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Integrated Green Biorefinery for the Production of Anthocyanins, Fermentable Sugars, and High Pure Lignin from Miscanthus × giganteus

Background/Objective

Miscanthus x giganteus (Mxg) is a promising perennial crop for producing natural colorants, renewable fuels, and bioproducts. However, natural recalcitrance and high pretreatment cost are major barriers to their complete conversion. Building on our previous study of natural deep eutectic solvents (NADES) applied to bioenergy crops as a less expensive green solvent system for extraction, we investigated various choline chloride-based NADES systems for efficient recovery of natural pigments (anthocyanins), fermentable sugars, and pure lignin from Mxg genotypes.

Approach

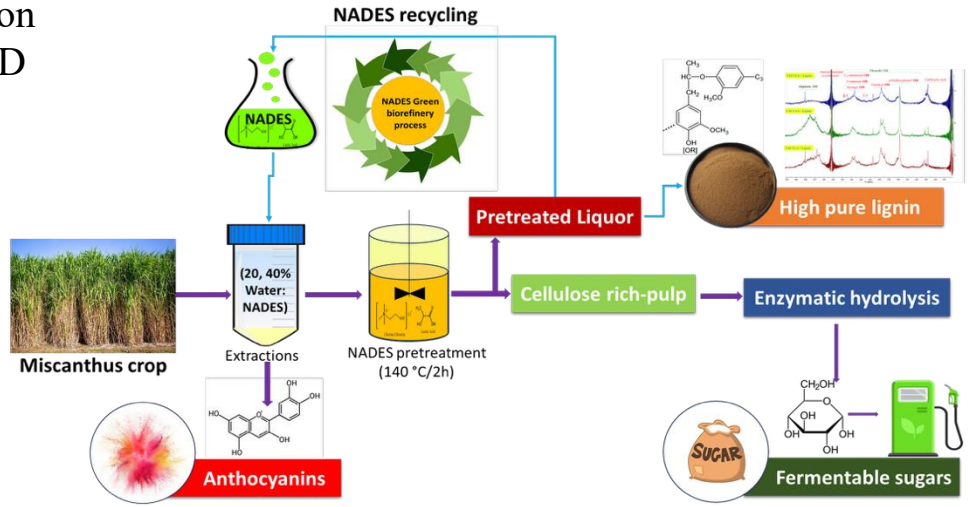
Seven choline chloride-based, aqueous NADES systems, lactic acid (ChCl:LA), acetic acid (ChCl:AA), malic acid (ChCl:MA), citric acid (ChCl:Cit), glycerol (ChCl:Gly), ethylene glycol (ChCl:EG), and glucose (ChCl:Glu), were evaluated for pretreatment of Mxg bagasse at 10% (w/w) solids, followed by enzymatic saccharification. The effective extraction of high-purity lignin containing higher β-aryl ether (β–O–4) bonds is crucial for lignin valorization. A composition analysis of NADES-precipitated lignin was performed using compositional ^{31}P NMR and 2D HSQC analysis.

Results

Biomass processed with ChCl:LA resulted in ~67 µg/g of anthocyanins from dry biomass and a maximum glucose yield of 94.1% after enzymatic saccharification. Notably, highly pure lignin (≈93.4%) was achieved after low-temperature pretreatment while retaining lignin's native structure. Total phenolics for ChCl:LA-processed lignin was 1.20 mmol/g hydroxyls. The relative monolignol composition of syringyl (S), guaiacyl (G), and p-hydroxyphenyl (H) is 19.0, 65.7, and 14.3%, respectively.

Significance/Impacts

This study provides a novel approach for obtaining natural colorants, fermentable sugars, and high-purity lignin bioproducts leveraging current cellulosic biorefinery technologies.



NADES-assisted bioprocessing of Mxg to produce anthocyanins, sugars, and lignin.

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