ALKIMIA : Jurnal Ilmu Kimia dan Terapan

ARTICLES

View Article Online
View Journal | View Issue

OPEN ACCESS

Activated Calcium Oxide As An Adsorbent For Metal Lead Ions

Febriani Alhidayah[a], Siti Rodiah[a*], M. Mahfudz Fauzi[a], Hasan Marzuki[a], Damayanti Iskandar[a]

Abstract. The rapid development of industry increases lead heavy metal pollution (Pb). The heavy metal lead is known for its toxicity to humans. Adsorption is one way to minimize the negative impact of lead. Increasing the ability of adsorbents through the activation process is very important in the role of minimizing the adverse effects of lead. This study aimed to determine the activity of NaOH-activated Calcium Oxide (CaO) as an adsorbent for lead metal (Pb) ions. FT-IR spectra show Ca-O bond vibrations at wave numbers 842 cm^{-1} in CaO adsorbent, and 845 cm^{-1}, 781 cm^{-1} in activated CaO adsorbent. Meanwhile, from the results of the AAS analysis, the adsorption capacity of activated CaO is 3% higher than CaO for the adsorption of lead metal ions.

Keywords : Heavy metal pollution, Lead metal ions, adsorption, CaO, activation

[a]*Department of Chemistry, Universitas Islam Negeri Raden Fatah Palembang, Palembang City 30254, Indonesia*
Correspondence and requests for materials should be addressed to Siti Rodiah (email: siti.rodiah_uin@radenfatah.ac.id)

Introduction

The rapid development of industry not only has a positive impact but also has a negative impact on the environment due to waste from industrial activities. Pollutants contained in waste pollute the environment, for example lead metal ions [1]. High lead metal pollution in waters was considered very dangerous because it can cause fish and water consumed by humans to be contaminated by lead [2-3].

Lead is a persistent metal in all parts of the environment, in air, water, soil and mainly comes from various manufactured products such as leaded gasoline, paint, ceramics, solder, water pipes, hair dyes, cosmetics, aircraft manufacture, agricultural equipment, shields for x-ray machines, etc. Lead is considered a potent environmental toxin with its non-biodegradable nature and toxic effects [4].

According to data released by UNICEF in 2020, I of 3 children (±800 million) have lead levels above 5 µg/dL. Lead that enters the body can cause lung dysfunction, hematological changes (anemia), liver damage and even death [5]. Various methods have been used as an effort to minimize the effects of lead heavy metal contamination such as the adsorption method.

Several types of adsorbents used in the heavy metal adsorption process such as silica gel, zeolite, calcium oxide and activated carbon. Among the available adsorbents, Calcium oxide (CaO) was often used because of its high adsorption capacity [6] and also considered a safe material for humans and animals [7]. This study was conducted to determine the activity of activated calcium oxide as an adsorbent for the heavy metal lead. CaO was synthesized from golden snail shells through calcination at 900℃ for 2 hours, which has been done by previous researchers [8].

Experimental

Materials. The tools used were a set of glassware, oven, shaker, analytical balance, stopwatch, pH meter mettler toledo, sample bottle, FT-IR Spectrophotometer ALPHA II Compact Bruker and AAS Thermo8Scientific ICE 35008Vacum8generator. While the materials were CaO, NaOH, $Pb(NO_3)_2$, filter paper and Aquades.

CaO Activation. A total of 10 g of CaO was put into 50 ml of 30% NaOH solution and left for 24 hours then filtered. Then rinsed with aquades repeatedly until the pH approaches the original pH of CaO, the pH is measured using a pH Meter. The activated CaO was dried at a temperature of 105ºC for 60 minutes [9].

Preparation of Pb Standard Solution. 0.39 grams of Pb(NO3)2 was dissolved in sufficient distilled water, then put into a 250 ml measuring flask and added distilled water to the limit mark. This solution was diluted from an initial concentration of 1000 ppm to 100 ppm [10].

Adsorption of Pb metal using activated CaO. A total of 50 ml of 100 ppm Pb solution was put into a 250 ml Erlenmeyer flask, then 0.5 grams of adsorbent was added and stirred with a shaker for 20 minutes [5]. The mixture was filtered using filter paper. The filtrate was analyzed using an AAS instrument.

Result and Discussion

In this study, base activation was carried out on CaO by adding NaOH. After CaO is activated, the

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)}$$

$$Ca(OH)_{2(aq)} \rightleftharpoons Ca(OH)_{2(s)}$$

$$Ca(OH)_{2(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2OH^{-}_{(aq)}$$

$$Na(OH)_{(aq)} \longrightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)}$$

$$Ca(OH)_{2\ \text{activated}} \xrightarrow{105℃} CaO_{\ \text{activated}}$$

(1)

pH of CaO increases from 12.45 to 13 due to the addition of NaOH. CaO that reacts with water will form $Ca(OH)_2$. Then this $Ca(OH)_2$ will be ionized into Ca^{2+} and OH^- which form an equilibrium reaction. The addition of NaOH in the activation process causes the amount of OH- to increase and the equilibrium shifts towards the product, which means that the formation of $Ca(OH)_2$ increases. During heating, $Ca(OH)_2$ will be partially hydrated to form activated CaO. The reaction process that occurs during activation is as described in Equation 1.

FT-IR spectra of CaO and activated CaO showed at Figure 1. Spectra FT-IR showed at wave number of 3641 cm-1 indicated the presence of OH group from hydrating CaO by air in CaO adsorbent, while in activated CaO appeared at wave number 3542 cm^{-1} and 3635 cm^{-1}. FT-IR spectrum of activated CaO showed a wide OH peak as a sign that the detected OH group is bound to other atoms, while for OH which has a sharp peak is free OH. In addition to the OH group, the C-O function was also observed at wave numbers of 1000 cm^{-1} to 1500 cm^{-1}, which probably came from $CaCO_3$ from snail shells (basic CaO material). In both adsorbents, the presence of Ca-O groups was found at 842 cm^{-1} in CaO, and 845 cm^{-1}, 781 cm^{-1} in activated CaO. The shift in wave numbers from 842 cm^{-1} to 781 cm^{-1} is due to the presence of side chain atoms that affect the bond energy so that the wave number shifts.

Table 1 shows the comparison of adsorption performance between CaO and activated CaO adsorbents. CaO and activated CaO adsorbents are able to absorb lead metal by 70.58% and 73.97%, respectively. The adsorption capacity of activated CaO is 3% higher than that of CaO adsorbents, this can be caused by activated CaO having more OH ions which then react with Pb ions to form $Pb(OH)^{3-}$. The $Pb(OH)^{3-}$ species has low solubility in water so it will precipitate and reduce the concentration of Pb in water. In addition, there is a possibility that the $Pb(OH)^{3-}$ complex will then react with Ca^{2+} ions which will also precipitate when left to stand.

Table 1. Results of Adsorption of Lead Metal Ions by CaO and Activated CaO Adsorbents

	CaO	CaO teraktivasi
Massa adsorben	0,5 gram	0,5 gram
Volume	100 mL	100 mL
Konsentrasi awal	100 ppm	100 ppm
Konsentrasi akhir	29,42 ppm	26,03 ppm

Conclusion

From the results of this study, it can be concluded that activation with NaOH increases the ability of CaO to adsorb lead metal ions. The adsorption capacity of activated CaO is 3% higher than that of CaO adsorbents, because there is an addition of OH ions originating from NaOH. However, it is necessary to further analyze other influences such as the possible influence of adsorbent characteristics such as

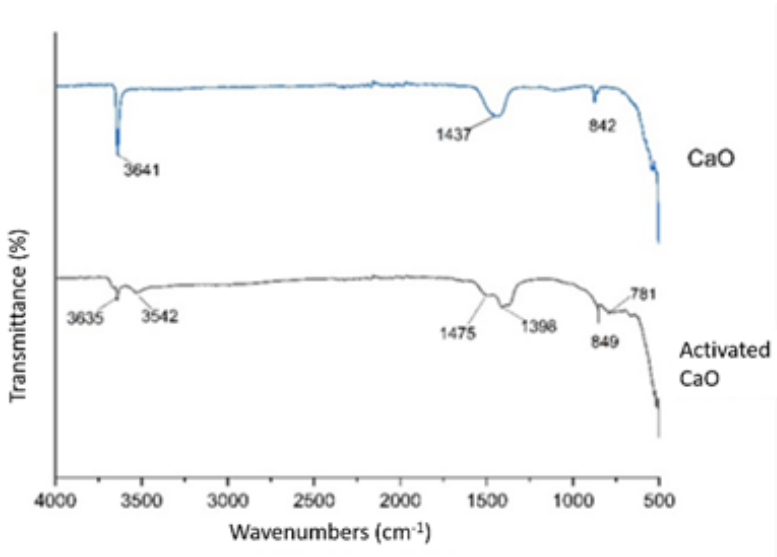

Figure 1. FTIR spectra of CaO and activated CaO

the appearance of the adsorbent surface, the surface area of the adsorbent, and so on. Optimal conditions in the adsorption process need to be observed for further research.

Acknowledgements

The authors would like to thank and appreciate the assistance from all parties, including the integrated laboratory authorities of UIN Raden Fatah Palembang who have provided research facilities.

Author Contributions

Febriani Alhidayah collected data and wrote the manuscripts; Siti Rodiah designed and supervised the research and completed the manuscripts; M. Mahfudz Fauzi, Hasan Marzuki, Damayanti Iskandar supervised and completed the manuscripts.

References

[1] Komarawidjaja, W. (2017). Paparan Limbah Cair Industri Mengandung Logam Berat pada Lahan Sawah di Desa Jelegong , Kecamatan Rancaekek , Kabupaten Bandung Industrial Wastewater Containing Heavy Metal Exposures on Paddy Field in Jelegong Village , Rancaekek District , Bandung Regenc. Jurnal Teknologi Lingkungan, 18(2), 173–181.

[2] Azizah, M. (2022). Kandungan Logam Berat Timbal (Pb), Kadmium (Cd), dan Merkuri (Hg) di dalam Tubuh Ikan Wader (Barbodes binotatus) dan Air Sungai Cikaniki , Kabupaten Bogor. 28(2), 83–93.

[3] Putra, W. E., Setiani, O. (2020). Kandungan Logam Berat Pb Pada Air Bersih Dan Pada Darah Wanita. 8(November), 840–846.

[4] Boskabady, M., Marefati, N., Farkhondeh, T., Shakeri, F., & Farshbaf, A. (2018). The e ff ect of environmental lead exposure on human health and the contribution of in fl ammatory mechanisms , a review. Environment International, 120(August), 404–420. https://doi.org/10.1016/j.envint.2018.08.013

[5] Balali-mood, M., Naseri, K., Tahergorabi, Z., & Khazdair, M. R. (2021). Toxic Mechanisms of Five Heavy Metals : Mercury , Lead , Chromium , Cadmium , and Arsenic. Frontiesrs in Pharmacology, 12, 1–19. https://doi.org/10.3389/fphar.2021.643972

[6] Jefri, & Rodiah, S. (2022). CaO Adsorbent For Reducing Metal Content Of Fe, Mn, And Zn From Pet-Set Waste Water. Jambura Journal of Health Sciences and Research, 4(3).

[7] Anantharaman, A., Ramalakshmi, S., & George, M. (2016). Green Synthesis of Calcium Oxide Nanoparticles and Its Applications. Journal of Engineering Research and Applicatiom, 6(10), 27–31.

[8] Rodiah, S., Erviana, D., Rahman, F., & Budaya, A.W. (2020). Modified CaO Catalyst from Golden Snail Shell (Pomacea canaliculata) for Transesterification Reaction of Used Cooking Oil. Al-Kimia, 8(1). 83-92.

[9] Rasyid, R., Ifa, L., & Kardiman. (2019). Pembuatan Adsorben Dari Sabut Kelapa Sebagai Penyerap Logam Berat Pb (II). ILTEK, 14(02).

[10] Aminin, D., Oktasari, A., & Wijayanti, F. (2021). Pemanfaatan Cangkang Buah Karet (Hevea brasiliensis) Sebagai Adsorben Logam Berat Timbal (Pb). Cakra Kimia, 9(1).