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Development of an ammonia pretreatment that creates synergies between biorefineries and advanced biomass logistics models†

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A novel ammonia-based pretreatment for densified lignocellulosic biomass was developed to reduce ammonia usage and integrate with viable biomass logistics scenarios. The COmpacted Biomass with Recycled Ammonia (COBRA) pretreatment performed at 100 °C allows >95% conversion of sugarcane bagasse (SCB) carbohydrates into soluble monomeric and oligomeric sugars (glucose and xylose) using industrially relevant 6% glucan loading (~21% solids loading) enzymatic hydrolysis conditions at reduced enzyme loadings. Pretreatment *via* COBRA with simultaneous lignin extraction (COBRA-LE) improved *Saccharomyces cerevisiae* 424A(LNH-ST) metabolic yield from 89% to 97.5% relative to COBRA without delignification, allowing a process ethanol yield of 71.6%. A technoeconomic analysis on SCB biorefining to ethanol in the state of São Paulo, Brazil, compared COBRA to other mature technologies, such as AFEX and steam-explosion. Amongst all scenarios studied, biorefineries based on COBRA-LE pretreatment offered the lowest average minimum ethanol selling price of US$1.45 per gallon ethanol. COBRA pretreatment was subsequently tested on perennial grasses and hardwoods, and >80% total sugar yields were achieved for all cases.

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1. Introduction

The future of the bioeconomy depends on the development and implementation of a feasible biorefinery concept. In the context of a biochemical refinery, it hinges on (1) robust and effective pretreatment and fractionation technologies that maximize lignocellulosic biomass conversion to usable sugars during enzyme hydrolysis and (2) technologies that enable the upgrading of lignin to fuels and chemicals. This and similar statements are often emphasized in the literature,[1] but there are other key factors that are also universal to biomass processing and should be considered when developing viable biorefinery systems. For example, viable biorefinery systems must integrate within a feedstock logistics platform that provides stable, year-round biomass storage and handling, achieves essential economies of scale, and minimizes the biofuel carbon footprint. The work presented herein reports on the development of a robust ammonia-based pretreatment system for lignocellulosic biomass with those required attributes. The proposed system consists of a scalable feedstock supply chain integrated with sustainable year-round biofuel and bio-based chemical production from lignocellulosic biomass at high process yields and low chemical requirements.

1.1. Pretreatment in the biorefinery context

Recent trends in lignocellulosic biomass pretreatment development focus on the fractionation of plant cell wall components, notably lignin and carbohydrates, so that they are processed

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