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Removal of Pb(II) from aqueous solution using KCC-1: Optimization by response surface methodology (RSM)

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ABSTRACT

The performance of KCC-1 as adsorbent towards Pb(II) removal was investigated. The TEM, XRD, FTIR, and BET results proved that the synthesized KCC-1 contains fibrous silica structure with the surface area of 298.87 m^2/g. The influence of prominent factors (initial concentration (X_1), time (X_2) and adsorbent dosage (X_3)) on Pb(II) removal was evaluated by response surface methodology (RSM). The most significant factor was the linear function of adsorbent dosage (X_3), while the quadratic effect of time (X_2^2) was the least significant factor. Maximum Pb(II) removal of 84.54% predictably and 83.06% experimentally were achieved under the optimal conditions (X_1 = 281.7 mg/L, X_2 = 80 min and X_3 = 3.7 g/L). The feasibility of KCC-1 in Pb(II) removal was confirmed by its good performance during five cycles of reusability study. It is affirmed that the KCC-1 has a high potential to be used in adsorption of Pb(II) from aqueous solution.

1. Introduction

Wastewater effluent from various industries including mining, battery, metallurgical, and paints, contains a potentially dangerous amount of heavy metals for example lead, cadmium, mercury, and arsenic (Fatimah, 2018; Siddiqui, 2015; Yousefzadeh et al., 2018). Lead (Pb(II)) has been acknowledged as one of the most hazardous heavy metals, which may cause numerous health problems including damage to kidney, liver and nervous system (Ekka et al., 2015; Gang et al., 2015; Liu et al., 2011; Tan et al., 2012; Yousefzadeh et al., 2018). Additionally, Pb(II) is considered toxic even at low concentration (Rengaraj et al., 2001), with the permissible limit in drinking water of 0.015 mg/L and 0.01 mg/L, as set up by the United States Environmental Protection Agency (EPA, 2009) and World Health Organization (1984), respectively. Thus, Pb(II)-containing effluent must be properly treated before being discharged into receiving waters.

Numerous techniques have been reported for Pb(II) removal such as an exchange of ions (Rengaraj et al., 2001), coagulation-flocculation (Hargreaves et al., 2018), chemical precipitation (Merganpour et al., 2015), solvent extraction (Baba and Adekola, 2013) and adsorption (Ekka et al., 2015; Gomes et al., 2013; Radi et al., 2015). Among the stated techniques, adsorption process appears as an attractive method owing to its excellent removal capability, convenience, economic cost, and simplicity (Lalchhingpuii et al., 2017; Lowe et al., 2015; Okoye et al., 2018; Tan et al., 2012). Mesoporous silica has attracted considerable attention for Pb(II) removal owing to its high surface area, good structural stability, accessible adsorption sites, and large uniform pores (Ekka et al., 2015; Lalchhingpuii et al., 2017). Besides, the negative charge of the silica surface induce more active sites on the mesoporous material, thus enhance the adsorption process (Lowe et al., 2015).

Recently, a new type of mesoporous silica material which is known as fibrous silica nanosphere (KCC-1), has attracted much attention in various types of application such as hydrogen storage (Ouyang et al., 2016), catalysis (Siddiqui et al., 2014), and CO_2 capture-conversion (Hamid et al., 2017), due to its high surface area, fibrous surface morphology, wide pore diameter, high mechanical, and thermal stability (Borah et al., 2015; Polshettiwar et al., 2010; Qureshi et al., 2016). Owing to its excellent properties and performances, the application of KCC-1 as an adsorbent is promising to be explored. Additionally, there is no study on the application of KCC-1 towards the heavy metal

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