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A coated of Ca/Fe layered hydroxide onto a synthesized adsorbent from (banana peels) for removal of cadmium from simulated wastewater

Hayder M. Abdul-Hameed

College of engineering, Environmental Engineering Department, University of Baghdad, Iraq

E-mail: hayderabdul_hameed@yahoo.com

ABSTRACT

Ca/Fe layered hydroxide (LH) coated with a produced adsorbent was synthesized and characterized by adsorbent from banana peels by a co-precipitation method. The SEM and EDS tests revealed that the particles on the surface of the adsorbent extra-fine, well spread, and the structure of LHs is heterogeneous. The contents of the Fe and Ca after the process increase well according to the EDS analysis. From analysis, it was an enhancement in the specific surface area of the adsorbent from 44.39 $m^2 g^{-1}$ (before synthesizing) to 1022.08 $m^2 g^{-1}$ (after synthesizing). The produced Ca/Fe LH was used for the removal of ($Cd^{++)}$ from aqueous solution; a series of the batch experiments with different dynamic parameters reveals the best removal efficiency of (93.4%) for a (Ca /Fe molar ratio of 2).

Key words: Banana peels, Activation, Layered double hydroxide, Cadmium. Short Communication

Article type: Short Communication.

INTRODUCTION

One of the most widely used technology for removing heavy metals from wastewater is adsorption (Najiah *et al.* 2014; Fasial & Naji 2019). Agricultural waste, back-yard trimming waste and natural materials can be considered as low cost adsorbents and once coating by other inorganic adsorbents such as calcium oxide, manganese oxide, aluminum oxide, and ferric oxide, it will produce the layered double hydroxides (LHs), which are considered as a new type of adsorbent which improves the adsorption concept (Facui *et al.* 2016). The LHs can be synthesized comparatively economically. The LHs have a high capacity of anion exchange (5-8 meq g^1 and high surface area, which considered the most promising properties, comparable to those of good thermal stability and anion exchange resins (Das *et al.* 2006). The low cost adsorbent produced from agricultural wastes with chemical and physical modification processes such as the activation of banana peels, show high removal efficiency for heavy metal (Goncharuk *et al.* 2011; Tran *et al.* 2018). Thus, this low-cost and good-adsorbent with high surface area derived from banana peels is modified by Ca/Fe LH to produced more economic and effective new adsorbent for removal of cadmium from aqueous solution. There are several studies about removal of toxic substances from the environment (Zaribafan *et al.* 2017; Banimahd Keivani M 2018; Bozorgpanah Kharat *et al.* 2018; Olasehinde *et al.* 2020; Azizi, *et al.* 2020; Al-Juboury 2021; Alshamri *et al.* 2021). Cadmium waste streams from the industries mainly end up in soils (Goncharuk *et al.* 2011; Tran *et al.* 2018). The causes of these waste streams are for instance, zinc production, phosphate ore implication and bio-industrial manure. Cadmium waste streams may also enter the air through (household) waste combustion and burning of fossil fuels (Ahmed & Theydan 2012; Abdul-Hameed & Al-Juboury 2019). Another important source of cadmium emission is the production of artificial phosphate fertilizers. An exposure to significantly higher cadmium levels occurs when people smoke. Tobacco smoke transports cadmium into the lungs. Blood will transport it through the rest of the body where it can increase effects

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by potentiating cadmium that is already present from cadmium-rich food (Abdul-Hameed 2009; Abdul-Hameed & Al-Juboury 2019).

MATERIALS AND METHODS

Preparation of the adsorbent

The banana peels were originally collected from the local markets, houses and sorting activities in the transfer stations, washed thoroughly with distilled water and dried in the sun light for 10 days, followed by grinding banana peels using a mechanical grinder (YETIO-230) and sieving by LARMANN sieves with 0.5, 0.75 and 1mm opening. The sieved particles were then carbonized at 270 ºC with flowing 130-mL min^{-1} N_2 for 1 h and activated by physical activation at 600 ºC, with flowing 110 mL min^{-1} CO_2 respectively for 2 h.

Synthesis of LDH coated onto banana peels:

The co-precipitation method was used to prepare LDHs at normal room temperature. The method was conducted using different synthesized adsorbent dosage (0.1, 0.15, 0.2, and 0.2 g 100 mL^{-1}) and different molar ratio of Ca/Fe (0.5/1, 1/1, 1.5/1 and 2/1) of solution containing Ca $(NO_3)_2 \cdot 4\ H_2O$ and $FeCl_3 \cdot 4\ H_2O$ with stirring at 400 rpm for 1 h. The pH of the solution were kept at 7 by adding $CaCO_3$ (0.2 mole) and CaOH (1 mole). The solution resulted from this process were filtered using WATTMAN filter paper ash less type and the filtrates solids were dried for 1 h at 105 ºC.

RESULTS AND DISCUSSIONS

The effect of Ca/Fe molar ratio and amount of adsorbent on the preparation process

For selecting the optimum molar ratio of Ca/Fe for preparation of a local adsorbent-Ca/Fe, different molar ratio of Ca/Fe ranges were used, and the effect of this parameter on the removal efficiency of Cd^{+2} were studied and tabulated (Table 1).

As shown in Table 1, at molar ratio of Ca/Fe equal two, the removal efficiency for Cd^{+2} onto local adsorbent was 93.4% and it considered as the highest value. So the optimum value of Ca/Fe = 2 was fixed for synthesize the coated adsorbent (Abdul-Hameed & Al-Juboury 2020). Also, the removal efficiency for Cd^{+2} at different dosages of the coated adsorbent were investigated. Different dosages range of 0.1, 0.20, 0.30, 0.4, and 0.5 g were used at Ca/Fe = 2 molar ratio (Table 2).

Characterization of the adsorbent

Scanning electron microscopy (SEM)

The coated adsorbent had a structure and high surface area that made it possible and applicable to be coated by other coating materials such as Ca/Fe-LDH as shown in a SEM analysis. After coating, the Ca\Fe-LDH with size ranging from 18.11 to 93.17 were coated the adsorbent surface. The structure of Ca/Fe is typical semi-fine structure and the particulates are in non-homogenous and irregular distribution.

According to Table 2, the removal efficiency of cadmium by the coated adsorbent was increased as the dosage of the coated adsorbent increase.

Table 1. Removal efficiency for Cd^{+2} at different molar ratio of Fe and Ca at dosage = 0.2 g 50 mL^{-1}), pH = 7, adsorption time = 2 h and contaminant concentration = 1 mg L^{-1}).

Fe	Ca	Cd^{+2} %
1	0.5	43.1
1	1	60.8
1	1.5	91.6
1	2	93.4

Energy dispersive Spectroscopy (EDS)

High content of the Ca, O, and C, while a less content of O was shown by EDS spectrum data of the coated adsorbent (Table 3). This high content clearly occurred after coating fixation. Hence, Ca\Fe-LDH successfully implanted and embedded onto the synthesized adsorbent.

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Table 2. Removal efficiency for Cd^{+2} at different dosage of coated adsorbent, pH = 7, adsorption time = 2 h and contaminant concentration = 1 mg L^{-1}).

Dosage	Cd^{+2} removal (%)
0.1	33.1
0.2	35.4
0.3	48.2
0.4	76.8
0.5	93.2

Table 3. EDS characterization for the Ca/Fe- LDH.

CK	47.05	Ca K	23.11
OK	7.21	Fe M	20.33
ZnK	1.79	CuK	0.51

CONCLUSION

Ca/Fe layered double hydroxide coated was synthesized by a co-precipitation method. The XRD and SEM displayed that the particles on the surface of adsorbent resulted from banana peels are irregular, fine with spread distribution. Based on EDS analysis, it was verified that the Ca/Fe-LDH was successfully embedded by co-precipitation method on the produced adsorbent from banana peels.

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