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Treatment with Triton-X 100: An Enhancement Approach for Cardboard Bioprocessing

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Abstract : Diverse approaches and pathways are under development with the determination to develop cellulosic biofuels and other bio-products eventually at commercial scale in “bio-refineries”; however, the key challenge is mainly the high level of complexity in processing the feedstock which is complicated and energy consuming. To overcome the complications in utilizing the naturally occurring lignocellulose biomass, using waste paper as a feedstock for bio-production may solve the problem. Besides being abundant and cheap, bioprocessing of waste paper has evolved in response to the public concern from rising landfill cost from shrinking landfill capacity. Cardboard (CB) is one of the major components of municipal solid waste and one of the most important items to recycle. Although 50-70% of cardboard constitute is known to be cellulose and hemicellulose, the presence of lignin around them cause hydrophobic cross-link which physically obstructs the hydrolysis by rendering it resistant to enzymatic cleavage. Therefore, pretreatment is required to disrupt this resistance and to enhance the exposure of the targeted carbohydrates to the hydrolytic enzymes. Several pretreatment approaches have been explored, and the best ones would be those can influence cellulose conversion rates and hydrolytic enzyme performance with minimal or less cost and downstream processes. One of the promising strategies in this field is the application of surfactants, especially non-ionic surfactants. In this study, triton-X 100 was used as surfactants to treat cardboard prior enzymatic hydrolysis and compare it with acid treatment using 0.1% H2SO4. The effect of the surfactant enhancement was evaluated through its effect on hydrolysis rate in respect to time in addition to evaluating the structural changes and modification by scanning electron microscope (SEM) and X-ray diffraction (XRD) and through compositional analysis. Further work was performed to produce ethanol from CB treated with triton-X 100 via separate hydrolysis and fermentation (SHF) and simultaneous saccharification and fermentation (SSF). The hydrolysis studies have demonstrated enhancement in saccharification by 35%. After 72 h of hydrolysis, a saccharification rate of 98% was achieved from CB enhanced with triton-X 100, while only 89 of saccharification achieved from acid pre-treated CB. At 120 h, the saccharification % exceeded 100 as reducing sugars continued to increase with time. This enhancement was not supported by any significant changes in the cardboard content as the cellulose, hemicellulose and lignin content remained same after treatment, but obvious structural changes were observed through SEM images. The cellulose fibers were clearly exposed with very less debris and deposits compared to cardboard without triton-X 100. The XRD pattern has also revealed the ability of the surfactant in removing calcium carbonate, a filler found in waste paper known to have negative effect on enzymatic hydrolysis. The cellulose crystallinity without surfactant was 73.18% and reduced to 66.68% rendering it more amorphous and susceptible to enzymatic attack. Triton-X 100 has proved to effectively enhance CB hydrolysis and eventually had positive effect on the ethanol yield via SSF. Treating cardboard with only triton-X 100 was a sufficient treatment to enhance the enzymatic hydrolysis and ethanol production.

Keywords : cardboard, enhancement, ethanol, hydrolysis, treatment, Triton-X 100
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