ECONOMICAL KNF-CHT-ALG BEADS FOR THE ADSORPTION OF PB (II) IONS IN WATER

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Abstract: *The present study has been carried out using two types of beads which are CHT-ALG and KNF-CHT-ALG beads for the removal of Pb (II) ions. Among these two beads, KNF-CHT- ALG showed the highest adsorbent due to the availability of high surface roughness and large pores as examined in the FESEM analysis. Meanwhile, FTIR spectra has confirmed the existence of extra functional groups such as NH2, OH^-, COO^-, C-O, CO, and C-O-C in KNF-CHT-ALG which promoting Pb (II) ions to bind. The chitosan optimisation of the KNF-CHT-ALG beads also contributed to economical cost of the beads while maintaining the same performance of the metals removal. Clearly, from the research conducted, the KNF-CHT-ALG beads with ratio 0.6g:0.4g:0.6g for each material were found to be a suitable adsorbent for Pb (II) ions removal. The prime important is, the main part of the adsorbent which is KNF core is known to be a zero cost and abundantly available waste products that could serve as a practical means for metal ions adsorption such as at wastewater treatment plant. In the long term, this study is committed to targets for SDG 6 which is clean water and sanitation by 2030.*

Keywords: Kenaf beads; economical; metals removal; adsorption; SDG 6

1. Introduction

The untreated heavy metals, which emanate from various industries including mining, electroplating, automotive, battery enterprises and agricultural activities have resulted in the contamination of wastewater [1]. The exceeded amounts of heavy metals such as Pb (II), Cu (II), Ni (II) and Zn (II) cannot be naturally degraded in the water body, and this may be detrimental to human as they can cause many dangerous effects to human health and aquatic lives. Long-term low-level lead exposure can reduce IQ development in children while high level of lead exposure can cause kidney damage, bone abnormalities and even death [2].

The common traditional treatments such as coagulation, chemical precipitation, and electrochemical technologies are not in use anymore since they demand a large amount of processed energy, high operational, expensive maintenance costs, and highly qualified personnel, since they are based on an advance technology [3]. Alternatively, there are many reports on the removal of heavy metals by using adsorption technique that is commonly employed natural adsorbents to take up heavy metals and surprisingly the result shows promising outcome. This is because, the adsorption process offers many advantages such as simple equipment requirement, high effective adsorption and cost-effective since thenatural-based adsorbent used usually are zero cost, abundantly available and safe to use [4].

In the present study, the researcher aims to investigate which beads either CHT-ALG or KNF-CHT- ALG portrays the highest Pb (II) ions removal from wastewater using batch mode experiment. It is also the aim to study the economical kenaf beads with less-dependency on the chemicals.

2. Materials and Methods

2.1. Equipment and Materials

For the adsorbent synthesized in this research, the KNF plants is obtained from the Raw Material Collecting Centre (RMCC), which is owned by Lembaga Kenaf Dan Tembakau Negara (LKTN), in Cherating Kuantan, Pahang. After separating the fibre part from the core, the core part will be dried in an open space for a week. Then, the dried core part is powdered by sander machine and filtered by lginate (ALG) and chitosan (CHT) powder from Sigma Aldrich, Germany are also used to produce the beads.

2.2. Characterisation of the beads

The surface morphologies of the beads were observed using the FEsieve analysis size 300 ɥm. The kenaf core powder is kept in an air-tight plastic bag for further analysis. In addition, sodium aSEM Zeiss MERLIN in Research Instrumental Management (RIM), Universiti Kebangsaan Malaysia (UKM). The presence of functional groups in the beads were observed by FTIR spectroscopy using the FTIR Spectrometer (Perkin Elmer, Spectrum 400) in Characterization and Measurement Research Lab, Faculty of Applied Sciences, UiTM.The removal concentration of Pb (II) ions by the beads were observed using the Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) in MyBiorec Laboratory, School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Selangor.

2.3. Preparation of the beads

CHT powder were added in a sodium alginate solution and stirred homogeneously. The blended solution was dripped into 100 ml of calcium chloride to form smooth CHT-ALG beads. Then, the beads were rinsed with ultrapure water 3 times and dried at 60°C for 2 hours. Same procedure followed as before but with addition of KNF core powder to form KNF-CHT-ALG beads. To study the removal of Pb (II) ions using the beads, a batch adsorption experiment was conducted in a 250 mL glass flask. The originalratio of kenaf, chitosan and alginate dosage used is 0.6:0.6:0.6 which means 0.6g weight were used for each material. Then a certain amount of adsorbent (0.5 g) was added into the flask containing 50 mL of Pb (II) ions solution at a concentration of 50 mg/L. Next, the solution was shaken in an incubator shaker at 125 rpm, 25°C for 60 minutes. Afterwards, beads were separated from the solution through filtration. Then, the residual concentration of Pb (II) ions in the solution was analysed using ICP analysis.

2.4. Chitosan optimisation

In order to study the effect of chitosan dosage on KNF-CHT-ALG beads towards Pb (II) ions removal, theTable 1 below shows the KNF-CHT-ALG beads composition that were modified by varying the CHT dosage ranges from 0.2 to 1 g. At the same time, the KNF and ALG powder were fixed at dosage of 0.6g.

Table 1. Composition of the KNF, CHT and ALG powder.

Material	Dosage (g)				
KNF	0.6	0.6	0.6	0.6	0.6
CHT	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**
ALG	0.6	0.6	0.6	0.6	0.6

3. Results and Discussion

3.1. Surface morphology of the beads

FESEM analysis was performed on individual beads of each sample type (CHT-ALG and KNF-CHT- ALG) as depicted in Figure 1 below. The FESEM images of KNF-CHT-ALG in Figure 1b shows a significant morphological change compared to CHT-ALG in Figure 1a. This is due to the presence of fibrous cellulose materials with groove and uneven surface structure which indicates higher surface areathat helps the adsorption process of Pb (II) ions [5]. Among these two types of beads, KNF-CHT-ALG beads portrayed the highest surface roughness which potentially adsorb maximum Pb (II) ions.

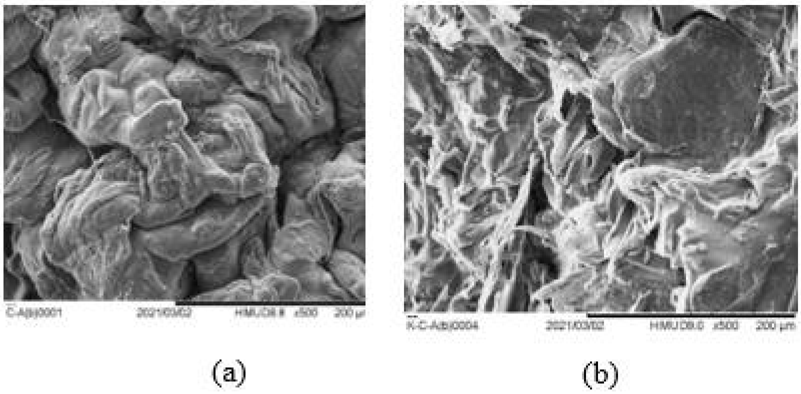

Figure 1. The FESEM images at 500X magnification of (a) CHT-ALG, and (b) KNF-CHT-ALGbeads.

3.2. Functional groups spectra of the beads

The FTIR analysis was used to investigate the functional groups presence in CHT-ALG and KNF-CHT-ALG beads. The results are shown in Figure 2. A wide band appeared at the range of 3200-3300 cm^{-1} for both beads confirming the presence of free OH^- groups imposing the hydroxyl functions [6]. The FTIR spectrum at around 1590 cm^{-1} attributed to bending vibration of NH2 and OH^- in the CHT-ALG beads [7]. Meanwhile, FTIR spectrum at around 1590 cm^{-1} in the KNF-CHT-ALG can be due to the immobilization of carbonyl groups onto cellulose groups of kenaf powder [5]. Next, the band perceivedat the range of 1416-1418 cm^{-1} represents stretching of COO^- and C-O while the band at 1008-1028 cm^{-1} shows stretching vibration of alginate and chitosan polymer [7]. Interestingly, the peaks of 1734 cm^{-1} in KNF-CHT-ALG is closer to which attributed to the presence of CO that confirmed the existence of carbonyl in the carboxyl group (-COOH) [6]. On the other hand, an extra band exist in the KNF-CHT- ALG beads occurring at 1244 cm^{-1} wavelength was corresponded to C-O-C stretching vibration due to the addition of KNF core powder in the beads [5]. As we can see from the FTIR spectra picturized in Figure 2, the KNF-CHT-ALG beads portrays extra two functional groups compared to the CHT-ALG beads.

Therefore, it will be further use in chitosan optimisation stage whereby it has extra spots in promoting the binding process of the metal ions.

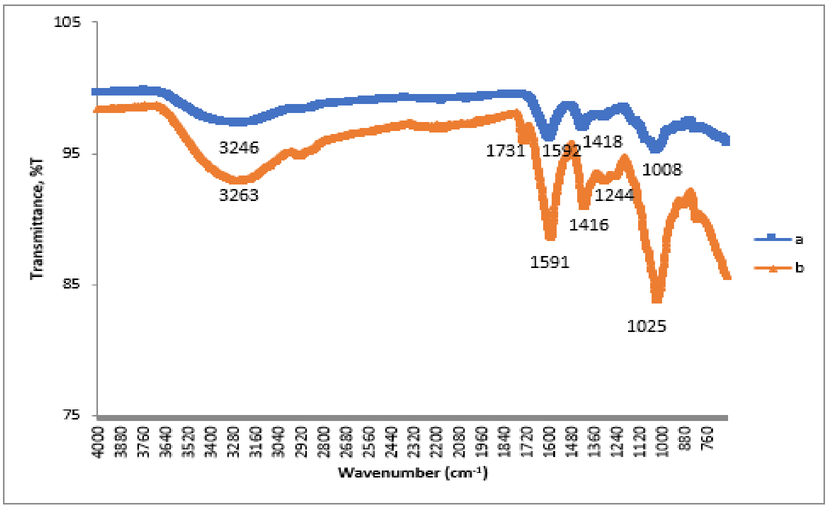

Figure 2. FTIR spectra of (a) CHT-ALG, and (b) KNF-CHT-ALG.

3.3. Pb (II) ions removal of the beads

The study was carried out to compare the Pb (II) ions percentage removal of CHT-ALG and KNF-CHT-ALG beads. The results are plotted in the graph and shown in Figure 3 below. It was found that amongthese two types of beads synthesized, the elimination percentage of Pb (II) ions by KNF-CHT-ALG beads was significantly higher than CHT-ALG. As we can see from the figure, the KNF-CHT-ALGdid removed up to 95.27% Pb (II) ions. This is because, the inclusion of kenaf into the adsorbents can exhibit higher removal of Pb (II) ions due to the availability of higher surface area and larger pores thathelps the adsorption of heavy metals [8]. The surface of kenaf are rich with hydroxyl groups which canattract more positively charged of heavy metals [5, 9].

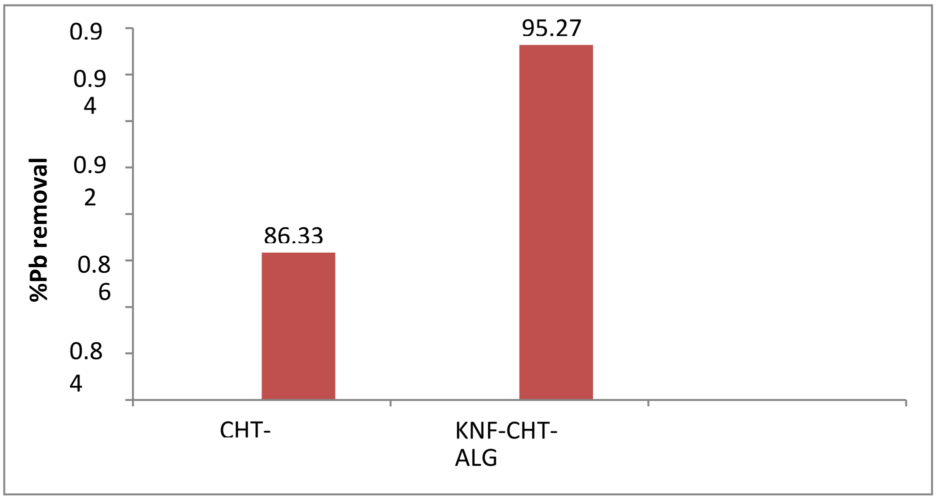

Figure 3. Pb (II) ions removal using CHT-ALG and KNF-CHT-ALG

In comparison of these two types of beads, KNF-CHT-ALG beads will be further use based on the highest Pb (II) ions adsorption and existence of extra functional groups in the FTIR analysis. The previous Figure 1b shows the KNF-CHT-ALG beads have rougher surface which indicating the presence of agglutinative flakes of fibrous cellulose materials that helps the adsorption rates of Pb (II) ions. Meanwhile, the image of KNF-CHT-ALG beads after Pb (II) ions adsorption in Figure 4 below represents smoother and denser surface due to the formation of Pb (II) ions layer over the surface of the beads [10].

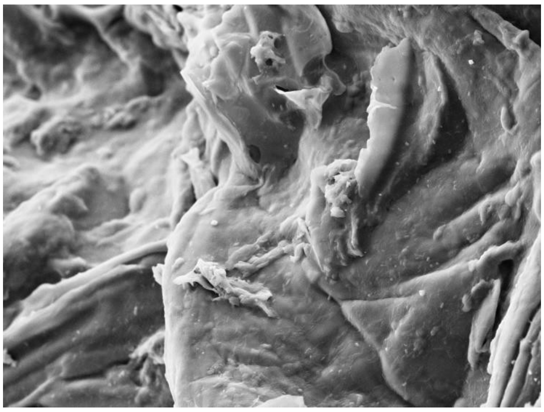

Figure 4. FESEM image of KNF-CHT-ALG beads after adsorption at 1000X magnification.

3.4. Chitosan Optimisation

The chosen of KNF-CHT-ALG beads ratio depends on its chitosan dosage. This is to minimise the cost of the beads while maintaining the same performance of the removal of heavy metals. The objective of this subsequent section was to optimize the most expensive material which is chitosan. The beads were modified by varying the chitosan dosage from 0.2 to 1.0 g. The percentage removal (% R) is plotted against the KNF-CHT-ALG ratio as shown in Figure 5 below. It is obvious from the figure, with increase of chitosan dosage up to 0.4g, the removal percentage increases to 93.26% and after that, decreasing. The results shown below indicates that the removal of Pb (II) ions by KNF-CHT-ALG beads at chitosan dosage of 0.6, 0.8 and 1.0 g were continuously decreasing at 91.18%, 88.02% and 87.50%, respectively. This is due to surface of the beads are saturated with the Pb (II) ions. The successful rate of adsorption of heavy metals using the kenaf beads shows less-dependency on the chemical-based adsorbent. The kenaf is a crop found in abundance in Malaysia, that had the potential to reduce the production cost of adsorbents. The economical kenaf beads may cost around USD 18/kg compare to the commercial adsorbent, which is around USD 57/kg, that is three times cheaper.

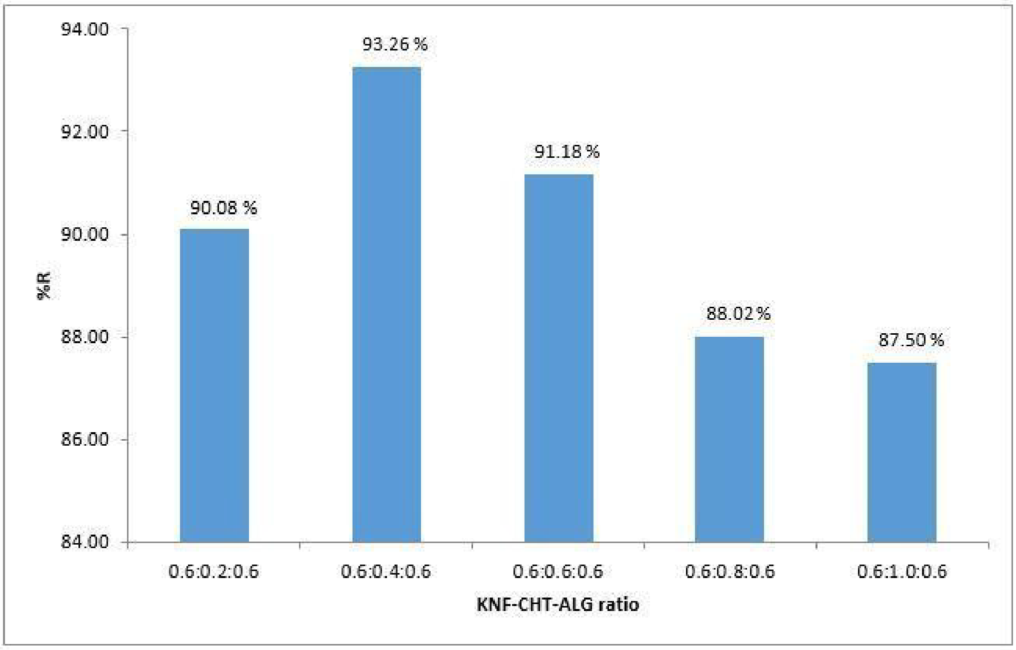

Figure 5. The percentage removal of Pb (II) ions against KNF-CHT-ALG beads ratio.

4. Conclusions

The present study has been carried out two types of beads (CHT-ALG and KNF-CHT-ALG) for the successful removal of lead ions. Among these two beads prepared, KNF-CHT-ALG bead showed highest Pb (II) ions removal. This is believed to be due to the availability of higher surface roughness and larger pores as examined in the FESEM analysis. Meanwhile, FTIR spectra has confirmed the existence of extra functional groups in KNF-CHT-ALG which promoting more Pb (II) ions to bind. Tounderstand the effect of chitosan dosage on KNF-CHT-ALG beads towards Pb (II) ions removal, the beads were modified by varying the chitosan dosage (0.2, 0.4, 0.6, 0.8 and 1g). Clearly, with increase of chitosan dosage up to 0.4 g, the removal increases to 93.26% and after that the removal decreasing. The main kenaf is stable green nanocomposite and abundant in Malaysia. The kenaf based adorbent to for heavy metals can be utilize in wastewater treatment plant or water-environment industries. The cleaner and safer discharged water will ensure the water security to humans including animals and environment in alligned with the SDG 6 by 2030.

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