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Effect of Acid Activation of Vermiculite on Its Carbon Dioxide Adsorption Behaviors

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Abstract : The scientific community is paying more and more attention to the problem of air pollution. Carbon dioxide is classified as one of the most harmful gases. Its emissions are generated during fossil fuel burning, waste management, and combustion and are responsible for global warming. Clay minerals constitute a group of promising materials for the role of adsorbents. They are composed of two types of phyllosilicate sheets: tetrahedral and octahedral, which form 1:1 or 2:1 structures. Vermiculite is one of their best-known representative, which can be used as an adsorbent from water and gaseous phase. The aim of the presented work was carbon dioxide adsorption on vermiculite. Acid-activated samples (W_NO3_x) were prepared by acid treatment with different concentrations of nitric acid (1, 2, 3, 4 mol L^{-1}). Vermiculite was subjected to modification in order to increase its porosity and adsorption properties. The prepared adsorbents were characterized using the BET-specific surface area analysis, thermogravimetry (TG), attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy, X-ray diffraction (XRD) and scanning electron microscopy (SEM). Applied modifications significantly increase the specific surface area from 78,21 m^2 g^{-1} for the unmodified sample (W_REF) to 536 m^2 g-1 for W_NO3_4. Obtained results showed that acid treatment tunes the material's functional properties by increasing the contact surface and generating more active sites in its structure. The adsorption performance in terms carbon dioxide adsorption capacities follows the order of W_REF (25.91 mg g^{-1}) < W_NO3_1 (38.54 mg g^{-1}) < W_NO3_2 (44.03 mg g^{-1}) W_NO3_4 (67.51 mg g^{-1}) < W_NO3_3 (70.48 mg g^{-1}). Acid activation significantly improved the carbon dioxide adsorption properties of modified samples compared to raw material. These results demonstrate that vermiculite-based samples have the potential to be used as effective CO_2 adsorbents. Furthermore, acid treatment is a promising technique for improving the adsorption properties of clay minerals.

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