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Highly sustainable cascade pretreatment of low-pressure steam heating and organic acid on pineapple waste biomass for efficient delignification

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ABSTRACT

Cascade pretreatment of low-pressure steam heating (LPSH) and maleic acid (MA) on pineapple waste (PW) biomass aims to improve delignification, increase enzyme accessibility to carbohydrate in the feedstock while reducing inhibitor by-products. The best conditions for LPSH pretreatment were determined using one-factor-at-a-time (OFAT) while the conditions of MA pretreatment (temperature, acid concentration and time) were optimized by Box-Behnken design. A total of 68% (w/w) delignification with 79.5% (w/w) hemicellulose removal were achieved while 77.6% (w/w) cellulose was retained in the solid residue after the cascade pretreatment. No 5-hydroxylmethyl furfural (5-HMF) and acceptable furfural (1.8 g/L) were detected in the hydrolysate by high performance liquid chromatography analysis, with negligible amount of phenolic compounds (0.01 g/L). Compared to the pretreatment with combined LPSH and conventional sulphuric acid pretreatment (H_2SO_4), the pretreated PW produced 3.6 g/L of furfural and 0.4 g/L of HMF at similar optimized conditions. The pretreated PW were further characterized by scanning electron microscopy and Fourier transform infrared spectroscopy to analyze structural morphology and functional group changes. The pooled solid and liquid hydrolysate fractions generated from the LPSH and MA cascade pretreatment and subsequent enzyme hydrolysis has successfully generated 356.32 mg/g glucose and 156.91 mg/g xylose. The optimized cascade pretreatments provide up to 54.79% of glucose yield and 69.23% of xylose yield. Furthermore, 67.87% reduction of lignin content from the cascade pretreatment can substantially enhance the glucose yield up to 95.76% and xylose yield up to 99.07% during enzymatic hydrolysis using the mixture of cellulase and hemicellulase.

1. Introduction

The study of biofuel production from agriculture residues biomass as an alternative to fossil fuel has become an interesting research topic since many years ago. Carbohydrate content inside the biomass is the source of sugar which can be converted into biofuel such as bioethanol from an anaerobic fermentation by microorganisms mainly yeasts [1]. Malaysia is one of the main producers of canned pineapples in Asian countries in 2017 and has recorded 299,912 tons of pineapple crops produced by year 2019 according to the Food and Agriculture Organization [2]. The highly efficient conversion of lignocellulose to fermentable sugars usually comprises two major series of biochemical reactions which are pretreatment and enzyme hydrolysis [3]. The recalcitrance of the biomass, which are contributed by the cellulose

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