HIGH SOLIDS LOADING AQUEOUS SLURRY FORMATION OF CORN STOVER BEFORE PRETREATMENT IN A FED-BATCH BIOREACTOR

Diana M.R. Gutierrez[1*], Antonio José Gonçalves da Cruz[1,6], Carlos Torres[1,9], Xueli Chen[1] , Rosineide Gomes da Silva Cruz[1,6], Luana Serra[1,4], Ria Corder[8], Nathan Mosier[1], David Thompson[2], John Aston[2], James Dooley[3], Pankaj Sharma[1], João Ricardo M. Almeida[4,5],Kendra Erk[8], Eduardo Ximenes[1] and Michael R. Ladisch[1]

(1)Purdue University/Laboratory of Renewable Resources Engineering (LORRE), West Lafayette, IN, USA, (2)Idaho National Laboratory, Idaho Falls, ID, USA, (3)Forest Concepts LLC, Alburn, WA, USA, (4)University of Brasília, Brasilia, Brazil, (5)Embrapa-Agroenergia, Brasilia, Brazil, (6)Universidade Federal de São Carlos, São Carlos, Brazil, (8)Purdue University/School of Materials Engineering, West Lafayette, IN, USA. (9) Universidad Nacional de Colombia, Bogota, Colombia

Abstract

With the increase on population the world will depend on renewable sources to meet the increasingly energy needs. Use of lignocellulosic biomass as a renewable source has been proven efficient for conversion to cellulosic ethanol and capable of contributing to achieve the threshold on energy demand while reducing greenhouse gases in 90% when compared with fossil fuels (Wang et al., 2007, 2012). However, the processing of biomass encounters limitations in feeding and flow within biorefineries due to the system plugging by compaction and slurry high yield stress, preventing transport of biomass materials and in some cases unexpected plant shutdowns that results in high operational costs (dos Santos et al., 2021; Ximenes et al., 2021).

Different solutions for biomass handling and slurry formation from densified materials like pellets have been studied. Cellulosic biomass residues are typically processed in pretreatment reactors to which acid or base is added (Humbird et al., 2002). Other pretreatments such as liquid hot water (LHW) and steam explosion that act without the addition of chemicals use pressures above the saturation vapor of water, to disrupt biomass structure (Ruiz et al., 2021). Although these methods are widely known, the use of pretreatments like acid digestion and LHW present challenges like waste disposal and could be energy inefficient (Mosier et al., 2005). Alternatively other approaches like enzymatic liquefaction have been applied for biomass transformation into slurries with promising results and without the use of pretreatments (dos Santos et al., 2021).

Nevertheless, enzymatic liquefaction implementation faces difficulties due to the recalcitrant properties of biomass, its variability, and the release of enzyme inhibitors. While it has been proven that

* Corresponding author: Diana Ramirez, Laboratory of Renewable Resources Engineering,225 S. University Street, Purdue University, West Lafayette, IN 47907-2032, United States. Tel.: 7657017127. E-mail address: ramir120@purdue.edu.

chemical composition properties in biomass have effects on enzyme inhibition (Huang et al., 2022; Kim et al., 2011; Zhai et al., 2018), hindering the efficiency of the liquefaction, not ample research has been conducted in understanding the physical properties as particle size, porosity, water adsorption retention and their effect in the ability to form a slurry at high solids concentration (Yan et al., 2020).

In order to improve lignocellulosic biomass handling and formation of biomass slurries, enzyme-assisted liquefaction for slurry creation from corn stover at solids loadings up to 30% is reported in this work. Two different kinds of biomass (pelleted corn stover and cobs) were liquefied in a fed-batch process using commercial enzymes Celluclast 1.5L or Ctec-2 at 1FPU or 3 FPU per gram of dry solids in 10 mM sodium citrate buffer solution (pH 4.8). Pellets were fed into a 1 L stirred bioreactor according to a pre-defined fed-batch protocol over the first 5 hours until reaching 30% of solids loading. After 6, 24 and 96 hours, samples were taken and characterized with respect to their sugar composition, rheology and water absorption. Successful slurry creation with dramatically reduced yield stress was achieved for corn stover for both assessed enzymes. Yield stresses of 178±7 Pa (3 FPU, Celluclast 1.5L) and 79±6 Pa (3 FPU, Ctec-2) were measured for corn stover at 24 hours, compared to 6,000 Pa for samples without enzyme. Yield stress was 155± 29 Pa (3FPU, Ctec-2) and 257 ± 72 Pa (1 FPU, Celluclast 1.5L) for corn cobs at 24 hours. Yield stress decreased when residence time increased with an enhanced fluidity noted for higher enzyme concentrations. A profile for 6, 24 and 96h of yield stress measurements is presented.

Acknowledgments: DOE Cooperative Agreement 8652 and 8910

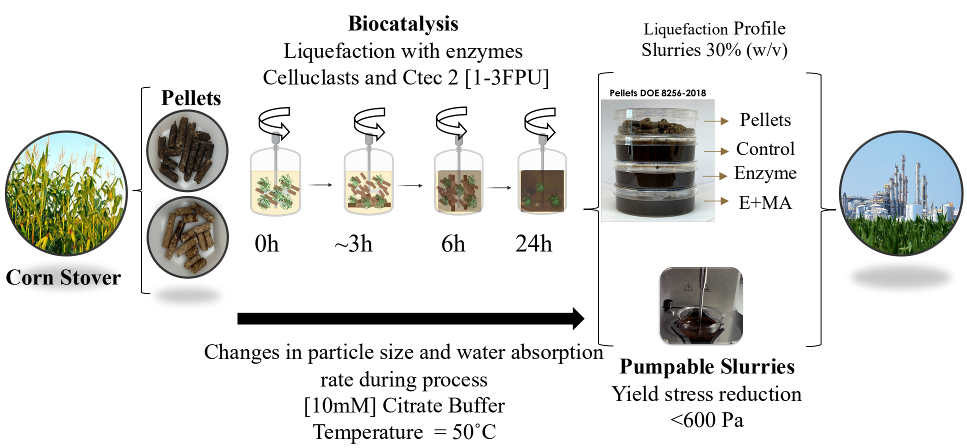

Figure 1. Visual Abstract