Solid-State NMR at Natural Abundance for Bioenergy Applications

Background

- Solid-state Nuclear Magnetic Resonance (ssNMR) of ^{13}C-enriched biomass has been highly valuable over the past decade for revealing the nanoscale structure of intact lignocellulose and related bioenergy materials. While powerful, ^{13}C-enrichment is hindered by high cost and limited scale. This review highlights the potential of ssNMR at natural isotopic abundance to provide non-destructive molecular insights into bioenergy materials.

Approach

This review explores ssNMR techniques for lignocellulosic biomass focusing on:

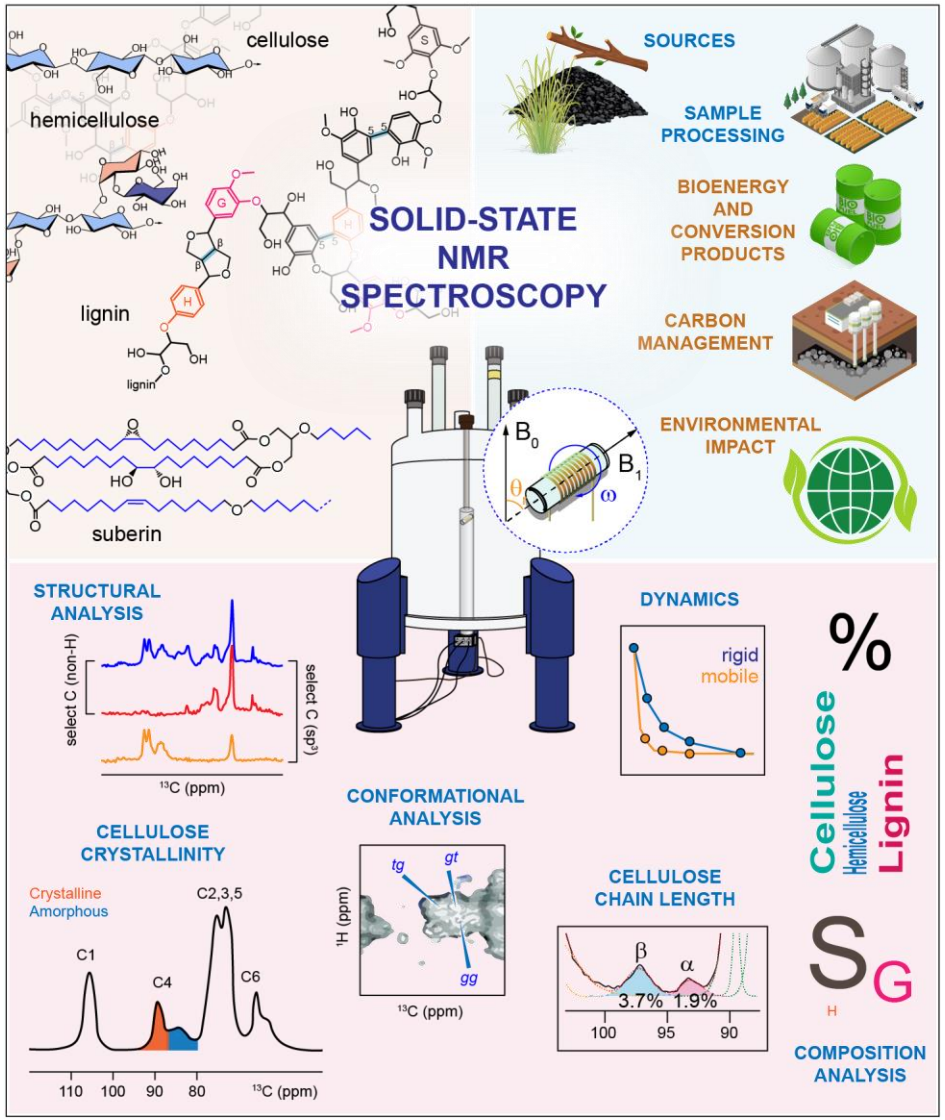
- Introduction to fundamentals of ssNMR.
- Articulation of common polymers and chemical species observable by ssNMR.
- Demonstration of routine ssNMR methods applied to biomass and its deconstruction.
- Description and demonstration of advanced 1D and 2D ssNMR methods at natural abundance.

Results

- ssNMR of natural abundance biomass reveals non-destructive insights into composition, conformation, spatial arrangement, and dynamics.
- ssNMR effectively tracks chemical and structural changes in lignocellulose during conversion to value-added fuels and products.

Significance/Impacts

- ssNMR offers a robust, non-destructive platform for molecular-level analysis of lignocellulosic biomass and other energy-relevant materials, eliminating the need for expensive isotopic labeling. This review aims to promotes expanding access to ssNMR methodologies for broader adoption of this technique in bioenergy research, reinforcing its role as a pivotal analytical tool in sustainable biomass utilization and the advancement of a carbon-neutral bioeconomy.



Overview ssNMR applications for structural and compositional analysis of lignocellulosic biomasses.

Addison, B. et al. *Biotechnol. biofuels bioprod* (2025), https://doi.org/10.1186/s13068-025-02648-z