

Synthesis and Characterization of Sulfonated Activated Carbon-Derived From Oil Palm Empty Fruit Bunches (EFB) As Solid Acid Catalyst For Production of Bioethanol

Asyrani Azwar^a, Sabiha Hanim^{ab*}

Structured Abstract

Background: An abundant amount of oil palm empty fruit bunches (OPEFB) is generated by the agricultural industry, prompting the need for sustainable waste utilization. In Malaysia, a total dry matter (TDM) of oil palm exceeding 55 tonnes per hectare is generated, which forms part of environmental issues as a majority of the biomass remains unused and usually discarded through burning or open dumping. Although it can be converted to value-added products like bioethanol or activated carbon, its efficient use is not fully done. This study aims to convert OPEFB into sulfonated activated carbon (SAC) to serve as a solid acid catalyst for the hydrolysis of cellulose into glucose, and subsequently, for bioethanol production. The effect of catalyst loading was also investigated.

Methods: OPEFB was pre-treated by soaking in 50% phosphoric acid (H_3PO_4) for 4 hours, followed by carbonization at 400 °C for 3 hours in muffle furnace. The resulting activated carbon was then sulfonated using concentrated sulphuric acid (H_2SO_4) to obtain SAC. Characterization was carried out using thermogravimetric analysis (TGA), Brunauer-Emmett-Teller (BET) surface area analysis, Fourier-transform infrared spectroscopy (FT-IR), Scanning electron microscopy with energy-dispersive X-ray (SEM-EDX), and CHNS elemental analysis.

Results: BET analysis showed that the SAC possessed a high surface area of 167.03 m²/g with a predominantly mesoporous structure. In the hydrolysis process, the catalyst demonstrated effective performance, yielding glucose concentrations of 1008.5 ppm and 785.17 ppm with 3% and 2% (w/v) catalyst loading, respectively. Subsequent fermentation of the corresponding glucose samples produced bioethanol concentrations of 39.73% and 34.64% (v/v), respectively, from the corresponding glucose sample. The samples were denoted as BE-SAC3% and BE-SAC2% according to catalyst loading.

Conclusion: Although the ethanol yield was relatively moderate, the SAC catalyst exhibits good catalytic activity, favourable textural properties, and recyclability, supporting its potential for lignocellulosic biomass conversion in bioethanol production.

Keywords: Sulfonated activated carbon, oil palm biomass, bioethanol, solid acid catalyst, hydrolysis

*Correspondence: sabihahanim@uitm.edu.my

^aSchool of Chemistry & Environment, Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia

^bIndustrial Waste Conversion Technology Research Group, Universiti Teknologi MARA, Shah Alam, Malaysia