Investigation of the effect of temperature on the removal of cobalt from aqueous solutions by low cost activated carbon material

Maryam K Hafshejani[1], Mehdi Khazaei[2], Ameneh Langari[3]

[1] Shahrekord University of Medical Sciences, Shahrekord, Iran
[2] Bushehr University of Medical Sciences, Bushehr, Iran
[3] North Khorasan University of Medical Sciences, Bojnurd, Iran
Email: amenehlangari@yahoo.com

Abstract: It is well recognized that the Cobalt is among the prominent contaminants in aqueous solutions. This hazardous metal can result in a high risk contamination and causes illness. It should be mentioned that the Cobalt metal also appears in wastewaters of a lot of manufacture and it can produce variety of undesirable effects. For removal of this contaminant from water many methods are used in this way. This paper investigates removal of Co (II) on activated carbon which was prepared from Iranian oak bark, from solutions. The bark of oak is intended as an alternative, low-cost, filter material for contaminated waters. Adsorption of Co (II) was studied in batch tests. In this research, the initial temperature operation conditions were investigated.

[Maryam K Hafshejani, Mehdi Khazaei and Ameneh Langari. **Investigation of the effect of temperature on the removal of cobalt from aqueous solutions by low cost activated carbon material**. *Life Sci J* 2013;10(4):3650-3653]. (ISSN: 1097-8135). http://www.lifesciencesite.com. 490

Keywords: Effect of temperature; Removal; Adsorption; Activated Carbon; Oak; Cobalt.

1. Introduction

With recent growth in industrial activities and demand for huge massive production of goods and products, the contamination have become a major research field for environment engineers. It is well recognized that with recent development in industrial activities, contaminants are become one of the major problems especially in developed countries as well as third world countries. Therefore, the removal of contaminants is one of the most important problems for health and medical science and health fields as well as engineering fields.

It is well recognized that the Cobalt is among the prominent contaminants in aqueous solutions. This hazardous metal can result in a high risk contamination and causes illness. It should be mentioned that the Cobalt metal also appears in wastewaters of a lot of manufacture and it can produce variety of undesirable effects like nausea, vomiting, asthma, damage to heart, causing heart failure, damage to thyroid and liver on human beings[1-2].

For removal of this contaminant from water many methods are used in this way. Some nanoparticles such as ZnO can be used for contaminant degradation [3-5]. Among these methods the important are membrane filteration, liquid extraction, reverse osmosis, electrochemical operation, flotation, electrodialysis and adsorption [6-12]. Adsorption is a very useful technique in the removal of organic and inorganic contaminants from waters.

Activated carbon is one of the most widely used adsorbents for the adsorption of contaminants. It exists mainly in powder, granular or cloth (fiber) forms. Recently, activated carbon cloth (ACC) has received considerable attention as a potential adsorbent material for wastewater treatment etc. applications.

It has several unique characteristics compared to conventionally used powder or granular activated carbons. One of the most important traits of this adsorbent is cheapness. So far, many studies have been done on producing and designing the activated carbon material.

Activated carbon is produced by two methods [13-15]. In chemical method, Activated carbon after carbonization is activated by chemical agents such as KOH, NaOH, and H3PO4. But in physical method, after carbonization, carbon is activated by CO2 and H2O vapor. Its raw materials are available and low cost. Agricultural materials and sold waste can be suitable for producing activated carbon that is a good performance absorbent material.

Only a few studies have been published for the removal of Co (II) from aqueous solution using various adsorbents. Recent studies revealed that adsorbents with sulphur groups are very effective for the removal of heavy metal ions from aqueous solutions. In this track, Gomez-Serrano et al. studied the ability of commercial activated carbon loaded with sulphur groups for the removal of Hg (II), Pb(II) and Cd(II) from aqueous solutions.

In this research paper, the activated carbon material has been produced by low cost agricultural solid waste preform material. It should be mentioned that the activated carbon has been designed and produced by bark of Iranian oak. After carbonization, black product has been activated by H_2SO_4. The effect of the operational temperature has been investigated. The obtain results are discussed in order to shed light on this issue and better understanding the issue.

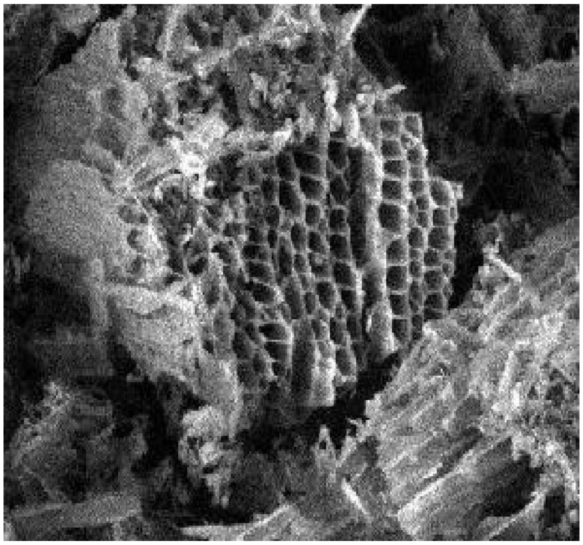

Figure 1: SEM image of activated carbon. A pours structure is observed [16].

2. Material and Methods

Oak bark, collected from a local source, was dried and ground. The powdered samples (below mesh No. 150) were impregnated with H_2SO_4 concentrated solution (98%), in a (shell: H_2SO_4) weight ratio of 1:1 (OC).

The resulting product was then dried in an oven at 120◦C for at least 8 h. Impregnated sample was placed on a ceramic boat, inserted in a tubular furnace.

The sample was heated to the carbonization temperature under N_2 flow at the rate of 10◦C/min. The activated carbon product was then dried in an oven at 110◦C.

The adsorbent particle size distribution was obtained and the mean diameter was about 0.104 mm. All the chemical and reagents used were of analytical reagent grade obtained from Merck Company.

Batch Study

The adsorption of Co(II) from aqueous solutions by bark of oak activated carbon was studied as follow. Each adsorbate containing solution was prepared by dissolving necessary amount of $CoCl_2$ in the distilled water.

Each solution was then diluted to obtain standard solutions containing 50–200 ppm of Co prior to adsorption experiments.

Batch adsorption studies were carried out with 0.08 g sorbent and 50 ml of Hg solution with a desired concentration at pH 5.5 in three conical flasks, simultaneously.

The flasks containing adsorbent and adsorbate were agitated for predetermined time intervals at 22◦C on a mechanical shaker with 600 rpm. At the end of agitation, the suspensions were filtered by the aid of filter paper.

The amount of Co (II) ion in the final 20 ml volume was determined by atomic absorption spectrophotometer equipped with a Zeeman atomizer. The obtained results for two similar solutions were averaged and then reported.

Iodine number

The surface activity of activated carbons towards iodine was determined by using the DIN 53582 standard method. The iodine No. of the sample is obtained as 850 mg/g.

3. Results and discussion

It is well recognized that the efficiency removal factor (equation1) is one of the most important indicative for investigating the performance of the material.

Fig. 2 shows the variation of the efficiency removal factor (equation1) versus the time at different sorption temperatures of 22, 42 and 62◦C. Constant parameters of solutions were: ion concentration of 50 mg/l, adsorbent dose of 0.08 g and pH = 5.5.

This hazardous metal can result in a high risk contamination and causes illness. It should be mentioned that the Cobalt metal also appears in wastewaters of a lot of manufacture and it can produce variety of undesirable effects like nausea, vomiting, asthma, damage to heart, causing heart failure, damage to thyroid and also to the liver on human beings.

The obtained experimental data show that solution concentration of Co (II) ions reduces with increase in the temperature indicating an endothermic nature of the sorption processes, while the time required reaching equilibrium remains practically unaffected. Increase in the adsorption capacity with temperature suggests that active centers on the surface available for adsorption increase with temperature.

This could also be attributed to the change in pore size and enhanced rate of intraparticle diffusion of the solute as diffusion is an endothermic process. In these results, it can be found that the diffusion step is determining reaction.

$$R = \frac{(C_0 - C)}{C} \times 100 \quad (1)$$

Where in the above relation, parameter R is the removal efficiency of adsorbent, parameters C0 and C are the initial and equilibrium concentrations of metal ion (ppm) in the aqueous solution. These parameters are measured experimentally.

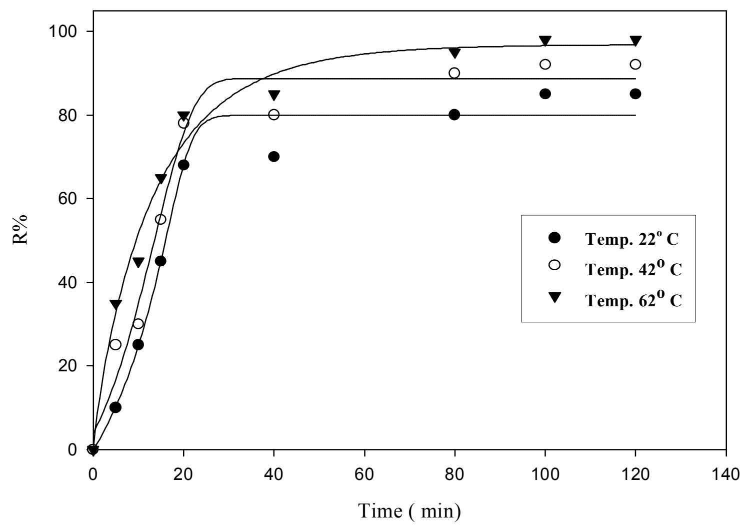

Fig. 2. Effect of Temperature (pH=5.5, Dose=0.08, Initial concentration=50 ppm).

4. Conclusion

It is well recognized that the Cobalt is among the prominent contaminants in aqueous solutions. This hazardous metal can result in a high risk contamination and causes illness. It should be mentioned that the Cobalt metal also appears in wastewaters of a lot of manufacture and it can produce variety of undesirable effects. For removal of this contaminant from water many methods are used in this way. In this work it has been indicated that designed activated carbon from oak bark can be effectively used for the removal of Co (II) from aqueous solutions. The investigated adsorbent was cost effective as well as eco-friendly. The increase in percentage adsorption with increase in temperature demonstrated the endothermic nature of adsorption. It is clear bark of oak is known as trifling matter, but in this research we have shown that this solid waste can be used as the best adsorbent to remove Co(II) from water as dangerous contaminant.

Acknowledgement

Authors are thankful to Dr Ebrahimi for his assistance on the paper.

Corresponding Author:
Ameneh Langari
North Khorasan University of Medical Sciences, Bojnurd, Iran
Email: amenehlangari@yahoo.com

References

1. Parab H, Joshi S, Shenoy N, Lali A, Sarma U S, Sudersanan M. Determination of kinetic and equilibrium parameters of the batch adsorption of Co(II), Cr(III) and Ni(II) onto coir pith. Process Biochem 2006; 41: 609–615.
2. Rengaraj S, Moon S H. Kinetics of adsorption of Co (II) removal from water and wastewater by ion exchange resins. Water Res 2002; 36: 1783–1793.
3. Kazemi A S, Abadyan M, Ketabi S A. Controlled structural and optical properties of ZnO nano-particles. Physica Scripta 2010;82:035801 (9pp).
4. Kazemi A S, Ketabi S A, Bagheri-Mohagheghi M M, Abadyan M. The effect of the activity coefficient on growth control of ZnO nanoparticles. Physica Scripta 2011; 83:015801 (8pp)
5. Kazemi A S, Afzalzadeh R, Abadyan M. Zno nanoparticles as ethanol gas sensors and the effective parameters on their performance.

Journal of Material Science and Technology 2013; 29(5): 393–400.
6. Sheng P X, Ting Y P, Chen J P, Hong L. Sorption of lead, copper, cadmium, zinc and nickel by marine algal biomass: characterization of biosorptive capacity and investigation of mechanisms. J Colloid Interf Sci 2004; 275:131–141.
7. Rengaraj S, Yeon K H, Moon S H. Removal of chromium from water and wastewaters by ion exchange resins. J Hazard Mater 2001; 87:273–287.
8. Tiravanti G, Petruzzelli D, Passino R. Pretreatment of tannery wastewaters by an ion exchange process for Cr(III) removal and recovery. Water Sci Technol 1997; 36:197–207.
9. Shaalan H, Sorour M, Tewfik S. Simulation and optimization of a membrane system for chromium recovery from tanning wastes. Desalination 2001; 14:315–324.
10. Matis K A, Mavros P. Recovery of metals by ion flotation from dilute aqueous solutions. Sep Purif Meth 1991; 20:1–48.
11. Mohammadi T, Moheb A, Sadrzadeh M, Razmi A. Modeling of metal ion removal from wastewater by electrodialysis. Sep Purif Technol 2005; 41:73–82.
12. Netzer A, Hughes D E. Adsorption of copper, lead and cobalt by activated carbon. Water Res 1984; 18:927–933.
13. Duman O, Ayranci E. Attachment of benzo-crown ethers onto activated carbon cloth to enhance the removal of chromium, cobalt and nickel ions from aqueous solutions by adsorption. Journal of Hazardous Materials 2010; 176:231–238.
14. Kalmykova Y, Strömvall A M, Steenari B M. Adsorption of Cd, Cu, Ni, Pb and Zn on Sphagnum peat from solutions with low metal concentrations. Journal of Hazardous Materials 2008;152:885–891.
15. Doulati Ardejani F, Badii K, Yousefi Limaee N, Shafaei S Z, Mirhabibi A R. Adsorption of Direct Red 80 dye from aqueous solution onto almond shells: Effect of pH, initial concentration and shell type. Journal of Hazardous Materials 2008; 151:730–737.
16. http://en.wikipedia.org/wiki/Activated_carbon

12/12/2013