Adsorption mechanism of hexavalent chromium onto layered double hydroxides-based adsorbents : a systematic in-depth review

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ABSTRACT

An attempt has been made in this review to provide some insights into the possible adsorption mechanisms of hexavalent chromium onto layered double hydroxides-based adsorbents by critically examining the past and present literature. Layered double hydroxides (LDH) nanomaterials are typical dual-electronic adsorbents because they exhibit positively charged external surfaces and abundant interlayer anions. A high positive zeta potential value indicates that LDH has a high affinity to Cr(VI) anions in solution through electrostatic attraction. The host interlayer anions (i.e., Cl^-, NO_3^-, SO_4^{2-}, and CO_3^{2-}) provide a high anion exchange capacity (53–520 meq/100 g) which is expected to have an excellent exchangeable capacity to Cr(VI) oxyanions in water. Regarding the adsorption-coupled reduction mechanism, when Cr(VI) anions make contact with the electron-donor groups in the LDH, they are partly reduced to Cr(III) cations. The reduced Cr(III) cations are then adsorbed by

LDH via numerous interactions, such as isomorphic substitution and complexation. Nonetheless, the adsorption-coupled reduction mechanism is greatly dependent on: (1) the nature of divalent and trivalent salts utilized in LDH preparation, and the types of interlayer anions (i.e., guest intercalated organic anions), and (3) the adsorption experiment conditions. The low Brunauer–Emmett–Teller specific surface area of LDH (1.80–179 m^2/g) suggests that pore filling played an insignificant role in Cr(VI) adsorption. The Langmuir maximum adsorption capacity of LDH (Q^o_{max}) toward Cr(VI) was significantly affected by the natures of used inorganic salts and synthetic methods of LDH. The Q^o_{max} values range from 16.3 mg/g to 726 mg/g. Almost all adsorption processes of Cr(VI) by LDH-based adsorbent occur spontaneously ($\Delta G° < 0$) and endothermically ($\Delta H° > 0$) and increase the randomness ($\Delta S° > 0$) in the system. Thus, LDH has much potential as a promising material that can effectively remove anion pollutants, especially Cr(VI) anions in industrial wastewater.

KEYWORDS
Hexavalent chromium; Layered double hydroxides; Adsorption-coupled reduction; Anion exchange; Isomorphic substitution; Critical review

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