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Synthesis, characterization and use of layered double hydroxides containing chloride as a sorbent for environmental hazards

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In recent decades, a class of anionic clays known as Layered Double Hydroxides (LDHs) or hydrotalcite-like compounds has attracted considerable attention from both industries. The general formula for an LDH is $[M^{II}(1\text{-}x)\ M^{III}x(OH)_2]\ [A^{n-}x/n\ .mH_2O]$, where M^{II} represents a divalent metal and MIII represents a trivalent metal. An enormous variety of interlayer anions (A^{n-}) can be incorporated in LDHs such as CO_3^{2-}, SO_4^{2-}, NO^{3-} or Cl^-. From a structural viewpoint, the effect of divalent/trivalent cations and interlayer anionic compositions may provide insights regarding the crystal chemistry of different LDHs types, which may ultimately govern their ability to adsorb organic pollutants. In this work, Mg-Al, Ni-Al and Zn-Al layered double hydroxide (LDH) materials with molar ratio (M^{2+}/Al^{3+}) of 3 were synthesized via a co-precipitation route. The as-synthesized samples were characterized by X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Transmission Electron Microscopy (TEM) and Simultaneous Thermogravimetric-Differential Thermal Analysis (TGA/DTA). XRD analyses showed that Zn-Al-SO_4 had the greatest lattices' parameters followed by Mg-Al-SO_4 and Ni-Al-SO_4. FTIR confirmed clearly the presence of sulfate anions in the structure of LDHs in the interlayer. Two major stages of mass loss occurred for all the samples with better thermal stability of Zn-Al-SO_4 vs. Ni-Al-SO_4 and Mg-Al-SO_4. The capability of LDHs for dye removal from aqueous solutions was investigated using methyl orange as a model and an industrial textile effluent. The "batch" method for evaluating the adsorption of methyl orange dye into synthesized LDHs was investigated under various conditions such as solution pH, contact time and initial dye concentration. Experimental results showed that pH is the most affecting factor on the adsorbent effect. The effective pH range for dye removal was between 3.5 and 4.5. The adsorption process can be well described by the pseudo-second-order kinetic model. The equilibrium adsorption data was analyzed using three isotherm models: Langmuir, Freundlich and Dubinin-Radushkevich. The results showed that Langmuir model fit with exceptional maximum adsorption capacities of 2758, 1622 and 800 mg/g, respectively for Zn-Al-SO_4, Mg-Al-SO_4 and Ni-Al-SO_4.

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