Study of the mercury removal for health care and the effect of PH in mercury removal from aqueous solutions by activated carbons

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Abstract: A serious environmental threat from heavy metal ion pollution, especially mercury, has generated a great deal of attention in recent years. Mercury is one of the priority pollutant listed by USEPA as it can easily pass the blood-brain barrier and affect the fetal brain. High concentration of Hg (II) causes impairment of pulmonary function and kidney, chest pain and dyspnoea. Consequently, removal of mercury in water and wastewater assumes importance. In this review paper, we have evaluated the efforts which have been done for controlling the mercury emissions from aqueous solutions. According to the EPA agency, the tolerance limit for Hg (II) for discharge into inland surface water is 10µg/l and for drinking water is 1µg/l. Mercury (Hg) is one of the heavy metals of concern and has been found in the waste waters coming from manufacturing industry, and natural sources. Among several types of technology for removing of Hg in water (chemical precipitation, reverse osmosis, ion-exchange, etc.), adsorption is one of most frequently used. It is a complex process involving physical, chemical, and electrical interactions at sorbent surfaces. Therefore, in this study will investigate effective parameters such as pH, initial concentration and surface characteristic.

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Key words: Mercury, Adsorption, Surface area, Activated carbon, Wastewater.

1. Introduction:

Metals are known for their toxicity towards the aquatic environment. The discharge of effluents containing metals in the environment can constitute a threat to the aquatic life and have serious repercussions on the food chain. One of these metals is mercury [1-2]. Due to its high degree of microporosity, just one gram of activated carbon has a surface area in excess of 500 m2, as determined by adsorption isotherms of carbon dioxide gas at room or 0.0 °C temperature. An activation level sufficient for useful application may be attained solely from high surface area; however, further chemical treatment often enhances adsorption properties. Activated carbon is usually derived from charcoal [1]. Activated carbons are complex products which are difficult to classify on the basis of their behaviour, surface characteristics and preparation methods. However, some broad classification is made for general purpose based on their physical characteristics. Figure 1 shows the scanning electron microscope (SEM) image of activated carbon.

The adsorption of metallic ions from liquid has been studied for years, as well as the use of some so-called available absorbents. One of the low cost adsorbents is activated carbon. Activated carbon can be produced from a variety of carbonaceous raw materials, by either a physical or chemical activation methods. The adsorptive capacity of the final product depends on internal surface area, pore structure and surface chemistry that are defined by the nature of the starting material and production process [3].Among other reported techniques for the treatment of wastewater containing organic mercury, adsorption process shows good potential and can be cost efficient [4]. A carbon sorbent selected for mercury capture should have a suitable pore size distribution and large surface area, as a result of activation process. A carbon sorbent selected for mercury capture should have a suitable pore size distribution and large surface area, as a result of activation process. Activated carbons are widely used as adsorbents for removing different pollutants from drinking water usually, micropores posses the majority of the active sites for mercury adsorption, while mesopores act as transportation routes.

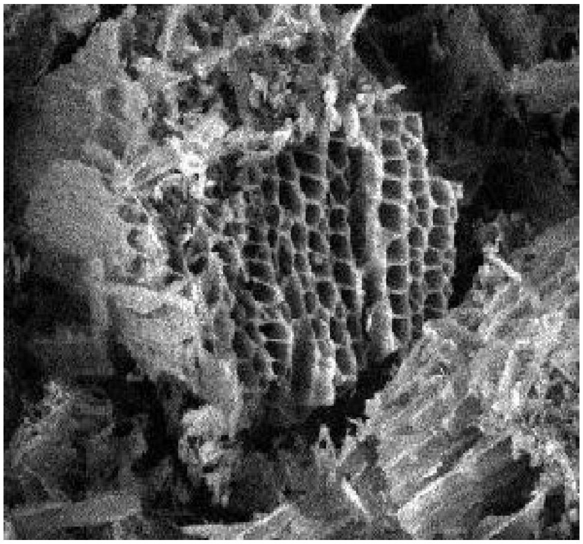

Figure 1: SEM image of activated carbon. A pours structure is observed [1].

Adsorption of Hg by activated carbons at ambient temperatures (e.g. 238C) has been suggested to be a combination of chemisorption and physisorption, whereas chemisorption is prevalent at higher temperatures; e.g. 1400C [5]. Many factors have been found to influence the efficiency of mercury removal, including carbon characteristics, flue gas composition, and the presence of active components [6].

The aim of the present work was to study the review of mercury (II) removal in aqueous solution by activated carbon. At first, the adsorption of mercury present in aqueous solutions onto fly ashes was studied in static reactor. Then a leaching test was also carried out to estimate the capacity of solids to retain durably the mercuric ions. Finally, the surface of spent ash samples after the adsorption experiments were investigated to understand mechanisms involved by mercury adsorption. In this paper activated carbon design has been studied. Therefore, some parameters such as temperature, initial concentration, and pH and isotherm models have been investigated as effective parameters.

2. Methods and materials:

The method of preparation of activated carbon involves two steps: the carbonization of the raw carbonaceous material in an inert atmosphere and the activation of the carbonized product. Various types of activated carbons with different pore size distributions can be obtained by using different raw materials and activation methods. The activation methods can be classified into physical and chemical activation. The former involves heating the carbonaceous materials at a high temperature with a reactant such as CO2 and H2O. The chemical activation involves heating the carbonaceous material at relatively low temperatures with the addition of activating agents such as H3PO4, ZnCl2, K2CO3, and KOH [7–8].

The adsorption capacity of designed activated carbon towards Hg(II) ion is investigated using an aqueous solution of the metal. The adsorbate stock solution of the test metal is prepared by dissolving the necessary amount of $HgCl_2$ in distilled water. This stocksolution is diluted to obtain standard solutions containing fixed Hg(II) concentration. Batch adsorption studies are carried out with fixed amount of adsorbent and fixed volume of Hg solution with the desired concentration at one defined by conical flasks.

Stoppered flasks containing the adsorbent and the adsorbate are agitated for predetermined time intervals at room temperature on the mechanical shaker. At the end of agitation the suspensions are filtered through microporous filter paper. The amount of the Hg(II) in the final volume is determined by atomic adsorption device.

3. Results

In the pH range of acidic condition, decreasing pH value would decrease the amount of Hg (II) concentration in result solutions. Higher Hg (II) removal will be achieved by increasing the pH value as it shown in Figure 2.

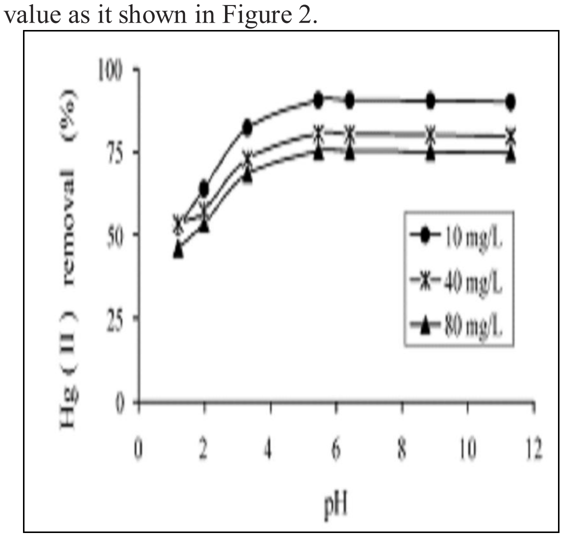

Figure 2. Effect of pH on Hg (II) removal with different initial Hg concentration by sewage sludge carbons [9].

Several studies have reported that the percentage of Hg (II) removal increased with the increase of pH value by using different adsorbents [9-11]. This effect was more significant when the mercury concentration was low. The prominent points is that with increasing in initial concentration of mercury in liquid the removal of mercury will be increased which has been shown in Figure 3.

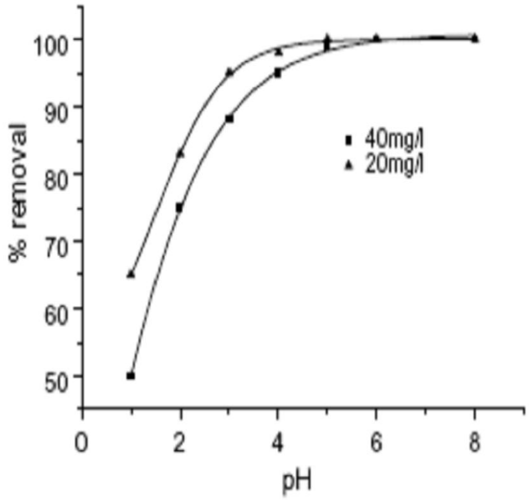

Figure 3. Effect of pH on Hg (II) removal with different mercury concentration: ▲20 mg/l, ■40 mg/l [11].

4. Conclusions:

It is well established that a serious environmental threat from heavy metal ion pollution, especially mercury, has generated a great deal of attention in recent years. The mercury is one of the priority pollutants and health threatening material listed by USEPA as it can easily pass the blood-brain barrier and affect the fetal brain. In this work we found that:

1- The results of several investigations on the adsorption of mercury ion by activated carbons from aqueous solutions reveal that the best absorbent is activated carbon with agricultural solid waste base.
2- By employing the activated carbons, adsorption will be increased by increasing initial Hg (II) concentration, pH of the solution, contact time and surface area of the absorbent.
3- With physical activation, carbonization temperature in the adsorbent preparation step, and with chemical activation, types of chemicals used in the impregnation step are the most influencing parameters on adsorption of mercury.
4- Another important factor is the structure of porosity. The best size of pore is meso size.

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References:

1. http://en.wikipedia.org/wiki/Activated_carbon
2. Yardim M F, Budinova T, Ekinci E, Petrov N, Razvigorova M, Minkova V. Removal of mercury (II) from aqueous solution by activated carbon obtained from furfural. Chemosphere 2003; 52:835–841.
3. Rio S, Delebarre A, Removal of mercury in aqueous solution by fluidized bed plant fly ash, Fuel 82 (2003) 153–159.
4. Skodrasa G, Diamantopouloua Ir, Sakellaropoulos G P. Role of activated carbon structural properties and surface chemistry in mercury adsorption. Desalination 2007; 210:281–286.
5. Logsdon G S, James M S. Mercury removal by conventional water-treatment techniques. J. Am. Water Works Assoc. 1973; 65:554.
6. Kelleher B P, O'Callaghan M, Leahy M J, O'Dwyer T F, Leahy J J. The use of fly ash from the combustion of poultry litter for the adsorptionof chromium(III) from aqueous solution. J. Chem. Technol. Biotechnol. 2002; 77:1212–1218.
7. Kadivelu K, Kavipriya M, Karthika C, Vennilamani N, Pattabhi S. Mercury(II) adsorption by activated carbon made from sago waste. Carbon 2004; 42:745–752.
8. Shiue A, Den W, Kang Y H, Hu S C, Jou G T, Lin C H, Hue V, Lin S I. Validation and application of adsorption breakthrough models for the chemical filters used in the make-up air unit (MAU) of a cleanroom. Building and Environment 2011; 46:468-477.
9. Popescu M, Joly J P, Carre J, Danatoiu C. Dynamical adsorption and temperature-programmed desorption of VOCs (toluene, butyl acetate and butanol) on activated carbons. Carbon 2003; 4:739–748.
10. Zhang F S, Nriagu J O, Itoh H. Photocatalytic removaland recovery ofmercury from waterusing TiO2-modified sewage sludgecarbon. Journal of Photochemistry and Photobiology A: Chemistry 2004; 167:223–228.
11. Zhang J, Bishop P L. Stabilization/solidification (S/S) ofmercury-containing wastes using reactivated carbon and Portland cement. Journal of Hazardous Materials B2002;92:199–212.
12. Yardim M F, Budinova T, Ekinci E, Petrov N, Razvigorova M, Minkova V. Removal of mercury (II) from aqueous solution by activated carbon obtained fromfurfural. Chemosphere 2003; 52:835–84.

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