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Adsorption Studies for the Removal Heavy Metal by Chitosan Crosslinked with Glutaraldeyde Absorbent Hydrogel

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ABSTRACT: In present research work natural bio polymer "Chitosan" was crosslinked with glutaraldehyde and adsorption of some heavy metal studied by batch method. The adsorption of heavy metal cations, Cu(II), Cd(II), Ni(II), and Pb(II) from aqueous solution by newly-synthesized crosslinked superabsorbent hydrogel of chitosan was investigated. The superabsorbent gel was characterized on the basis of FTIR, Scanning electron Microscopy and thermal properties. The percentage adsorptions of metal ions on adsorbent were determined by batch methods using atomic absorption spectrophotometry (AAS). The effect of experimental parameters, such as pH, treatment time, temperature, adsorbent dose, initial metal ion concentra-tion on the removal of metal ions was also studied. Chitosan crosslinked with glutaraldehyde proved to be an effective adsorbent for the removal of different heavy metal ions from aqueous solution.

Key words: Hydrogel, chitosan, superabsorbent, Glutaraldehyde, HeavyMetal, Bio-adsorption

Abbreviations: **Abbreviations: P(Chito),** Crosslinked Chitosan**, SEM,** scanning electron microscopy; **DSC** Differential Scanning Colourimentry**, FTIR,** Fouirer transfer infra red spectroscopy

INTRODUCTION

Toxic metals can be distinguished from other pollutants, since they are not biodegradable and can be accumulated in nature. The complete removal of toxic heavy metal ions that are incom-patible with biological systems requires expensive treatment in order to produce water that is again useful for domestic use (1) It is essential to extend methods for removal of metal ions to decrease the pollution load on the environment. Classical techniques of heavy metal removal from solutions include the following processes: sol-vent extraction, precipitation and co-precipitation, electrochemical reduction, chemical- and biosorption, pre-concentration.

In recent years, the adsorption process has also received much attention and has become one of the more popular methods for the removal of heavy metal ions from wastewater, because of its competitive and effective process. Numerous adsorbents have been reported for the removal of toxic metal ions, such as chitin, chitosan, starch, cellulose, guaran, and cyclodextrin, which are not only eco-friendly and cost-effective but are also effective in remediation of common effluents present in wastewater. Other polysaccharide-based materials and alumino-silicates are used as adsorbents in wastewater treatment. Adsorption using commercial activated carbon. Resins prepared with divinyl benzene-styrene backbone are hydrophobic. These resins, prepared from petrochemicals, are costly. Their ion exchange capacity depends mainly on the quantity of functional groups and the pH of the solution. The most widespread chelating functional groups used for removal of metal ions from effluents are thiol, thio-urea, dithionite, aspar-tate and triisobutyl phosphine sulphide.

The main purpose of this work was to determine the percentage of sorption of different heavy metal on newly synthesized Chitosan" was crosslinked with glutaraldehyde hydrogel sorbent.

MATERIAL AND METHODS

Materials

Chitosan (from Sigma Aldrich Mol wt. 22742 Da and (degree of deacetylation of 75%), 25% glutaraldehyde from sigma aldrich was used as received.

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Chemical and Reagents

Stock solutions of copper chloride, cobalt chloride ,lead nitrate and nickel chloride of 100 mg/l were used as adsorbate, and solutions of various concentrations were obtained by diluting the stock solution with distilled water. Copper Cobalt, and Nickel concentrations were determined by AAS. All the chemicals used were of analytical grade reagent and all experiments were carried out in 500 ml glass bottles at the laboratory ambient temperature of 25 °C.

Synthesis of glutaraldehyde Crosslinked hydrogels

2 gm of Chitosan dissolved into 100 ml of 10 % acetic acid solution and kept for stirring for 24 hors. After that 1% glutaraldehyde solution added into chitosan solution and kept in petry dish for hydrogel formation at room temperature for 2 hours after that it kept in oven for 24 hours.gel get formed. Hard gelled particle were formed which can further washed with water and drying then sieved through mesh 60-80 mesh. Dried hydro gel product is then sieved through 60 Mesh Particle size for better and uniform adsorption study by batch method.

Characterization of adsorbents glutaraldehyde Crosslinked Chitosan Hydrogel

The new material was well characterized by elemental analysis, FT-IR spectra, Differational scanning colourimentry (DSC), and scanning electron microscopy (SEM). The new sorbent surface exhibits good chemical and thermal stability. IR analysis indicates enviourment of –OH from chitosan backbone in the grafting which is indicating by broad band 3342 cm^{-1}.DSC indicates crystalline nature of hydrogel.SEM indicates porous structure & support permeation of water molecule in sorbent hydrogel. (3-5)

METHODOLOGY

Batch Sorption Experiments

All the sorption experiments were performed at 25 °C and 150 rpm for on an orbital shaker with 100 mg of the sorbent in a 250 mL flask containing 100 mL of copper, cadmium, nickel and lead solution with 30 min shaking time. Batch adsorption experiments were conducted to examine the sorption kinetics and equilibrium. In the sorption kinetic experiments, a 1 ppm of copper, nickel, lead cadmium solution at different initial solution pHs was used. In the sorption isotherm experiments conducted over 24 h, the initial solution pH was adjusted to 5, with 100 mg of sorbent in 100 mL of metal solution at various concentrations. Same procedure was repeat by adjusting pH 4,3,2 and 1 using buffer tablet. After sorption, the sorbent was separated from the solution by membrane filtration, rinsed with DI water, (6-8) while The metal concentration in the filtrate was analyzed using a flame atomic absorption spectrophotometer AAnalyst200 (Perkin Elmer, USA) All the sorption experiments were conducted in duplicate, and the mean values were reported. As 1 ppm (100 microgram per 100 ml) metal loaded for batch study of metal sorption then decreasing metal conceration from aq. Phase is calculated in percentages format (Fig. 1 to 4).

RESULT AND CONCLUSION

Sorption Kinetics Study- Graph shows the sorption kinetics of copper, nickel, lead and cadmium ions using the sorbent hydrogel at different solution pHs. The sorption of both the metals was time-dependent. The sorption kinetics of copper was rapid in the first 60 min, before becoming more gradual until equilibrium was reached. At pH4 and pH5, the equilibrium for copper sorption was attained within 120 and180 min, respectively. In cadmium sorption, the sorption kinetics was similar. As the sorbent surface is bare in the initial stage, the sorption kinetics is fast and normally governed by the diffusion process from the bulk solution to the surface. In the later stage, the sorption is likely an attachment-controlled process due to less available adsorption sites. (9-10).

Effect of pH on Metal Sorption- pH is an important parameter that affects metal ion sorption; it not only influences the properties of sorbent surface but also affects metal speciation in solution. In our experiments, the initial solution pHs at 5.0 and 6.0 for copper metal (Fig 1) gives 80-90% of metal extraction. But for cadmium in get adsorbed higher at pH 4 (Fig 2). The sorption capacity increased with an increase in initial pH upto pH-6. The final solution pH after 24 h of sorption (shown in Figure 1) The results of the kinetics of copper sorption on the sorbent at pH 5 without pH adjustment during the sorption process revealed that the sorption was rapid and the equilibrium was achieved within 30 min.In

Nickel sorption, the sorption capacity increased with increasing pH of solution at pH-5 to 6 (Fig no. 3). The effect of pH on lead sorption, presented in (Figure 4), shows a similar increase in sorption

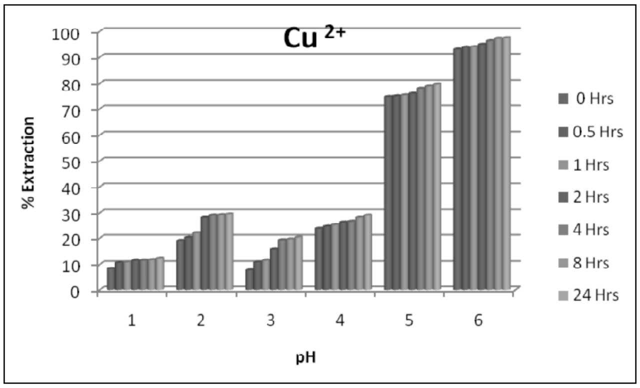

Figure 1

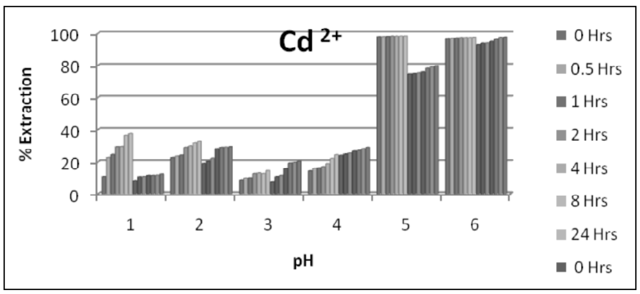

Figure 2

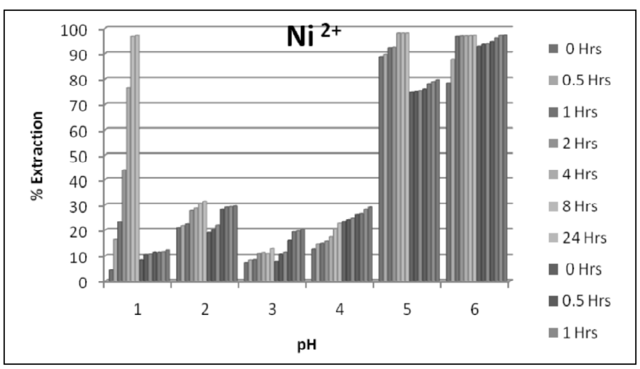

Figure 3

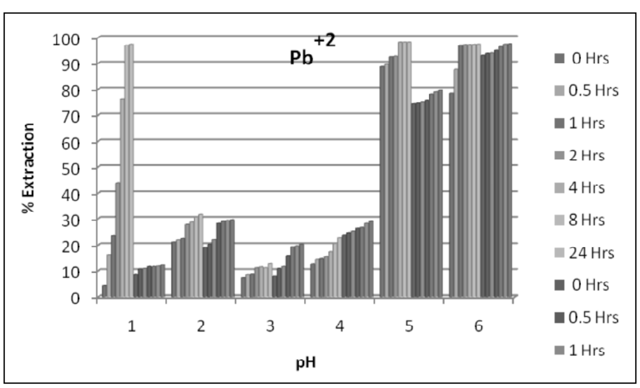

Figure 4

capacity with at pH 3 to 5. A sorption capacity of was achieved at pH 6.(11-14).

CONCLUSION

Natural bio polymer "Chitosan" based sorbent provides green route of metal extraction. The characterization of Chitosan crosslinked glutaraldehyde new sorbent material gives information about pore size, good chemical and thermal stability which revels applicability towards Metal extraction. This low-cost adsorbents are effective for the removal of Cu^{2+}, Cd^{2+},Ni^{2+} and Pb^{2+} ions from aqueous solutions. The batch method was employed parameters such as pH, contact time and metal concentration were studied at an ambient temperature 25 °C. The average percentage of extraction is 80-90% at pH 5 and 60 min as contact time. The optimum pH corresponding to the maximum adsorption of copper, cobalt, nickel and lead removal was pH 5-6. Copper cobalt, nickel and lead ions were adsorbed onto the adsorbents very rapidly within the first 60 min.

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