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Recent innovative research on chromium (VI) adsorption mechanism

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ABSTRACT

Chromium (VI) is an important heavy metal commonly found in tannery wastewater. In order to manage this type of environmental pollution, there needs to be a better understanding of Cr(VI) adsorption mechanisms. This article reviews the recent usage of various adsorbents to adsorb Cr(VI) from wastewater. The paper provides an overview of the removal capacity of numerous adsorbents in terms of Cr(VI) speciation, empirical modeling, surface complexation model (SCM) and spectroscopic measurements carried out by a wide number of researchers. Special emphasis was given to summarise various proposed Cr(VI) adsorption mechanism. It has been noted that Cr(VI) adsorption has been studied using a wide range of adsorbent materials with adsorption capacity from low to higher depending several factors including the nature and type of adsorbent, surface property of adsorbent, surface modification, pre-treatment of substrate, coexisting substrate and experimental conditions (equilibration time, solution pH, initial Cr(VI) concentration, ionic strength). Cr(VI) adsorption was highly dependent on solution pH and Cr(VI) adsorbed strongly in acidic pH while it exhibited weak or no adsorption in alkaline pH condition. Cr(VI) adsorption data has been studied using proton stoichiometry, kinetic, Langmuir, Freundlich, and surface complexation model (SCM). Adsorption data commonly fitted with a pseudo-second-order (PS2) kinetic model and Langmuir equation. Cr(VI) adsorbed typically by inner-sphere Cr(VI) complex at pH below 6.0 and by outer-sphere Cr(VI) complex above pH 6.0. Proton stoichiometry indicated that more than one reaction was involved in Cr(VI) adsorption. This review can be a centrepiece of researchers who wish to work on Cr(VI) adsorption. This study will shed new light on the understanding Cr(VI) adsorption onto the substrate at the water-solid interface and develop high-performance substrate to remove pollutants efficiently from wastewater.

1. Introduction

Chromium (VI) is an important naturally occurring metal widely used in a variety of areas, including mining, wood preservation, leather tanning, paint pigments, textile printing and dyeing, refractories (chrome and chrome-magnetite), aerospace, and electroplating (Dehghani et al., 2015; Dupont and Guillon, 2003; Fendorf, 1995; Nriagu and Nieboer, 1988). The release of a considerable amount of chromium in the environment is the result of leakage, poor storage, and improper disposal practices associated with industrial processes (Barakat, 2011; Jacobs and Testa, 2005; Palmer and Wittbrodt, 1991). At the same time, various chromium bearing minerals, including chromite are available in the soil and bedrock also releases natural chromium into the environment. Chromium is available in six different oxidation states (0 to VI) on the Earth's surface (Chebeir et al., 2016). Among them, Cr(VI) is a priority contaminant in soils and aquifers in industrial areas and is ranked the top sixteen toxic pollutants that have very harmful consequences on human health and aquatic life. Cr(VI) contamination of soil and aquatic systems is a significant problem worldwide. Acute exposure to Cr(VI) can cause diarrhea, nausea, kidney failure, liver diseases, lung cancer, ulcer formation and respiratory troubles (Ghashghaee and Farzaneh, 2016; Owalude and Tella, 2016b; Saha et al., 2011; Zhitkovich, 2011). Since Cr(VI) causes a great threat to humans as well as animals, removal of the contaminant to an acceptable threshold before its discharge from various industrial sources into the soil and water is of the utmost importance (Dupont and Guillon, 2003; Owalude and Tella, 2016b). The maximum allowable concentration limit for Cr(VI) in drinking waters suggested by the Environmental Protection Agency (EPA) is 0.05 mg/L (Parlayici and Pehlivan, 2019).

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