Characterization and application of heat-treated and acid-leached halloysites in the removal of malachite green: adsorption, desorption, and regeneration studies

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\textbf{ABSTRACT}

Algerian halloysite was processed at 600°C and with 5-N HCl (H600-5N), and compared with the forms treated thermally at 600°C (H600) and unmodified (H). The obtained samples were characterized by FTIR, TEM, and nitrogen adsorption, and employed as malachite green (MG) adsorbents from aqueous solutions. The effects of pH, contact time, solution concentration, and temperature were examined. A particular attention has been focused on desorption and regeneration. The ease in desorption and regeneration constitutes a major practical advantage for treating industrial effluents. Thermo-chemical activation leads to the leaching of Al ions from the octahedral sheet. As consequence, H600-5N presents a specific area of 503 m\textsuperscript{2} g\textsuperscript{-1}, i.e. eight orders of magnitude higher than that of H (63 m\textsuperscript{2} g\textsuperscript{-1}). For all halloysitic solids, the capacity in MG increases with decreasing adsorption temperature. The affinity sequence is H600-5N > H600 > H. The isotherms are found to be well represented by the Redlich–Peterson equation. The thermodynamic data show that the MG adsorption onto H600-5N is spontaneous and exothermic, consequence of the electrostatic attraction between positively charged molecules and negatively charged adsorption sites. Among the seven eluents used, methanol manifests the greatest desorption capacity from H600-5N, which increases overall with temperature. After four adsorption–desorption cycles, this material was easily desorbed and regenerated. On the basis of all these considerations and, also, its adsorption capacity (192.6 mg g\textsuperscript{-1} at 25°C), H600-5N appears very effective for removing dyes from wastewaters.

\textit{Keywords}: Halloysite; Modification; Removal; Malachite green; Desorption; Regeneration

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