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Extraction and Properties of Nonwoody Lignin: A Sustainable Perspective

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Abstract

Lignin, the second most abundant natural polymer after cellulose, is a key structural component of plant cell walls and a renewable feedstock for sustainable materials. Nonwoody lignin from agricultural residues and fast growing plants such as rice husk, wheat straw, sugarcane bagasse, hemp, flax, jute, sisal, and abaca differs markedly from woody lignin in structure and reactivity. It is rich in hydroxyphenyl units and ester linked hydroxycinnamic acids, giving it lower molecular weight, higher heterogeneity, and greater chemical reactivity. These features enhance its potential for conversion into functional biomaterials and biobased products. This chapter reviews extraction and characterization of nonwoody lignin. Conventional methods such as acid hydrolysis, alkaline pulping, and organosolv extraction remain common but often degrade lignin and generate waste. Newer green extraction approaches include deep eutectic solvents, ionic liquids, enzymatic treatments, microwave assisted processes, and supercritical fluids better preserve native structures, improve purity, and reduce environmental impact. The physicochemical properties of nonwoody lignin are examined through Fourier transform infrared (FTIR) spectroscopy, nuclear magnetic resonance (NMR), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and molecular weight analysis. These techniques reveal its diverse functional groups, relatively low thermal stability, and high reactivity, making it suitable for polymers, resins, composites, and specialty chemicals. Overall, sustainable extraction coupled with systematic characterization is essential to unlock the full potential of nonwoody lignin. Continued advances in green technologies and structural understanding will strengthen its role in the circular bioeconomy. © The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2026.

Author keywords

Circular bioeconomy; Extraction methods; Green technologies; Nonwoody lignin; Physicochemical properties; Sustainable biomaterials

Indexed keywords

PaperChem Variable

Alkaline Pulping; Bagasse; Extraction; Hemp; Molecular Weight; Reactivity

Engineering controlled terms

Agricultural wastes; Bioeconomy; Biomaterials; Chemical stability; Hemp; Ionic liquids; Lignin; Molecular weight; Physicochemical properties; Plants (botany); Supercritical fluid extraction

Engineering uncontrolled terms

Circular bioeconomy; Extraction method; Functionals; Green technology; Nonwoody lignin; Physicochemical property; Plant cell wall; Property; Structural component; Sustainable biomaterial

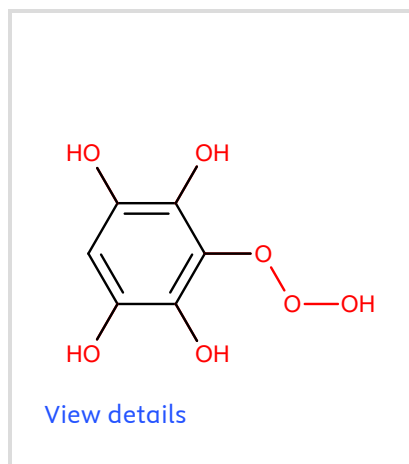
Engineering main heading

Differential scanning calorimetry; Fourier transform infrared spectroscopy

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