

Biogas from palm oil mill effluent: Characterization and removal of CO₂ using modified clinoptilolite zeolites in a fixed-bed column

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Abstrak

The main focus of this article was to investigate the potential of natural zeolite adsorbent for the removal of CO₂ and H₂S in biogas produced from palm oil mill effluent (POME) in fixed-bed column adsorption. The effects of the flowrates and dosage of the adsorbent on the CO₂ adsorption were also studied. The surface area of the adsorbent was determined using the Brunauer, Emmett, and Teller (BET) model, while the pore size distribution was calculated according to the Barrett, Joyner, and Halenda (BJH) model. The morphology of the adsorbent was determined by field emission scanning electron microscopy and energy dispersive x-ray (FESEM-EDX) analysis. Before and after purification, the biogas was analyzed by gas chromatography with a thermal conductivity detector and polydimethylsiloxane as a column. Biogas from the POME, via the anaerobic digestion process, produced 89% CH₄ and 11% CO₂. The surface and structure of the clinoptilolite zeolites was modified by a strong acid (1M HCl), strong base (1M NaOH), and calcination at 450°C, and the surface area of the natural zeolites was reduced up to 16%. The working capability of CO₂ adsorption by the modified zeolites decreased with increasing flow rates (100, 200, and 300 mL/min) of the biogas, with levels of CO₂ at 106,906, 112,237, and 115,256 mg/L. The removal of the CO₂ in the biogas by using adsorbent dosages of 1.5, 2.0, and 2.5 g was 97,878, 97,404 and 93,855 mg/L, respectively. The optimum purification of the biogas occurred under the flow rate of 100 mL/min and adsorbent dosage of 2.5 g. The high working capability of the modified zeolites for the removal of CO₂ in the biogas was a key factor, and the most important characteristic for the adsorbent. The results indicate that clinoptilolite zeolites are promising adsorbent materials for both the purification and upgrading of biogas.