Elimination of ponderous Metal ions from Aqueous Solutions by Considering Silica Aero gel As a Nanoadsorbent

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Abstract: Silica aero gel is a nanometer adsorbent and it is possible to use it in water treatments. in this research the removing of Zn(II) and(II) from water solutions by considering the usage of silica aero gel has been studied.we have examined and studied the relation between ion adsorption by using silica aero gel with contact time of solution with adsorbent, temperature and concentration of solutions which are include of ions and finally we achieved to the best adsorption conditions while the results of ion adsorption by using silica aero gel had been so satisfied,then we used the langrage kinetic model and earned the adsorption constant and also in the next stage the thermodynamic parameters such as ΔG^0, ΔH^0 and ΔS^0 have been calculated.

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1. Introduction:

During the recent decades the pollution of water resources because of heavy metals had been become one of the most important concerns for the world. On other hand it had identified that the heavy metals can be toxic or has a lot of harmful effects on the nature. Some of the metals which can be toxic for the human beings and environment are chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), manganese (Mn), cadmium (Cd), nickel (Ni), zinc (Zn) and iron (Fe),vanadium(V) and etc. The wastewater of many industries such as metallurgical, tannery, chemical manufacturing, mining, battery manufacturing industries and etc contains one or many toxic heavy metals. Nowadays silica aero gel is using as a polar adsorption.The distinctions of silica aero gel which are making it different by comparing with the other adsorptions are some of it's unique properties such as high adsorption capacity,easy preparation of it in different ways and sizes. In addition it is possible to change the surface or covering it by reactants is the other distinction of silica aero gel [2-5].

Silica aero gel is a new synthesis material which has a lot of great advantages such as low bulk density, high surface and low thermal conductivity that these properties have derived from the nanometer networks of connected particles. Silica aero gels are good kinds of thermal insulators and also are so useful for drug delivery systems while this feature is because of their unique and great texture.

2. Experimental

At the beginning we took the spectra of silica aero gel (fig1), the spectra FT-IR of silica aero gel powder by using a device which is FT-SR model BRUKER/TENSER 27has been drawn.

Then we have obtained the concentration of heavy metals by using atomic adsorption spectrometer(AAS)that it's model is PG990AA and by using the flame of acetylene we obtained the concentration of heavy metals and with saluting some of their salt in water obtained the heavy metal solutions, the salts that have used for Zn(II), V(II) ions are cadmium chloride, zinc chloride and next concentration of solution has been obtained by diluting with distillated water, silica aero gels are adsorbent materials that have been composed by covalently bonds with nanometer sizes. The results of this research calculations use to optimize the conditions in other to obtain the maximum removal of heavy metals. The percentage of removal heavy metals has obtained from the following equation:

Metal ion removal percentage (%)=(C0-Ce)×100/ C0 (1)

Where C0 is initial metal concentration mg/L, Ce is the equilibrium concentration of solution mg/L.

3. Results and discussion

3.1. Effect of heavy metal concentration

The effect of concentration on removal heavy metals by silica aero gel has been shown in figure 2. This figure shows that by increasing the concentration on other hand the percentage of removal heavy metals is decreasing.the concentration of heavy metal that we have used is 1-5mg/L for 5g/L adsorption. High concentration of heavy metal ions is able to be compared with the other existence sites of absorbent. Therefore the outlet percentage of heavy metals is depending on the concentration of initial metal ions.

3.2. Effect of contact time

Fig. 3 shows the variation of the outlet percentage of heavy metals with the contact time of metal ion solutions by using 5g/L silica aero gel. this research is about the effect of time which had been referred to optimizing of concentration.in fact in the optimized concentration we have the maximum percentage of outlet while it's optimized concentration had been a mg/L. We proved that the percentage of outlet metal ions of solution by increasing the time in other hand the percentage of outlet will increase too and after a period of time will become constant and by increasing contact time until equilibrium point the percentage of outlet of heavy metal sequel concentration will increase too.During the studies optimized contact time for silica aero gel has been obtained 24 hours.

3.3. Effect of temperature

In the optimum concentration (1mg/L) we have examined the effect of metal ion adsorption in different temperatures 20-60 ^{0}C and we found it out that as much as we are increasing the temperature the adsorption of metal ion is decreasing (Fig4).

The thermodynamic parameters such as ΔG^0, ΔH^0 and ΔS^0 by using the mentioned equations in this research has been reported in Table 1

Kc =CAc/Ce (2)

Where, Kc is the equilibrium constant, CA is the equilibrium concentration (mg/L) of the metal ion on absorbent and Ce is the equilibrium concentration of metal ion on solution and also ΔG^0 is calculating by using following equation :

ΔG^0 = RT lnKc (3)

Where T is temperature on the base of Kelvin (273 K) and R is gas constant (8.314×103 kJ/mol K)and also ΔH^0 is calculating by using the following equations:

$\Delta G^0 = \Delta H^0 - T\Delta S^0$ (4)

logKc $=\Delta S^0/2.303R - \Delta H^0/2.303RT$ (5)

ΔH^0 and ΔS^0 have been obtained from the slope and intercept of Vant Hoff plots by using log Kc plot which is on the base of 1/T (Fig. 5). The positive values of ΔH^0 have been shown that metal ion adsorption on silica aero gel is an endothermic phoneme. The negative values of ΔG^0 have been shown that adsorption metal ions on absorbent is a spontaneously and ΔS^0 that has obtained in laboratory conditions is insignificant therefore its possible to tolerate the changes entropy of adsorption.

3.4. Kinetic adsorption

The kinetic adsorption of heavy metals on silica aero gel follows first order rate expression which has given by Lagergren and Svenka.[16]

log (qe-q) = logqe -Kad. t/2.303 (6)

where, Kad (1/h) is the rate constant of adsorption, q is the amount of heavy metals that have been adsorbed (mg/L) on the base of time (h) and qe is the amount of heavy metals that have been adsorbed at equilibrium point which has been shown in log(qc-q) plot on the base of time (Fig6) and in addition the mentioned equation is so applicative for silica aero gel. The value of Kad of metal ion concentration has been calculated by the slope of linear plots. The results of these calculations have been listed in table 2.

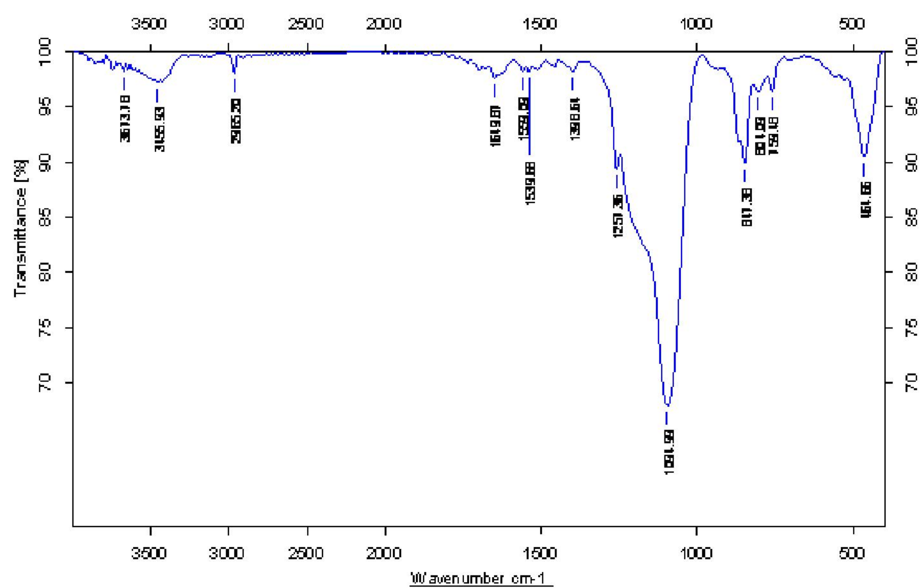

Fig. 1. FT-IR spectra of silica aero gel powder

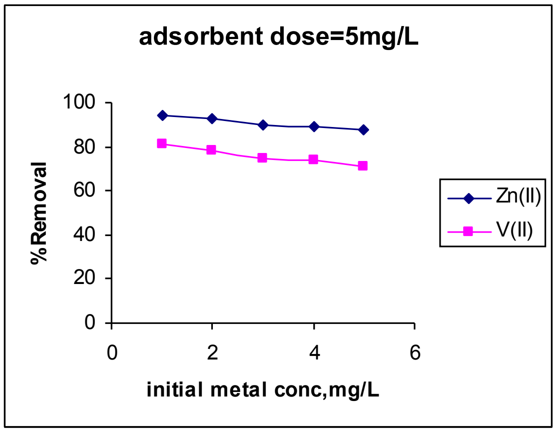

Fig. 2. Effect of metal concentration on outlet percentage of heavy metals by using silica aero gel.

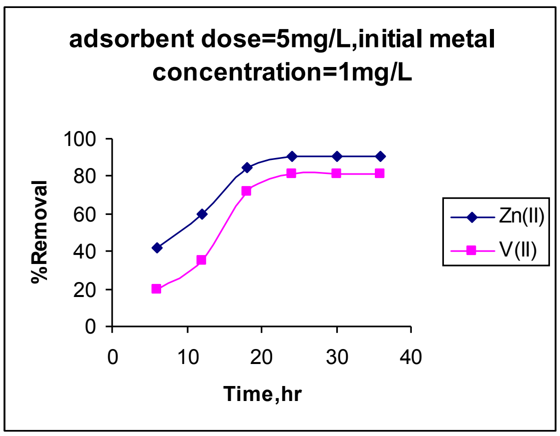

Fig. 3. Effect of contact time on outlet percentage of heavy metals by using silica aero gel.

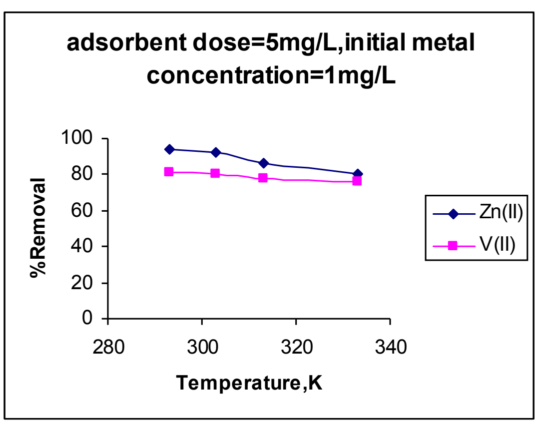

Fig. 4. Effect of temperate on outlet percentage of heavy metals by using silica aero gel.

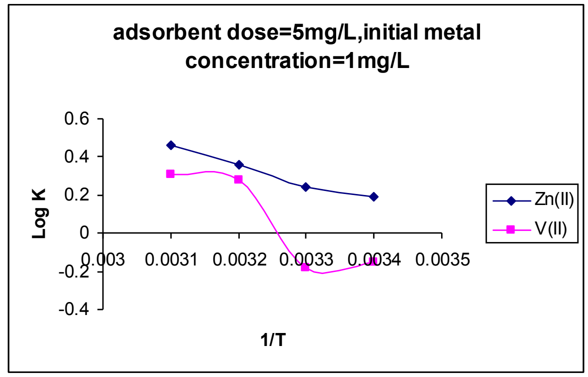

Fig 5. Plot of log *K*c and 1/*T* for heavy metals on silica aero gel that have been adsorbed.

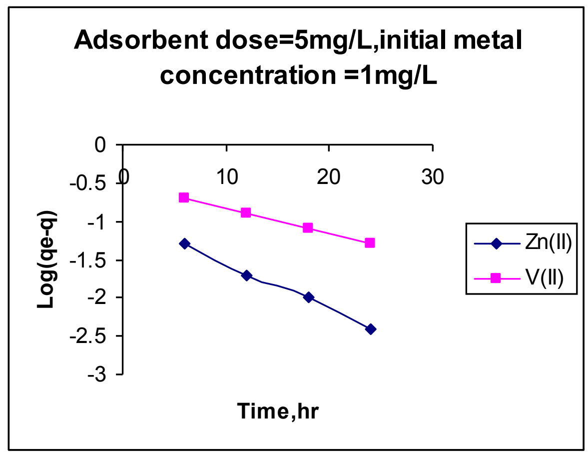

Fig.6. Plot of Lagergren rate constant for adsorption of heavy metal ions by using silica aero gel.

4. Conclusions

1. silica aero gel proved that approximately 100%seperates metal ions from solution under optimized conditions of concentration adsorbent 5 g/L and concentration of solution 1 mg/L under 24 h contact condition.

2. The adsorption is depends on first order kinetics or in other words is following it.

3. by using the Lagergren kinetic model adsorption rate constant has been determined.

4. Thermodynamic parameters such as ΔG^0, ΔH^0 and ΔS^0 have been calculated for adsorption the metal ions on adsorbent.

5. These experimental studies on adsorbents will be really useful in developing of removing heavy metal ions technology from waste waters.

Table 1. Equilibrium constants and thermodynamic parameters on the adsorption of heavy metal ions by silica aero gel

Metal	Temperature,ϴ	Kc	ΔG^0 (KJ/mol)	ΔS^0 (KJ/molK)	ΔH^0 (KJ/mol)
Zn(II)	**20**	**2.8840**	**-2.5802**	**0.0088**	**-0.0018**
Zn(II)	**30**	**2.2908**	**-2.0881**	**0.0068**	**-0.0277**
Zn(II)	**40**	**1.7378**	**-1.4380**	**0.0045**	**-0.0295**
Zn(II)	**60**	**1.5488**	**-1.2111**	**0.0036**	**0.0123**
V(II)	**20**	**2.0147**	**-1.7387**	**0.0059**	**-0.0010**
V(II)	**30**	**1.9054**	**-1.6240**	**0.0053**	**-0.0181**
V(II)	**40**	**0.6606**	**1.0789**	**-0.0034**	**0.0147**
V(II)	**60**	**0.6309**	**1.2752**	**-0.0028**	**0.3512**

Table 2. Kinetics constant for heavy metal ions adsorption

Metal ions	Adsorption rate constant (Kad)(1/h)
Zn(II)	**0.1218**
V(II)	**0.0766**

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