Preparing Activated Carbon from Chestnut Shell and Binding Polyacrylic Amidoxime to its Surface to Remove Some Metals from Aqueous Solution

Pardis Akbari*, Fatemeh Olfati

Eqbal Primary School, Professor Shamsipour Research Center, 22 Bahman, Behzisti Blvd., Kermanshah, Iran.

Abstract

Currently, one of the most important environmental pollutants is industrial effluents with heavy metals. Arsenic is one of these toxic metals that lead to many problems like keratosis and hypertension, osteoporosis and bone fragility, increase in disorders incidence and skin cancer. Thus, the removal of arsenic from the industrial effluent seems essential. The purpose of the study was to absorb arsenic by activated carbon obtained from chestnut shell, walnut shell, pistachio and coconut. For this purpose, the adsorbents were first prepared and used with 2.5 to 20 g / l concentrations to remove arsenic from the solution. The results of pH experiments showed that the absorption values for activated carbon adsorbents obtained from chestnut shell, coconut shell, pistachio-nut shell and walnut shell had the maximum absorption value at pH 6, 6, 6 and 7, respectively. The results of the electron microscope image showed that the activated carbon obtained from the chestnut shell had suitable pores as adsorbent sites for metal cations. Moreover, the results of the infrared spectroscopy indicated the presence of effective functional groups in the absorption of metal cations like arsenic.

Keywords: Chestnut shell, activated carbon, polyacrylonitrile, ceric ammonium nitrate, adsorption

Introduction

Heavy metal contamination is currently an environmental problem at global scale. Heavy metals are of the most common materials used in industry as raw materials, and the effluent of many industries has these types of contaminants. The rapid industrialization and the excessive use of fertilizers and pesticides have resulted in an increase in the entry of heavy metals into the environment. Arsenic has a great role in the contamination of surface waters [1]. At low concentrations – 0.013 to 0.02 g/l – it leads to many problems like keratosis and hypertension, osteoporosis and bone fragility, increase in disorders incidence and skin cancer [2]. The allowable limit of its pollutants in discharge to surface waters as well as agricultural uses and irrigation is determined as 0.01 mg/l [3].

Among the effective ways for the removal of heavy metals is adsorption process by activated carbon [4, 5]. Activated carbon is a kind of strong adsorbent with great adsorption that is highly porous with a high internal surface and mechanical strength [6]. Its most significant feature is the selective removal of contaminants that is used for recycling in some cases [7]. Metal cations bind to activated carbon functional groups like carboxylic (COOH) and hydroxyl (OH) and release H^+ [8, 9]. Pistachio and walnut shells contain aldehyde and ketone polar groups (a combination of alcohol and acetone), acid, tannin, lignin, and other phenolic compounds where these groups can transfer cations in these absorbents [10, 11]. Studies show that carboxyl groups at the absorbent surface of pistachio and walnut shells lead to absorption of arsenic from the aqueous environment [12]. Moreover, the results of the studies of chrome and copper removal by walnut shell and copper and zinc by activated carbon of chestnut shell [13, 14] where the shells of chestnut, walnut, pistachio and coconut have good capability in removal of heavy metals. The purpose of the study was to compare the kinetics of the adsorption of the absorbents of activated carbon (AC), walnut shell (AH), pistachio-nut shell (SD), and coconut (SH) in removal of arsenic heavy metal from aqueous environment.

Address for correspondence: Mrs. Pardis Akbari, Eqbal Primary School, Professor Shamsipour Research Center, 22 Bahman, Behzisti Blvd., Kermanshah, Iran.

How to cite this article: Akbari, P., Olfati, F. Preparing Activated Carbon from Chestnut Shell and Binding Polyacrylic Amidoxime to its Surface to Remove Some Metals from Aqueous Solution. Arch Pharma Pract 2020;11(S4):37-9.

Method

Preparing activated carbon from chestnut shell

At first, 5 grams of chestnut shell is washed with 0.05, 0.10, 0.15, and 0.20 KOH solutions, respectively and placed in the oven under vacuum at a temperature of up 400 to degrees after smoothing and drying the chestnut shell to prepare the activated carbon. Then, poly-acrylonitrile polymer is bound on the active Carbon formed by 0.15 washing. For this purpose, 5 ml of poly-acrylonitrile is added to a container containing half a gram of activated Carbon, and then start the reaction starts using ceric ammonium nitrate primer. In the final stage, solvent nitrile groups were converted to amidoxime group using hydroxyalamine in DMF. This change in functional group was done to absorb the metal ions more.

Batch experiments

Batch experiments were done to determine pH, equilibrium time, and the absorbents capacity.

Determining the optimal pH

One gram per liter of the activated absorbent was poured in a 100 ml Erlenmeyer flask. Then arsenic metal solution at a concentration of 10 mg/l was added to each of the flasks and various pHs were examined. The solutions were placed on a shaker for 12 hours at a speed of 150 rpm and controlled temperature and pH measurement was done pH meter device (PTR 79). The experiment was repeated for AH, SH, and SD absorbents [15, 16].

Measuring specific surface area

Methylene blue absorption was used to measure the absorbent specific surface area. In this method, first 1, 5, 10, 15, and 20 mg/l concentrations of methylene blue were prepared to develop calibration diagram and their concentration was measured and recorded at maximum wavelength of 660 nm.

Then 0.1 g of the absorbent was poured into 17.8 mg/l solution of methylene blue and was placed on the shaker at a speed of 150 rpm. After 60 minutes, the remaining solution was poured into special containers and was placed in a centrifuge at a rate of 3600 rpm for 10 minutes for sedimentation.

Then the solutions were removed from the device ad their final concentration was measured and the absorbent specific surface area was measured. The specific surface areas of SD, AC, AH, and SH were, respectively, 10.48, 12.65, 9.59 and 11.73 m^2/g [17, 18].

Results and Discussion

Determining the optimal absorption pH

In the adsorption process, solution pH has a significant role in the removal of heavy metals [19]. Figure (1) shows the effect of pH on arsenic absorption efficiency. The maximum absorption at pH of 6 was 0.78 mg/g for activated carbon, 7.57 mg/g for coconut shell and 5.60 mg/g for pistachio-nut shell, respectively, and walnut shell at pH 7 showed the absorption of 5.26. The intensity of arsenic absorption for activated carbon and coconut shell adsorbents increased from pH 2 to pH 6 with an almost constant slope and decreased slightly from pH 6 on. For pistachio-nut shell absorbent, the absorption intensity was relatively high from pH 2 to pH 4, but from pH 4 to pH 6 it increased with more slope, from pH 6 onwards the absorption intensity first decreased slightly and then remained almost constant. For walnut shell absorbent, the absorption intensity increased from pH 2 to pH 6 with low slope but with higher slope from pH 6 to pH 7.

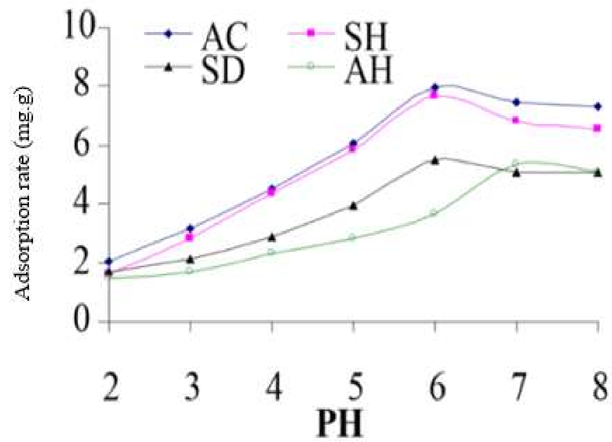

Figure 1: The effect of pH on the adsorption of nickel by AC, SH, SD, and AH absorbents

Infrared spectrum

The infrared spectrum of the active carbon in KBr solvent is shown in Figure (2). The wavelengths 1168, 1427, 1583, and 1650, respectively, show the presence of carboxylic acid, phenolic, amidoxime and laktan. The presence of these functional groups beside the high specific surface area of activated carbon is the main reason for the high absorption of metal cations by activated carbon.

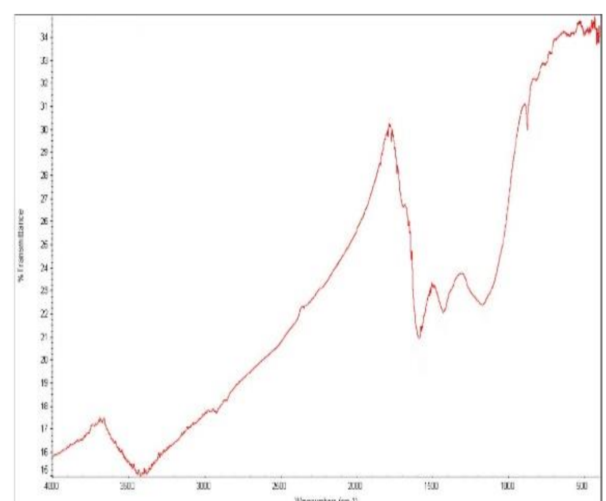

Figure 2: FT-IR spectrum of active carbon in KBr

SEM spectrum

Figure (3) indicates a scanning electron microscope (SEM) image of activated carbon in Figure (4). The figure shows the very porous properties of activated carbon. The porous surface of activated carbon is its strong point in arsenic absorption. Micro and meso pores in activated carbon act as absorption sites for metal absorption and other contaminants in water. The concentration of these pores can increase by thermal and chemical activation.

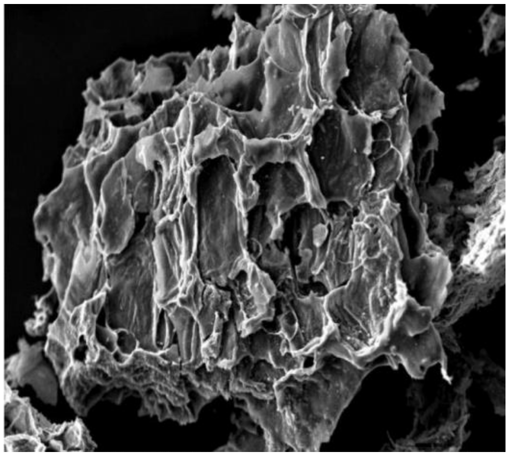

Figure 3: SEM image of activated carbon

Conclusion

The results showed that maximum arsenic absorption by activated carbon obtained from coconut shell, pistachio-nut shell, walnut shell, and chestnut shell was at 0.15 mg/l concentration. For the activated carbon, coconut shell, and pistachio-nut shell, the maximum absorption value was at pH 6 and for walnut shell at pH 7. The results of SEM image indicated that the activated carbon obtained from chestnut shell had suitable pores with high frequency as sites of adsorption of metal cations. Moreover, the results of the infrared spectroscopy indicated the presence of influential functional groups factors in the absorption of metal cations like arsenic. Arsenic adsorption rate by the absorbents of activated carbon obtained from chestnut shell, coconut shell, pistachio-nut shell, and walnut shell was as AC> SH> SD> AH.

References

1. Arsenic toxicity and potential mechanisms of action.Michael FHughes, Toxicology Letters, 2002; 133(1): 1-16.
2. Chronic arsenic toxicity in west Bengal--the worst calamity in the world. Mazumder DN, Das Gupta J, Santra A, Pal A, Ghose A, Sarkar S. Journal of the Indian Medical Association 01 Jan 1998, 96(1):4-7, 18.
3. Arsenic in Drinking Water. National Research Council, Division on Earth and Life Studies, Commission on Life Sciences, Subcommittee on Arsenic in Drinking Water, National Academies Press, Khordad 24, 1378 AP - Nature - 330 pages.
4. The removal of heavy metal cations by natural zeolites. E. Erdem, N. Karapinar, R. Donat. Journal of Colloid and Interface Science, 2004; 280(2): 309-314.
5. The Quest for Active Carbon Adsorbent Substitutes: Inexpensive Adsorbents for Toxic Metal Ions Removal from Wastewater. Imran Ali, Journal Separation & Purification Reviews ,Volume 39, 2010 - Issue 3-4, Pages 95-171 | Received 08 May 2010, Accepted 10 Sep 2010, Published online: 10 Dec 2010.
6. Activated carbon surface modifications by adsorption of bacteria and their effect on aqueous lead adsorption. J Rivera-Utrilla, I Bautista-Toledo, MA Ferro-García, C Moreno-Castilla. journal of technology and biotechnology, 2001; 76(12): 1209-1215 .
7. Applications of Pore-Expanded Mesoporous Silica. 1. Removal of Heavy Metal Cations and Organic Pollutants from Wastewater. AbdelhamidSayari, SafiaHamoudi, and Yong Yang,Chem. Mater., 2005, 17 (1), 212–216.
8. Removal of Cu(II), Pb(II), and Ni(II) by Adsorption onto Activated Carbon Cloths. K. Kadirvelu, C. Faur-Brasquet, and P. Le Cloirec, Langmuir, 2000, 16 (22): 8404–8409.
9. Adsorption of Cadmium Ions on Oxygen Surface Sites in Activated Carbon. Y. F. Jia, and K. M. Thomas, Langmuir, 2000, 16 (3): 1114–1122.
10. Kazemipour, M., Ansari, M., Tajrobehkar, Sh., Majdzadeh, M., Reihani Kermani, H., Journal of Hazardous Materials, 2008; 150(2): 322-327.
11. Preparation of activated carbon from Tunisian olive-waste cakes and its application for adsorption of heavy metal ions. R. Baccar, J. Bouzid, M. Feki, A. Montiel, Journal of Hazardous Materials, 2009; 162(2, 3): 1522-1529.
12. Metal ion removal from aqueous solution using physic seed hull. Masita Mohammad, SaikatMaitra, Naveed Ahmad, AzmiBustam, T.K. Sen b, Binay K. Dutta, Journal of Hazardous Materials, 2010: 179(1-3): 363-372.
13. Biosorption of chromium (VI) ion from aqueous solutions using walnut, hazelnut and almond shell. Erol Pehlivan, Türkan Altun, Journal of Hazardous Materials, 2008, 155(1, 2): 378-384.
14. A review of potentially low-cost sorbents for heavy metals. Susan E. Baileyab, Trudy J. Olinb, R. Mark Brickab, D. Dean Adriana, Water Research, 1999; 33(11): 2469-2479.
15. Babel, S., and Kurniawan, T.A. A research study on Cr (VI) removal from contaminated wastewater using natural zeolite. J. of Ion Exchange, 2003; 14, 289-292.
16. Aydin, H., Bulut, Y., Yerlikaya, C. Removal of copper (II) from aqueous solution by adsorption onto low- cost adsorbents. J. of Environment Management, 2008; 87, 37-45.
17. Gregg, S.J., Sing, K.S.W. The physical adsorption of gases by nonporous solids: The type II isotherm, in adsorption, surface area and porosity, Academic Press, London, 1982.
18. Hequet, E., Abidi, N., Gourlot, J.P. Application of methylene blue adsorption to cotton fiber specific surface area measurement: Part 1 methodology. J. of Cotton Science, 1998; 2, 164-173.
19. Crini, G., Badot, P.M. Application of chitosan, a natural aminopolysaccharide, for dye removal from aqueous solutions by adsorption processes using batch studies: A review of recent literature. J. of Prog. Polym. Sci., 2008; 33, 399-.