

Simultaneous Removal of Anionic and Cationic Dye Mixtures from Wastewater Using Calcined Zn₂-Al-CO₃ Layered Double Hydroxides

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Abstract: The discharge of wastewater containing dyes from textile, paper, leather, and dyeing industries represents a major environmental problem due to the high stability, toxicity, and persistence of these pollutants in aquatic environments. Industrial effluents frequently contain complex mixtures of anionic and cationic dyes, making their removal by conventional treatment methods particularly challenging. Therefore, the development of efficient and versatile adsorbent materials is essential for wastewater treatment.

In this study, Zn₂-Al-CO₃ layered double hydroxides (LDHs) were synthesized by the coprecipitation method and subsequently calcined to obtain mixed oxides with high specific surface area. These materials were evaluated for the removal of a mixture of anionic and cationic dyes in aqueous solution. A key advantage of calcined LDHs lies in their well-known memory effect, which enables the partial or complete reconstruction of the initial lamellar structure upon contact with water and anionic species present in solution.

The synthesized materials were characterized by X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). XRD results confirmed the transformation of the initial LDH lamellar structure into mixed oxides after calcination, as well as the reappearance of characteristic LDH reflections after reconstruction, indicating the intercalation of anions from the dyes or the reaction medium. FTIR analyses revealed the disappearance of bands associated with interlayer carbonate anions after calcination and their partial reappearance after reconstruction, thereby confirming the rehydration and structural reorganization mechanism. SEM observations showed a porous and heterogeneous morphology favorable for adsorption processes.

Removal performance was investigated by optimizing several operational parameters, including solution pH, adsorbent dosage, and contact time. The results demonstrated that calcined Zn₂-Al-CO₃ LDHs exhibit high efficiency for the simultaneous removal of anionic and cationic dyes, particularly under acidic conditions. This performance is attributed to the combined action of surface adsorption mechanisms for cationic dyes and structural reconstruction of calcined LDHs through intercalation of anionic dyes, highlighting the crucial role of the memory effect in the removal process.

Keywords: Layered double hydroxides (LDHs), Calcined , Memory effect, Structural reconstruction, Adsorption, Mixed dye systems, Anionic and cationic dyes, Wastewater treatment.

References :

1. Zaghloul, A., Ichou, A. A., Benhiti, R., Abali, M., & Soudani, A. (2019). Removal of methyl orange from aqueous solution using synthetic clay type MgAl-LDH : Characterization , Isotherm and thermodynamic studies. 9(2), 155–163.
2. Talat Mehrabad, J., Arjomandi Rad, F., & Mastourian, S. (2024). Molecular Simulation of Nalidixic Acid Intercalation in the Interlayer Space of Zn₂Al-LDH: Molecular Dynamic of Drug Delivery. Iranian Journal of Chemistry and Chemical Engineering, 43(12), 4251–4260. <https://doi.org/10.30492/ijcce.2024.2030941.6640>