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Synthesis of ultrasonicated amine-functionalized MgO-deposited empty fruit bunch (EFB)-derived biochar for CO_2 adsorption

Abstract

In this study, biochar derived from empty fruit bunch (EFB) was modified by sonication, amine functionalization, and MgO deposition to increase CO_2 uptake capacity towards addressing the global warming problem. The optimal conditions for amine functionalization were a biochar to melamine mass ratio of 5:2, an activation temperature of 700 °C, and a heating rate of 15 °C/min. The sequential sonication, amine functionalization, and MgO deposition resulted in the ultrasonicated amine-functionalized MgO-deposited biochar (UAMB) with the highest CO_2 uptake capacity of 84.95 mg/g, which is a 142% increase compared to the pristine biochar (35.10 mg/g). The results of XRD, SEM–EDX, FTIR, Raman, BET, Boehm titration, and XPS analysis showed that the sequential treatments improved the porosity, surface area, and surface chemistry of the modified biochar due to the presence of MgO, pyridine, pyrrole, and nitrile, resulting in a superior increase in CO_2 uptake capacity. Advantageously, this modified biochar exhibited the highest affinity for CO_2 compared to air, methane, and nitrogen and was stable up to 12 cycles of CO_2 adsorption–desorption. Kinetic studies showed that the Avrami kinetic model best described CO_2 adsorption on the biochar, with physisorption being the main adsorption mechanism and chemisorption making only a minor contribution to CO_2 adsorption. CO_2 capture tests in a fixed-bed adsorption system showed that the best adsorption conditions were at a gas flow rate of 30 mL/min, an initial CO_2 concentration of 15%, and an adsorption temperature of 30 °C. The excellent performance of this modified biochar is promising for efficient CO_2 capture to reduce CO_2 emissions.

Keywords

Adsorption mechanism; Amine functionalization; MgO deposition; Modified biochar; Sonication; Uptake capacity