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Research Article

Study on the Removal Performance of Phenol and Lead by Vernadite Synthesized via a New Method

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Vernadite has excellent oxidation and adsorption performance, suggesting that it has good application prospects for the removal of phenolic substances and heavy metals from wastewater. In this study, after vernadite was synthesized by two different methods, the removal performance difference between the samples synthesized by the new and traditional methods (Ver-H and Ver-OH, respectively) was explored by sample characterization, phenol degradation, and Pb^{2+} adsorption experiments. The results show that, compared with Ver-OH, Ver-H has a larger particle size, specific surface areas, and total organic carbon (TOC) degradation capacity; the equilibrium degradation capacity of TOC of Ver-H was increased by 31.3%. The difference in the amount of TOC degradation may be attributed to more Mn(IV) oxygen vacancies in Ver-H, which facilitate the removal of intermediate products formed during phenol degradation. In addition, the larger specific surface areas provide the mineral surface with a larger number of active sites; Ver-H can therefore adsorb more intermediate products to promote their mineralization into CO_2. The adsorptions of Pb^{2+} by Ver-H and Ver-OH are both consistent with Langmuir isothermal adsorption, and the maximum adsorption capacities are 569.79 g/kg and 623.10 g/kg, respectively. The lack of significant difference indicates that both vernadites have strong adsorption capacities for Pb^{2+}.

1. Introduction

Manganese oxides are widely distributed in the environment as important components of soil and sediments, with additional prevalence in oceans, rivers, and lakes. Owing to their high activity, catalytic efficiency, low toxicity, and abundance, they are widely used in the fields of adsorption and oxidative degradation, as well as in capacitors [1–6]. Vernadite is a layered manganese oxide commonly found in nature; it is formed by the close hexagonal accumulation of oxygen ions and water molecules [7]. It has a high specific surface area, structural defects, and a mixed valence state of Mn [8, 9] and plays a pivotal role in the biogeochemical cycle of metals and carbon. It is often used as a heavy metal adsorbent and oxidant for various organic and inorganic pollutants. For example, Zhang et al. [10] studied the adsorption and oxidation differences of vernadite with different Mn average oxidation states (Mn_{AOS}) on As and Cr, demonstrating that the Mn_{AOS} determines the oxidation capacity of vernadite on As to a certain extent. Higher Mn_{AOS} corresponds to greater As oxidation capacity; however, its influence on Cr is small. Dong et al. [11] studied the removal effect and mechanism of vernadite toward phenol under different experimental conditions. The results showed that vernadite has a strong phenol removal effect, and the removal mechanism is adsorption and oxidation, with pH being the most influential factor. When the pH was lower than 4, oxidation dominated; at pH exceeding 4, the removal of phenol was mainly due to vernadite adsorption.

Vernadite has a poorly crystalline lamellar structure that is unstable in the environment and easily aged into other Mn ores. Therefore, few reports exist regarding the application