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Halloysite Based Adsorbents for Removing Pollutants from Water Reservoirs

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Abstract : The rapid growth of the world's population and the resulting economic development have had an enormous influence on the environment. Multiple industrial processes generate huge amounts of wastewater containing dangerous substances, most of which are discharged into water bodies. These contaminants include pharmaceuticals and synthetic dyes. Regardless of the presence of wastewater treatment plants, a lot of pollutants cannot be easily eliminated by well-known technologies. Hence, more effective methods of removing resistant chemicals are being developed. Due to cost-effectiveness as well as the availability of a wide range of adsorbents, a large interest in the adsorption process as an alternative way of water purification has been observed. Clay minerals, e.g., halloysite, are one of the most researched natural adsorbents because of their availability, non-toxicity, high specific surface area, porosity, layered structure, and low cost. The negatively charged surface makes them ideal for binding cations and organic compounds. Halloysite can be subjected to modifications which enhance its adsorptive properties. The aim of the presented research was to apply pure and modified halloysite in removing particular pollutants (tetracycline, tartrazine, and phosphates) from aqueous solutions. Halloysite was modified with alcoholic and aqueous solutions of hexadecyltrimethylammonium bromide (CTAB) and urea in different concentrations and subsequently impregnated with lanthanum(III) chloride. Acidic and basic oxygen groups located on the surface of all materials were determined. Moreover, the adsorbents obtained were characterized by X-ray diffraction, low-temperature nitrogen adsorption, scanning, and transmission electron microscopy. The effectiveness of samples in tetracycline, tartrazine, and phosphates adsorption from the liquid phase was then studied in order to determine their potential application in eliminating contaminants from water reservoirs. Modifiers' employment enabled obtaining materials that possess better adsorption properties, which makes them useful for removing various pollutants from water. Modifying the pure halloysite with CTAB and urea solutions and impregnating $LaCl_3$ led to the formation of acidic and basic oxygen functional groups on the surface. Their amount increases with an increasing percentage of lanthanum content. The acid-base properties of materials, as well as the type of functional groups that appear on their surface, have a significant influence on their sorption capacities towards antibiotics, dyes, and phosphate(V) anions. The selected contaminants adsorb onto the halloysite studied following the Langmuir type isotherm. The thermodynamic study indicated that the adsorption was a spontaneous and exothermic process. The adsorption equilibrium was rapidly attained after 120 min of contact time. Research showed that synthesized materials based on halloysite may be applied as adsorbents for antibiotics, organic dyes, and PO_4^{3-} ions which are difficult to eliminate.

Keywords : adsorption processes, halloysite, minerals, water reservoirs pollutants
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