Hydrotropic Extraction of Lignin from Vegetation Mass

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Short Communication

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ABSTRACT

The current involves optimizing the extraction of lignin from dried leaf vegetation using the hydrotrope, a green solvent at low temperature and pressure. The optimum parameters for lignin extraction were 30% w/v of hydrotrope NaXS, 373 K extraction temperature, and 12.5% w/w leaf loading concentration. Thermal energy applied during the process disturbs the bonds within the lingo-cellulosic structures and increases the movement of the molecules and subsequently increases the mass transfer, and assists in the solubilization of the plant material

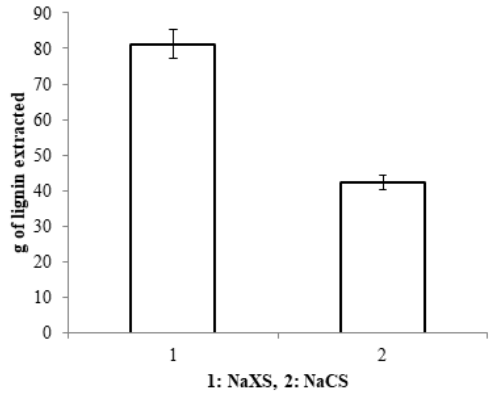
ABOUT THE STUDY

Dried leaf vegetation is a voluminous bio-waste serving as a source of a valuable chemical entity ‘lignin’[1,2]. The challenges involved in the available lignin extraction processes are lignin separation from the strong cellulosic bonds and involvement of chemicals, high temperature, and pressures in the process [3-7]. To overcome the shortfalls of the available extraction processes the current research focuses on optimizing lignin extraction and its characterization.

Effect of type of hydrotrope on extraction of lignin

The optimum parameters for lignin extraction were 30% w/v of hydrotrope NaXS which gave 81% w/w of lignin extraction compared to Na-CS (42% w/w), generally depending on the hydrocarbon chain length, the efficiency of hydrotropes to extract active materials from plant matrices varies 8 (Figure 1) The current study did not explain the reason for NaXS to be a more effective hydrotrope for the de-lignification of dried leaves. Nevertheless, it could be because of the much larger molecular weight of Lignin [8,9].

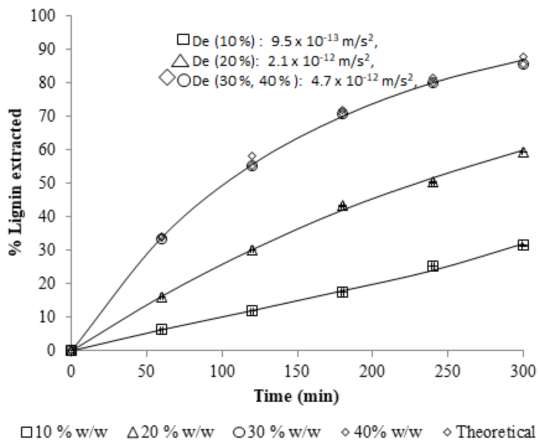
Figure 1. Effect of type of hydrotrope on de-lignification of dried foliage at 900 rpm, 100 °C, 5% w/w leaf loading concentration, 300 min extraction time.



Effect of concentration of hydrotrope on extraction of lignin

With increase in hydrotrope concentration from 10% to 30% w/w there was significant increase in delignification (Figure 2). The reason for significant increase in delignification with increased hydrotrope concentration was attributed to improved permeabilization of active material at the minimum hydrotrope concentration [10].

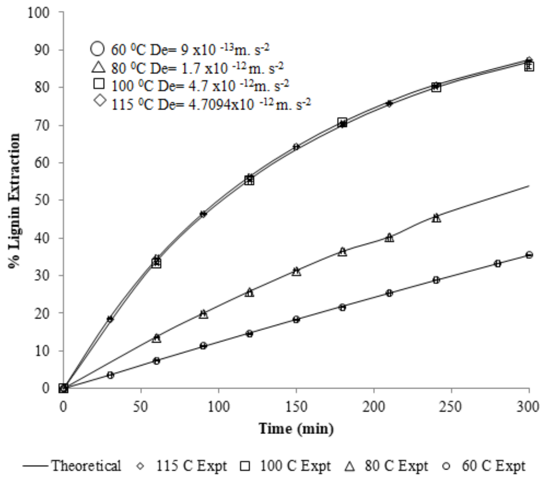
Figure 2. Effect of Concentration of NaXS on de-lignification of dried foliage at 900 rpm, 100 °C, 5% w/w leaf loading concentration, 300 min extraction time.



Effect of temperature on extraction of lignin

In the current study it was observed that with the incremental change in the temperature from 333 K to 373 K, the lignin extraction improved from 31.5% w/w to 81.1% w/w, while above 373 K, the de-lignification was insignificant (Figure 3). Thermal energy applied during the process disturbs the bonds within the lingo-cellulosic structures and increases the movement of the molecules and subsequently increases the mass transfer, and assists in the solubilization of the plant material [11].

Figure 3. Effect of temperature on hydrotropic extraction of lignin at 5% w/w leaf loading concentration, 900 rpm, 300 min extraction time, 30% hydrotrope NaXS.



Effect of leaf loading concentration on extraction of lignin

The lignin extraction increased with an increase in leaf loading from 5% w/w to 10% w/w. The percentage of lignin extracted was 80% to 81% w/w at 10% dry leaf loading concentration, but at and above 12.5% w/w of leaf loading concentration, the percentage of lignin extraction decreased. Hence, the solid loading concentration was limited to 10% w/v to allow the proper mass transfer and to improve contact of lignin with extracting hydrotrope (Figures 4a and 4b). In literature reports, such limitations for the solid loading concentration are observed [12].

Figure 4a. Effect of dried leaf loading concentration on the percentage of Lignin extraction at 80°C, 30% w/w hydrotrope NaXS, 900 rpm, 400 min extraction time.

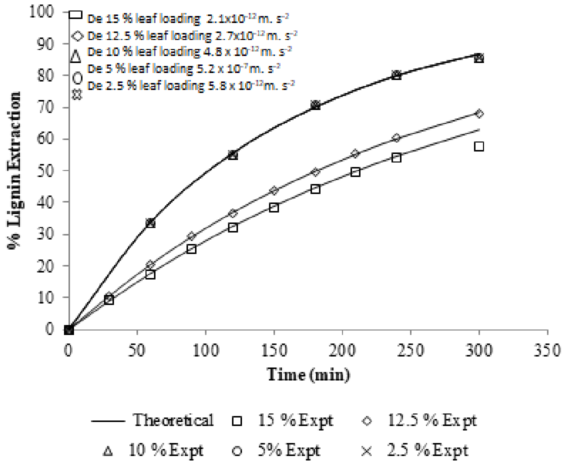
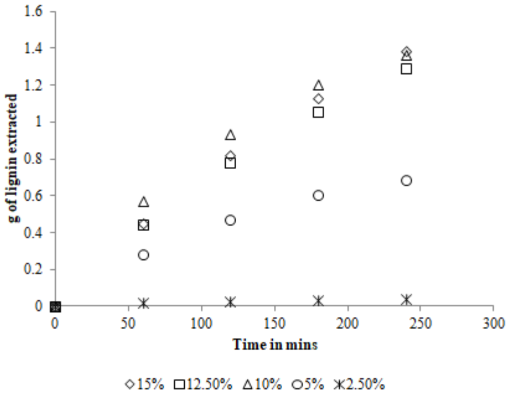


Figure 4b. Effect of the percentage of dried leaf loading concentration on Lignin extraction in gram unit.



The diffusion co-efficient of the optimized process was 4.8 × 10-12 m. s^{-2}, and the activation energy was 52.9 kJ.mol^{-1}. The obtained lignin was chemically and physically of standard quality confirmed by its UV-absorption spectrum, infrared spectroscopy, gas chromatography-mass spectroscopy, differential scanning calorimetry, X-ray diffraction study, scanning electron microscopy, gel permeation chromatography.

DISCUSSION

The current process assists in the selective extraction of free-flowing, amorphous, dark brown lignin powder with a molecular weight of 4509 g.mol^{-1} lignin simply by dilution with water at reduced temperatures; which is unlike several other tedious methods required for lignin extraction [13]. The delignification percentage is comparable to that mentioned in the literature, using 1, 4–butanediol and that using sodium xylene sulfonate solution and ionic liquid (IL) 1-ethyl-3-methylimidazolium and alkyl benzene sulfonates [14-16].

The physical characteristic of the extracted lignin was comparable with those mentioned in the literature [16-21]. The lignin extracted by the current process is free from traces of any solvents and chemicals. Hence, it can be denoted as lignin without giving it any additional suffix or prefixes unlike the e.g. kraft lignin or alkali lignin, etc named in the literature [4-7,22,23].

CONCLUSION

The investigation has focused on developing a green method for the extraction of lignin from dried leaves using aqueous hydrotropic solutions and is devoid of chemicals and solvents. Parameters including effect of extraction temperatures, time, hydrotrope concentrations, and suspension loading were optimized along with reusability of the hydrotrope. The process is an excellent replacement to the traditional de-lignification processes, where the recovery and generation of an effluent is a significant problem.

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