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Characterization of modified mineral waste material adsorbent as affected by thermal treatment for optimizing its adsorption of lead and methyl orange

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Abstract

Thermal treatment is one of the most common processes in mineral modification, and this process has been applied to the modification of mineral waste material to improve its adsorption ability of methyl orange (MO) and lead (Pb) in this study. The properties of modified mineral waste material (MMWM) before and after thermal modification were characterized by using the Brunauer–Emmett–Teller (BET) N_2 adsorption/desorption measurement, field emission scanning electron microscope (FESEM) coupled with energy-dispersive X-ray (EDX), X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR). Phase transformation was investigated related to the change in surface morphology and dehydroxylation that occurred in MMWM samples during the process of thermal treatment. To study adsorption performances of Pb and MO onto the newly modified MMWM, several experiments were carried out under different adsorption conditions and the results were determined using inductively coupled plasma optical emission spectrometry (ICP-OES) and UV-Vis spectrophotometry. The thermally treated MMWM samples showed morphological transformation and an increasing trend in BET specific surface area (SSA) up to 500 °C followed by a decreasing trend till 1000 °C. Thermal modification of MMWM successfully improved Pb adsorption from 349 to 515 mg/g, corresponding to the MMWM modified at 600 °C, and the methyl orange (MO) adsorption from 68 to 87.6 mg/g at 400 °C. The adsorptions of Pb and MO were mainly chemisorption and monolayer coverage, as the pseudo-second-order model and the Langmuir equation displayed good correlations for Pb and MO adsorption data.

Keywords: Adsorption, dehydroxylation, lead (Pb), methyl orange (MO), modified mineral waste material (MMWM)