Life Cycle Assessment of Ionic Liquid-based Biofuel Production

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Project Goals: Short statement of goals. (Limit to 1000 characters)

The main goals of this project are to investigate the environmental performance of various biofuel production pathways and develop a model for conducting life cycle environmental impact assessments of biofuels and chemicals developed at the Joint BioEnergy Institute. As biofuel production is a complex process requiring expertise in multiple scientific fields, this project requires close collaboration with other division members at the Lab including chemical engineers to incorporate process modeling and experimental results into life-cycle assessment models. This project will identify key opportunities for improving the economic and environmental performance of chemicals and fuels. The other goals include facilitating collaborations with academic, government, and industrial entities, and participate in educational and outreach.

Abstract text. Please limit to 2 pages.

There is a pressing need for efficient processes that can deconstruct biomass to sugars and subsequently convert sugars to biofuels, while achieving targeted environmental and socio-economic benefits. Pretreatment of lignocellulosic biomass is a key step to overcome biomass recalcitrance and make the sugars and lignin available for further deconstruction and conversion. Although ionic liquids (ILs) are considered to be potential alternatives to conventional biomass pretreatment solvents, their greenhouse gas (GHG) emissions-intensity and water footprint are not yet well understood. In this study, we developed a life cycle assessment model to evaluate GHG emissions of IL production, specifically Cholinium Lysinate ([Ch][Lys]), and of its subsequent use as a pretreatment solvent in a corn stover-to-ethanol production. The results are then compared with the dilute acid (DA) pretreatment method (in the context of a cellulosic biorefinery) and conventional gasoline. The results suggest that, depending on the location of lysine production, GHG emissions for [Ch][Lys] production range from 6 to 8 kg CO_2e/kg. Based on the biorefinery design considered, GHG emissions of IL-based biofuel range from 21 to 26 gCO_2e/MJ (78 % reduction compared to gasoline). Additionally, we found that high IL recovery (>99 wt. %) is important from GHG emissions reduction perspective. Major contributors to the total GHG emisisons includes fertilizers and GHG-intensive chemicals such as hydrochloric acid (HCl). This emphasizes the need for development of processes with high yields (thereby minimizing the GHG emissions associated with feedstock production) while minimizing the need for resource-intensive chemicals. Furthermore, the credits due to electricity export (i.e., by dispacing fossil derived electricity from grid) can be very high, which highlights

the need for energy-efficient biorefinery processes. Given the uncertainty with the several process parameters, detailed sensitivity analysis is conducted to better understand potential impact on emission intensity.

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