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Removal of Fe (II) and Zn (II) ions from Aqueous solutions by Synthesized Chitosan

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Abstract: Adsorption of Fe (II) and Zn (II) ions from aqueous solution onto chitosan was investigated in a batch system. The effects of initial ions concentration, solution pH, timeand temperature were studied. Results indicated that chitosan could be used as a biosorbent to remove the ions from contaminated water. Synthesize of chitosan involved three main stages, demineralization, deproteinization, and deacetylation. Chitosan was characterized using Fourier Transform Infrared Spectroscopy (FTIR) and solubility in 1% acetic acid.
Keywords: Adsorption; heavy metals; Chitosan, synthesized.

1. Introduction

The toxic metals, existing in high concentrations (even up to 500 mg.L^{-1}), have to be effectively removed from wastewaters[1]. In recent years, the removal of toxic heavy metal ions from sewage, industrial and mining waste effluents has been widely studied. Their presence in streams and lakes has been responsible for several types of health problems in animals, plants and human beings[2].

There are various physical-chemical methods of such polluted water treatment e.g. neutralization, ion exchange, precipitation, sorption, membrane processes, filtration, photocatalytic degradation and adsorption[3-24]. The choice of the suitable methods is based not only on the concentration of heavy metals in surface water but on economical factors, too. Sorption belongs to effective and economically acceptable methods to remove heavy metals[25]. To see the decrease of polluted water most researches were concentrated with treatment of heavy metals from industrial wastewater. It uses normal material to removal metals from different sides because it is valid largely in agriculture processes in addition to their low price as adsorbent materials[26-31]. The methods of dye removal from industrial wastewaters could require many processes such as biological treatment, coagulation, electrochemical techniques, adsorption, and oxidation. Among these methods, adsorption is considered an effective and economical method to remove ions from wastewaters[26-37]. It has been reported that many different types of adsorbents are effective in removing ions from aqueous effluents. Natural polymeric materials are gaining more and more interest for application as adsorbents in wastewater treatment due to their biodegradable and non-toxic nature. Currently, the most common procedure involves the use of activated carbon[38,39]. Activated carbon is regarded as an effective but expensive adsorbent due to the high cost of manufacturing and regeneration. Because of its relatively high cost, there have been attempts to utilize low cost and naturally occurring adsorbents. There are many different studies on the use of low cost materials such as various agricultural wastes[32,40-42], Chitosan (CS) offers an interesting set of characteristics, including non-toxicity, biodegradability, biocompatibility, and bioactivity. Chitosan and its derivatives have been extensively investigated as biosorbents for removal of heavy metals and dyes[43,44].

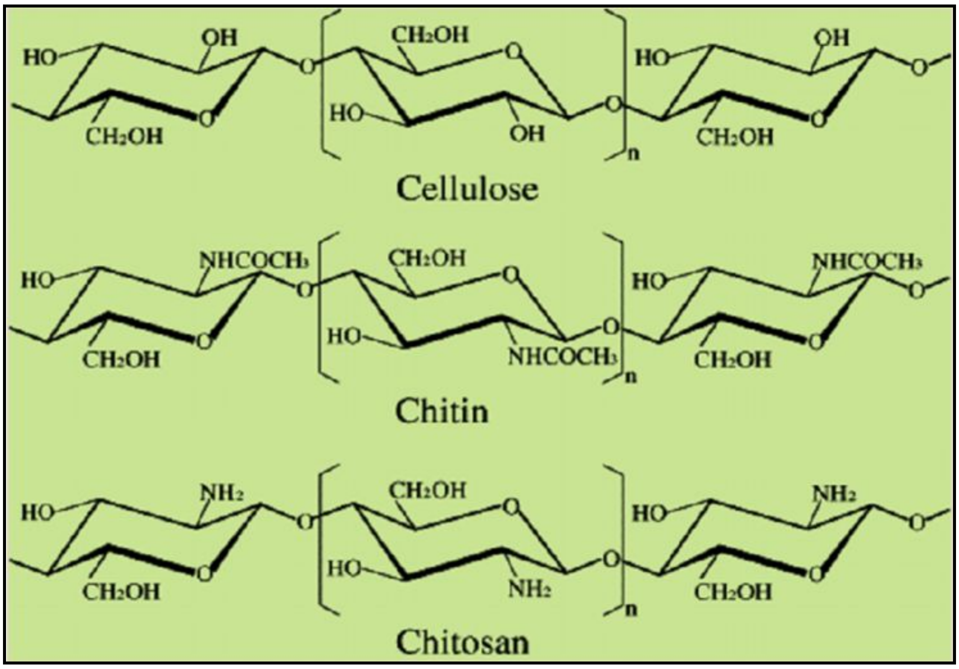

Figure1; Chemical structures of chitin, chitosan and cellulose.

The present paper is focused on utilization of the low cost sorbent chitosan to remove heavy metal ions such as Zn^{2+} and Fe^{2+} from model acidic solutions. The removal efficiency and the sorption capacity were determined. The studied parameters were heavy metal ions concentrations, contact time and changes of the pH solution during the experiment.

2. Materials and methods

2.1. Preparation of Sorbent:

Traditional isolation of chitin consists of three traditional steps as shown in (Figure 2): demineralization (DM), deproteinization (DP), and deacetylation (DA).

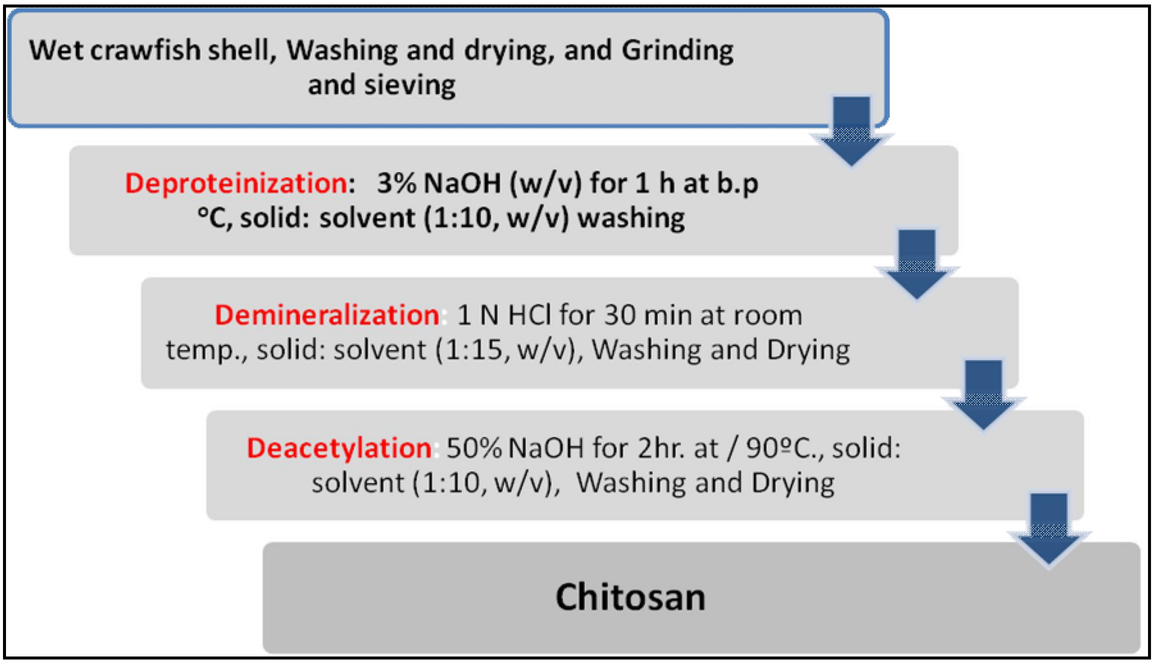

Figure 2; A simple Scheme of Chitosan Production.

2. 2. Batch adsorption experiments

A stock solution of heavy metals (1.0 g/L) was prepared by dissolving 1.48 and 1.13 g of Zn^{2+} and Fe^{2+}powder in 1 L of double distilled water. The desired concentrations ranging from 10 to 60 mg/L were obtained by dilution. For each adsorption experiment, 50 ml of the ions solution with a specified concentration was stirred at 100 rpm in a glass flask. The pH of solutions was adjusted to a desired value by adding dilute NaOH or HCl solution. Batch adsorption experiments were carried out using a thermo stated shaker for a certain contact time at a determined temperature at 100 rpm.

Batch adsorption experiments were carried out to examine effects of adsorbent dosage, initial dye concentration, solution pH, and time on the adsorption of ions on chitosan.

The amount of ions adsorbed on chitosan (at a predetermined time *t*), *qt* (in mg/g), was determined using the mass balance equation:

$$qt = (C_{\circ} - Ct) \times m / v \quad \ldots\ldots\ldots (1)$$

The decolorization rate (η) of ionswas calculated by the following equation:

$$\mu = (C_{\circ} - Ct) / C_{\circ} \times 100\% \quad \ldots\ldots\ldots (2)$$

WhereC_0 is the initial concentration of ions(in mg/L), *Ct* (in mg/L) is the instant concentration of ionsat a predetermined time *t*, *V* is the volume of the solution (in L), and *m* is the mass chitosan (in g).

3. Results and discussion

3.1. Effect of adsorbent dosage

The effect of adsorbent dosage (varied from 0.025 to 0.25 gm) on the percentage removal of 50 mg/L ions solution is shown in Fig. 3. The percentage removal of ions from the solution increased from (30% to 86%) for Zn^{2+} and (20% to 72%) for Fe^{2+} as the adsorbent dosage increased from 0.025 to 0.25 gm. This result is expected because of the increased adsorbent surface area and availability of more adsorption sites caused by increasing adsorbent dosage[45].

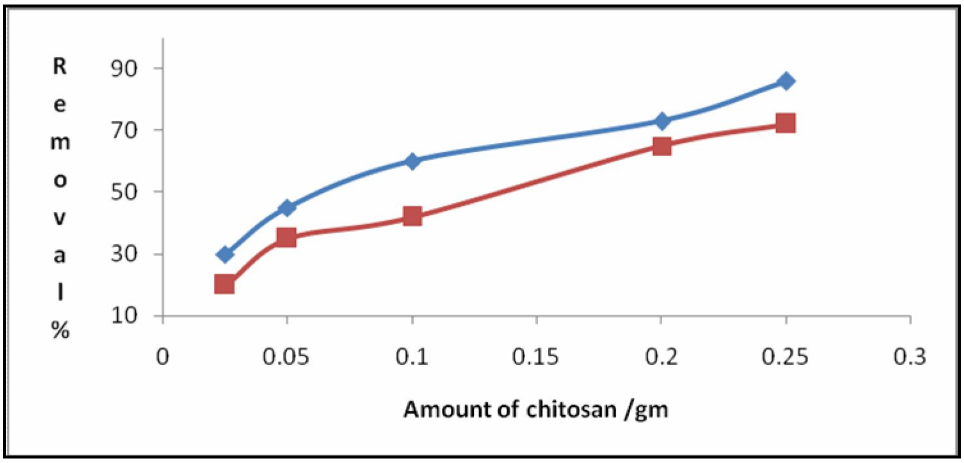

Figure3; Effect of adsorbent dosage in ions removal.

3.2. Effect of solution pH

The pH of theions solution affects the surface charge of the adsorbent, the degree of ionization of the materials, and the dissociation of functional groups on the active sites of the adsorbent[5,46,47]. The percentage removal of ions at different pH values is plotted in Fig. 4. The percentage removal increased from 40% to 73 % when pH was increased from 2 to 6 for Zn^{2+} and (25% to 72%) for Fe^{2+} when pH was increased from 2 to 8 for

Fe^{2+}ions. In low pH value, binding sites are generally protonated or positively charged (by the hydronium ions). Thus, repulsion occurs between the metal cation and the adsorbent at a higher pH value; binding sites start deprotonating, and makes different functional groups available for metal binding. In general, cation binding increases as pH increases[5,46,47].

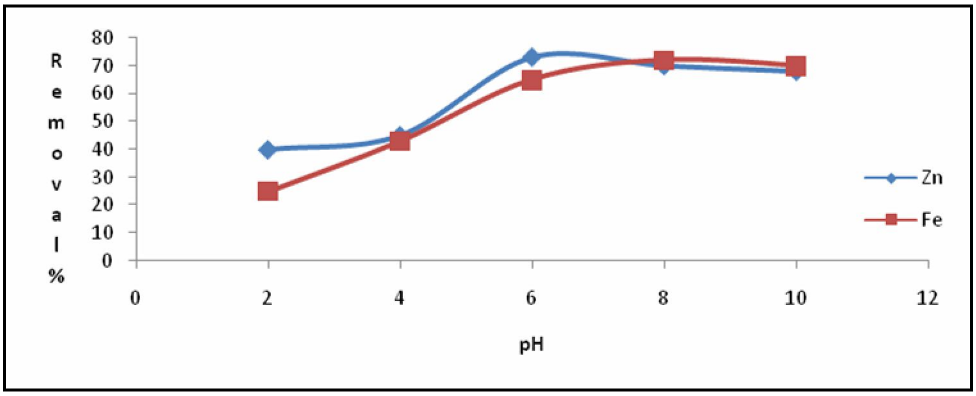

Figure 4; Adsorption of Zn^{2+} and $Fe^{2+}$by chitosan as a function of pH at initial concentration of 50mg/L and adsorbent dosage 0.1 g .

3.3. Effect of contact time:

A50ml of 50mg/L of Zn^{2+} and Fe^{2+} was taken in conical flasks and treated with 0.1 gm chitosan (adsorbent) at several times (20, 40, 60, 80, 100, 120 and 140 min.). The variation in percent removal of Zn^{2+} and $Fe^{2+}$with the time was shown in figure 5. It was found that the best time toremove these metal ions was 80 min. The results showedthat the removal percentage was73% $Zn^{2+}$and 65% Fe^{2+}, this due to saturation of active sites which do not allow further adsorption to take place[48].

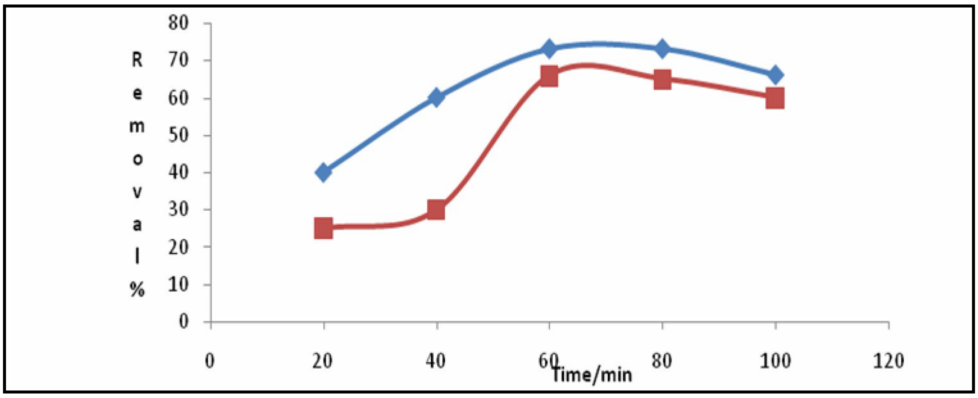

Figure 5; Effect of contact time on Zn^{2+} and Fe^{2+}adsorption(50mg/L) by 0.1gm chitosan.

3.4. Effect of initial metals ions concentration

The effect of initial Zn^{2+} and Fe^{2+}concentration on the percentage removal of the ions is shown in figure6. The initial metals ionsconcentration was varied from 10 to 60 mg/L. A rapid initial adsorption of ions took place within the first 20 min, after which the adsorption slowed down and then almost reached equilibrium at 120 min. The percentage of ions removal evidently decreased with increasing initial ions concentration. The percentage removal was 82.05% for 10 mg/L initial concentration and only 30.26% for 60 mg/L after 120 min of adsorption (figure 6). This was caused by an increase in the mass gradient pressure between the solution and adsorbent[44,45].

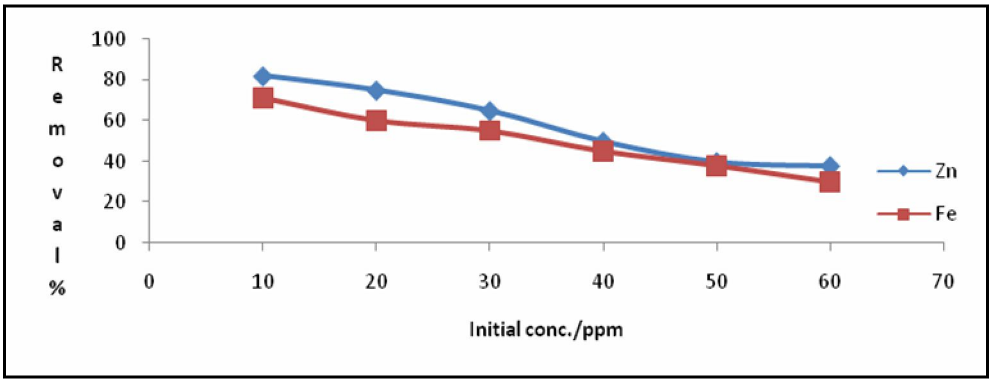

Figure6;The effect of variation of initial metal ions concentration on to their adsorption using chitosan.

4. Conclusion

The synthesize of chitosan involved three main stages demineralization, deproteinization, and deacetylation., it characterized by using Fourier Transform Infrared Spectroscopy (FTIR) and solubility in 1% acetic acid. Metal ions adsorption onto the chitosan depended highly on adsorbent dosage, initial ions concentration, solution pH and time.

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