Pretreatment of Iraqi Palm Fronds and Optimization of Fermentation Conditions for Bioethanol Production

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Abstract

Bioethanol production from Iraqi palm frond waste was investigated in this study, addressing both biofuel demand and agricultural waste management

In this work, palm frond (PF) was pretreated by physical and chemical method by using four different concentrations of 2%, 4%, 6%, and 8% of sulfuric acid (H2SO4) and sodium hydroxide (NaOH). Thereafter fresh palm frond juice (PFJ) was obtained by pressing the fresh PF petiole. PFJ was fermented in different fermentation variables, including fermentation time of 24-144 h, temperature of 25-45 °C, pH of 4-8, and Saccharomyces cerevisiae concentration of 2-10 g/L.

Raw PF characteristics were investigated, thermogravimetric analysis (TGA) was used to determine its compositions and how pretreatment effects the lignocellulosic structure. Ultraviolet (UV), Fourier Transform Infrared (FTIR), and Field Emission Scanning Electron Microscopy (FE-SEM) were employed to evaluate the sugar concentration, functional groups of PF, and the surface morphology respectively. High-performance Liquid Chromatography (HPLC) were employed to evaluate the concentration of bioethanol.

(TGA) revealed the composition of PF, containing 30.65% cellulose, 31.63% hemicellulose, 37.71% lignin. FTIR showed notable changes in the functional groups of PF, indicating the effect of pretreatment on its chemical composition. FE-SEM revealed alterations in the surface morphology of PF, demonstrating the impact of pretreatment on its physical structure. UV spectroscopy was used to evaluate the sugar concentration in PF, finding a concentration of 62.4 g/L.

Experimental results showed that chemical pretreatment with 8% NaOH proved most effective, reducing the lignin content from 37.71% to 5.71% and increasing the cellulose content from 30.65% to 72.05%. Additionally, the concentration of glucose in PFJ was 62.4 g/L, then reached 80.5 g/L after pretreatment. The maximum bioethanol yield (49%) was achieved at the fermentation conditions of 96 h, 35 °C, pH of 5, and Saccharomyces cerevisiae concentration of 8 g/L. The produced bioethanol was characterized to determine its properties. The analysis revealed the following results: a density of 0.79 (g/cm3), flash point of 14 °C, boiling point of 80 °C, specific gravity of 0.79, pH of 7.8, and boiling point of 78 °C.

Modeling and optimization were employed using Response Surface Methodology (RSM) to optimize the influencing factors for the bioethanol production yield. Optimization of these factors was able to achieve 48% bioethanol yield at the process conditions of 87.50 h, 34.63 °C, pH of 5.5, and Saccharomyces cerevisiae concentration of 7.94 g/L. The experimental optimum yield values were in good agreement with predicted values from RSM.