Effect of Pressurized Water + Ethanol on Hydrolysis of Wheat Straw

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1. Introduction

Wheat is one of the main cereal crops produced in Canada, and thus, a large amount of wheat straw is produced annually. Wheat straw was the dominant agricultural residue in Canada from 2001 to 2010[1]. Wheat straw is mainly composed of cellulose (40%), hemicellulose (31%), and lignin (18%)[2]. Recently, cellulose value-added derivatives, such as cellulose nanofibers, have gained attention[2]. To produce cellulose nanofibers, treatments such as acid/basic treatments, steam explosion, ammonia fiber explosion, organosolv process, and ionic liquids, among others, have been implemented. However, such treatments involve the use of corrosive and toxic solvents, neutralization steps, and consequently production of waste streams, among other drawbacks[3]. The hydrolysates are the co-products obtained. The main objective of this study was to determine the effect of SCW with different ethanol concentrations, and optimum conditions of temperature and time to hydrolyze non-cellulosic material from wheat straw.

2. Materials and Methods

2.1. *Materials*

Wheat straw was kindly provided by Dr. Barry Irving (University of Alberta). The sample was ground and sieved to <1 mm particle size in a centrifugal mill (Retsch, Haan, Germany). All chemicals used, such as sodium carbonate anhydrous (99%, ACS reagent), sulfuric acid (72%, ACS reagent), and sugar standards (≥ 96% purity) were obtained from Sigma Aldrich (Oakville, ON, Canada) and used as received without further purification.

2.2. *Pressurized aqueous ethanol treatment*

Pressurized aqueous ethanol (PAE) treatment of wheat straw was performed in a semi-continuous flow-type subcritical fluid system[3]. The experiments were conducted at 180°C, 50 bar, and ethanol concentrations of 0–100% (v/v) for 40 min. The pH and total phenolic content in the hydrolysates were analyzed. The solid residue left in the high-pressure vessel after each experiment was dried in an oven at 30 °C.

3. Results and discussion

The total phenolic content of wheat straw hydrolysates at different ethanol concentrations are shown in Fig. 1. Total phenolics obtained from the hydrolysis treatment indicated the rupture of lignin and cellulosic linkages[4]. According to the results, the treatments that used water and ethanol up to 40:60 v/v ratios are the most effective to extract phenolic compounds from wheat straw during the hydrolysis treatment.

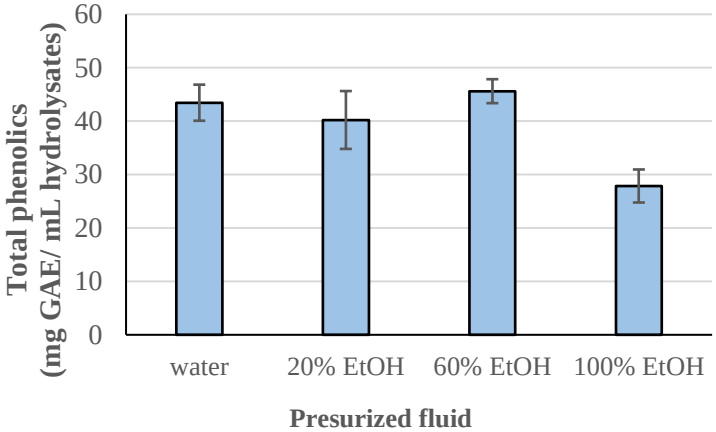

Fig. 1. Effect of ethanol concentration on total phenolic content of wheat straw using pressurized water + ethanol (EtOH) at 180°C, 50 bar and 5 mL/min.

In addition, the production of hydroxide ions from water at subcritical conditions may

result in the sequential degradation of hemicellulose[5]. Consequently, organic acids are produced, contributing to the decrease in the pH as observed in samples treated with aqueous ethanol solutions (Fig. 2). Therefore, the decrease of pH may be an indicator of straw depolymerization.

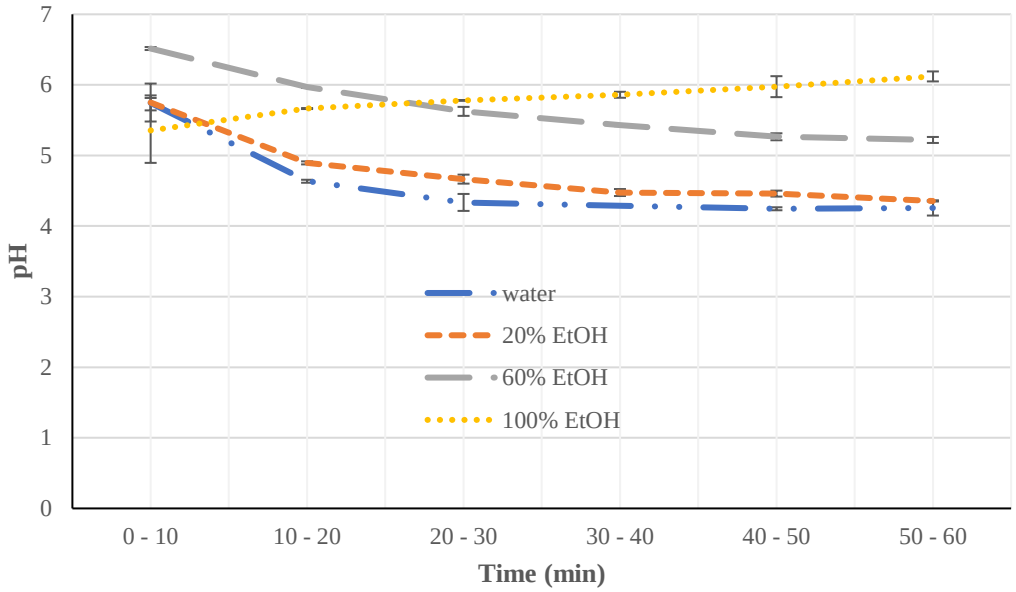

Fig. 2. Effect of ethanol concentration on pH of wheat straw using pressurized water + ethanol (EtOH) at 180°C, 50 bar, and 5 mL/min.

4. Conclusions

The use of SCW and pressurized water + ethanol has great potential for the hydrolysis of wheat straw. Water + ethanol up to 40:60 v/v ratios showed the highest phenolic content, while the SCW and pressurized water + ethanol at 80:20 v/v ratio produced hydrolysates with lower pH, causing depolymerization of the lignocellulosic straw.

Acknowledgments

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