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EXTRACTION OF HEMICELLULOSE FROM OIL PALM BIOMASS USING SUBCRITICAL WATER EXTRACTION TO PRODUCE VALUE-ADDED PRODUCT OR FINE CHEMICALS

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Summary: Renewable energy sources such as wind, hydro, solar, hydrogen, nuclear and biomass are various type of alternatives energy available to replace non-renewable fossil fuels. The total oil palm biomass produced by Malaysia alone is about 53.04 million tonnes (mt), which include 17.08 mt of empty fruit bunches, 9.66 mt of fibre, 5.2 mt of shell, 12.9 and 8.2 mt of fronds and trunks. This research will focused on the production of value-added product or fine chemicals based on extraction of xylose and xylooligosaccharides from hemicellulose of lignocellulosic biomass. As preliminary results, the pH value, TOC value and total sugar concentration were determined.

Keywords: Fine chemicals, Hemicellulose, Oil palm Biomass, Subcritical water extraction, Xylose

INTRODUCTION

Malaysia is the second largest palm oil producer and exporter country in the world after Indonesia. This country is estimated to produce about 19.2 million tonnes (mt) of palm oil biomass in 2013 compared to Indonesia 28.4 mt. Both countries are the major contributors to the worldwide palm oil production [1]. According to Hossein and Wahid (2014) the total oil palm biomass produced by Malaysia alone is about 53.04 million tonnes, which include 17.08 million tonnes of empty fruit bunches, 9.66 million tonnes of fibre, 5.2 million tonnes of shell, 12.9 and 8.2 million tonnes of fronds and trunks [2]. The main component in lignocellulosic biomass are cellulose, hemicellulose and lignin can be further converted to fine chemical using proper technology such as subcritical water extraction (SCW) [3][4][5]. SCW is define as water above boiling temperature and below critical point (374˚C), and pressure high enough to maintain liquid state. Water at this state possess unique solvation properties such as low polarity, viscosity, surface tension, dissociation constant which significantly lower then water at ambient temperature [6]. Therefore, research on the utilization of biomass should be undertaken particularly on the extraction of hemicellulose by using subcritical water extraction to produce promising and potential fine chemical and value-added product.

2. MATERIALS AND METHODS

2.1. Materials

D-xylose, D-glucose, D-galactose, D-arabinose, D-mannose, xylobiose, xylotriose, xylotetraose, cellulose, and xylan were purchased from Sigma (Chemical Co., USA) and Megazyme. Oil palm biomass samples (kernel shell, fruit press fiber, and empty fruit bunch) was kindly supplied by Sime Darby Plantation, Selangor, Malaysia. The sample were ground and sieved to >425µm in size.

2.2. Hydrothermal hydrolysis of fruit press fiber (FPF)

For each run, the microreactor was heated from ambient temperatures to the desired temperature. Experiments were carried out in a 200 mL microreactor (OM. Labtech Co.Ltd). All subcritical experimental runs were performed using 5 mg of air-dried FPF (>425 µm), 100 mL of deionized water were loaded into the machine together with the samples to obtain ratio of 1:20 solid-liquid ratio (FPF to water). Then, the mixture was heated in a hydrothermal liquefaction machine at temperature 170-270 ° C for 30 minutes. After the pre-treatment the products consist of solid, gas and liquid phase [7]. The solid and liquid products were separated from the machine through filtration by filter paper no. 4 (Whatman, England) into a beaker.

2.3. Analytical methods

Polysaccharides content in the liquid products was determined by using phenol-sulfuric acid method [8]. The total sugar content was determined using UV-1800 Spectrophotometer (Shimidzu, Japan) at 490 nm, and water was used as blank. Glucose solution was used as standard in this experiment. The pH value was determined using a pH meter (Mettler Toledo). Total organic carbon is the amount of carbon bound in an organic compound. TOC analyser (TOC-V_{CSN} , Shimidzu, Japan) was used to determine total organic carbon in the liquid products that been obtain from extraction. High-pressure liquid chromatography (HPLC) analysis was used to quantify acetic acid, sugars such as, monosaccharide, disaccharides and oligosaccharides. The analysis was done with an Agilent 1100 series chromatograph (Agilent, USA), using a Bio-Rad HPX87H column at 30 °C (Bio-Rad Laboratories, USA). The system was calibrated with glucose, xylose, arabinose, galactose, mannose, xylobiose, xylotriose, xylotetraose, xylopentaose and acetic acid standards (Sigma–Aldrich and Megazyme). (Nabarlatz, Ebringerová, & Montané, 2007). FT-IR spectra of liquid product were obtained with FT-IR spectrometer. Then fractionation and purification of hemicellulose to obtain xylose and xylooligosaccharides.

3. RESULTS

To investigate the effect of temperature on pH value, TOC value and total sugar determination, extraction process was carried out using different temperature of 170 ºC,180 ºC,190 ºC,200 ºC,210 ºC,220 ºC,230 ºC,240 ºC,250 ºC,260 ºC and 270ºC while other parameter were fixed as follow: Time: 30 min, pressure: depend on temperature

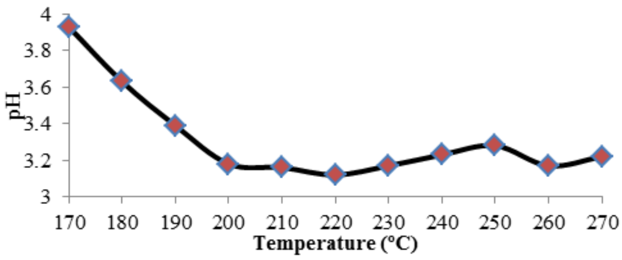

Fig. 1. The effect of temperature on the pHvalue of Fruit Press Fiber (FPF).

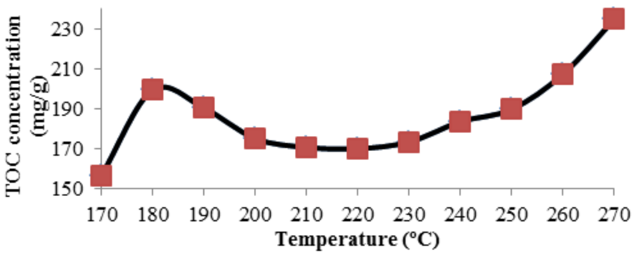

Fig. 2. The effect of temperature on TOC value of Fruit Press Fiber (FPF).

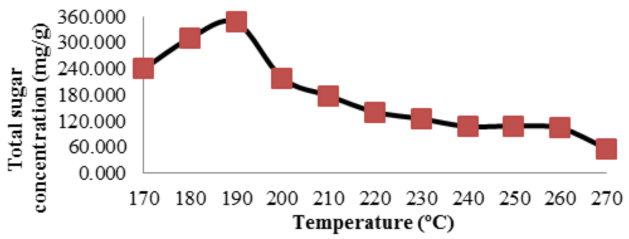

Fig. 3. The effect of temperature on total sugar concentration of Fruit Press Fiber (FPF).

4. DISCUSSION

Fig.1. Shown the effect of temperature on pH value. The pH reading fall significantly from temperature 170ºC to 200ºC that were 3.93, 3.63, 3.39, and 3.18. Higher temperatures promote the fragmentation of polysaccharides into monomers, especially hemicellulose and the formation of degradation compounds [9]. Fig.2. Show the effect of temperature on total organic carbon (TOC) value, which at temperature 170ºC to 180ºC show drastic increase in TOC value from 156.68mg/g to 199.36mg/g. It maybe because of rapid degradation of polysaccharides to its oligomers and monomer and from 180ºC to 230ºC the TOC value keep decreasing and the highest TOC value was at 270ºC maybe because further degradation of monomers into by-products occurred. Fig. 3 show the total sugar concentration, which at temperature 170ºC to190ºC the breakdown of polysaccharides into small monomer or sugars occurred rapidly from 239.57mg/g, 310.323mg/g, and 346.882mg/g. From 190ºC to 270ºC the total sugar concentration keep decreasing from 310.323mg/g to 56.344mg/g maybe because at 200ºC the formation of by-product and degradation compound had started. Later liquid products obtained will be test with HPLC analysis and FT-IR. After that, the liquid products will undergo fractionation and purification to obtain xylose and xylooligosaccharides.

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