for continuous and sustainable supply of energy in the form of biofuels and various value-added products. With the increasing demand to preserve the environment, the use of green solvents, such as deep eutectic solvents (DESs), is desirable, given their capability to reduce the generation of hazardous substances. In this work, choline chloride based DESs have been used to extract lignin from biomass. The structure and thermal stability of the extracted lignin are analysed using Fourier-transform infrared spectroscopy (FT-IR) and thermogravimetric analysis (TGA), respectively. FT-IR spectra revealed that chemical properties of lignin were determined through absorbance peaks corresponding to hydroxyl and C-H stretching, as well as the presence of carbonyl moieties and phenolic groups. TGA analysis of lignin showed weight loss peaks at 66 °C, 256 °C, and 319 °C, with major weight loss at 200 - 350 °C due to lignin degradation and release of monomeric phenols, resulting in a final residue consisting of non-volatile solids associated with condensed aromatic structures and lignin ash at 740 °C. The extracted lignin was then subjected to subcritical water-supercritical CO_2 hydrothermal liquefaction (HTL) and converted into bio-oil. In this context, HTL proves its benefits by providing the highest yield of 77.41 % using optimum parameters of lignin-to-water ratio (1:5), pressure (20 MPa), temperature (275 °C) and time (60 min). The functional groups of bio-oil derived from the extracted lignin were analysed using FT-IR, which proves the functional groups (phenols, carboxylic acid, ketones, carboxylic acid, esters and aromatic groups) present in the bio-oil. Detailed information regarding the HTL of lignin derived from biomass, which circumvents the need for energy-intensive drying procedures, is critical in mitigating the challenges posed by the abundance of biomass residues.

1. Introduction

As the search for a viable renewable energy source continues, many studies have been conducted over the years that have proven the potential of biomass. One of the potential sources of biomass is the Empty Fruit Bunch (EFB) which comes from oil palm mills. EFB has a high potential to be converted into renewable energy due to its characteristics as lignocellulosic biomass; it is mainly composed of polysaccharides (cellulose and hemicelluloses) and an aromatic polymer (lignin). Typical lignocellulosic biomass consists of 30 - 60 % cellulose, 20 - 40 % hemicellulose and 15 - 25 % lignin (Zoghlami and Paës, 2019). The lignin, cellulose, and hemicellulose in lignocellulosic biomass are clustered in a complex three-dimensional structure that renders it resistant to chemicals and microbial assault and difficult to hydrolyse (Yiin et al., 2015). Therefore, pretreatment processes are needed to unleash the trapped potential in lignocellulosic biomass.

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