ISSN : 0974 - 746X Volume 6 Issue 2

Trade Science Inc.

Inorganic CHEMISTRY

An Indian Journal

Short Communication

ICAIJ, 6(2), 2011 [91-93]

Study of sorption properties of Cr (VI) by carboxymethyl chitosan

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Received: 3rd February, 2011 ; Accepted: 13th February, 2011

ABSTRACT

Carboxymethylchitosan (CMC) was synthesized from Chitosan and monochloroacetic acid. Chitosan is a bio compatible & bio degradable material with numerous applications. The synthesized CMC was characterized using FTIR. Sorption of Cr (VI) ions on CMC was studied by suspending CMC in aqueous solution of potassium dichromate. The sorption behavior was studied using UV-Visible spectrophotometric measurements by varying concentrations of CMC, contact temperature and contact time. The results reveal that CMC could serve as a high capacity carrier of Cr (VI) even at very low concentration of 0.5 %.

KEYWORDS

Chitosan;
Carboxymethylchitosan;
Sorption of chromium;
Adsorption.

INTRODUCTION

In the recent times, environmental conservation has gained much social and economic importance. A particularly intractable pollution problem is that of the contamination of water by heavy metal ions present in the untreated effluents of industrial waste water from electroplating, metal-finishing, metallurgical, tannery, chemical manufacturing, mining and battery making industries. The heavy metals ions present a serious source of water contamination and a number of methods have been developed over the years for removing them from waste water. The traditional treatment methods includes Chemical Precipitation, Electro deposition, Ion Exchange and Membrane separation but many researchers have proved that the adsorption seems to be a better alternative and so many adsorbents have been tested for the adsorption of various heavy metal ions.

In recent years the researchers have worked on inexpensive materials such as chitosan, zeolites and many other adsorbents having high adsorption capacity and are locally available. Chitosan has been one of the most popular adsorbent for removal of metal ions from aqueous solutions and is widely used in water treatment, due to its adsorption functionality of amine and hydroxyl group, biodegradability and biocompatibility[1-4]. Chitosan and chitin are widely used for the adsorption of copper and iron from waste water[5]. Use of chitosan has been reported for the removal of Cu (II) and Cr(VI) ions[6,7]. Despite its prolific use, the adsorption ability of Chitosan has not been realized to a satisfying level, so various chemical modifications have been carried out to enhance its heavy metal adsorption capacity.

The main disadvantage of Chitosan is that the amino group of Chitosan is weak base and so they are predominately protonated when pH is less than 6.5. So Chitosan is soluble in dilute acidic solutions. To overcome this disadvantage many chemical modifications are carried out on Chitosan. One such modification is the carboxymethylation of Chitosan to produce carboxymethyl Chitosan. This modified polymer is soluble in solutions with a wide range of pH. The Carboxy methylation is carried out by treating Chitosan with monochloro acetic acid and sodium hydroxide in the presence of water or isopropanol[8]. The carboxymethyl Chitosan produced has many reactive functional groups, amino groups, Carboxy groups and primary & secondary hydroxyl groups at C-3 & C-6 positions respectively. Due to the presence of these groups the carboxymethyl Chitosan exhibit chelation with various heavy metal ions. It is also soluble in both acidic solutions and water.

MATERIALS AND METHODS

All chemicals used were of AR grade. Chitosan was procured from CIFT, Cochin.

Preparation of carboxymethyl chitosan

The method used for making carboxymethyl chitosan is the same as that used by Liping et al[9]. The carboxymethyl chitosan made was characterized using FTIR Perkin Elmer series 2000.

Preparation of chromium (VI) stock solution.

3.6 g potassium dichromate and 10 ml concentrated sulphuric acid were dissolved in 500 ml double distilled water. This solution was stirred properly and then diluted to about 1000 ml using double distilled water, this is referred to as standard solution. 10 ml of this standard solution was pipetted out & then diluted to 1000 ml in a volumetric flask. This solution was used as the stock solution. The initial concentration of chromium in the standard solution prepared from potassium dichromate was 11.303 μg.

Measurement of Cr (VI) sorption on carboxymethyl chitosan

For sorption investigation of Cr (VI) ions, various mixtures of stock solution and carboxymethyl chitosan were made and stirred for 24 hrs at a constant r.p.m of 250. The contents were filtered and the filtrate was analyzed for Cr (VI) ion concentration using UV–Visible spectrometry using diphenyl carbazide on systronic 156 UV–Visible spectrophotometer at 540 nm wavelength. The experiments were performed by varying the process conditions of contact time, percentage of carboxymethyl chitosan and temperature. Throughout the study the pH was maintained at 7.

Effect of CMC concentration for varying contact time

The effect of CMC concentration (0.1 % to 0.7 %) was studied for varying contact time from 6 hours to 24 hours. The contact temperature was fixed at 303K.

Effect of CMC concentration for varying contact temperature

The effect of CMC concentration (0.1 % to 0.7 %) was studied for varying contact temperature from 303 K to 343 K. The contact time was fixed at 6 hours.

RESULTS AND DISCUSSION

Characterization of carboxymethyl chitosan

CMC was characterized by recording IR spectra on Perkin Elmer series 2000 as shown in figure 1. The band at 1394 cm^{-1} corresponds to the stretching vibrations of carboxyl group which suggest that the carboxymethylation has occurred. The band at 1074cm^{-1} is associated with stretching of secondary hydroxyl group and the one at 1150 cm^{-1} corresponds to C-N bond. Moreover the wide peak at 3439 cm^{-1}corresponds to stretching of amino & hydroxyl groups. Thus, FTIR spectroscopy confirms the carboxymethylation of Chitosan to produce CMC.

Figure 1 : FTIR of carboxymethyl chitosan

Cr (VI) sorption on carboxymethyl chitosan

Figure 2 shows the adsorption behavior on CMC surface of a standard solution of potassium dichromate for varying contact time and percentage of carboxymethyl chitosan at a constant temperature of 303 K. It was observed that the removal of chromium increases with increase in the concentration of CMC and increase in contact time. The maximum reduction in chromium was obtained for 0.5 % CMC and contact time of 24 hrs. But the variation in chromium removal from 18 hours to 24 hours was minimal. Hence we may conclude that the optimum results are obtained at 0.5 % CMC at 18 hours.

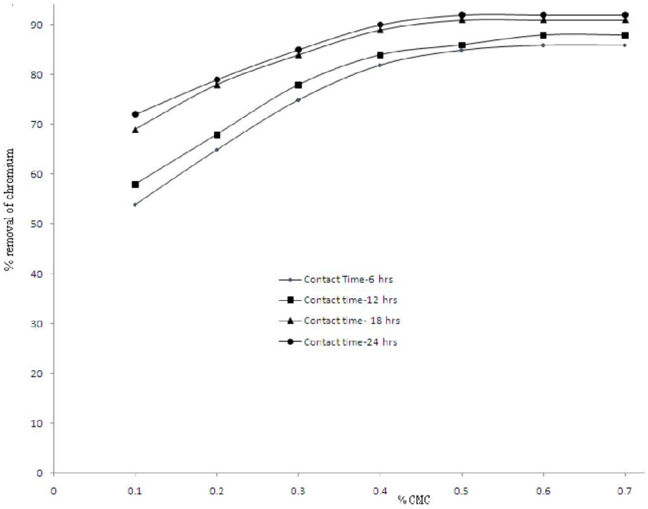

Figure 2

Figure 3 shows the adsorption behavior on CMC surface of a standard solution of potassium dichromate for varying contact temperature at a constant contact time of 6 hours. The chromium removal was observed to increase with contact temperature. At higher concentrations of CMC (above 0.3 %), the variation in chromium removal was insignificant after 313 K. The optimum conditions for chromium removal were found to be 0.5 % CMC at 313 K.

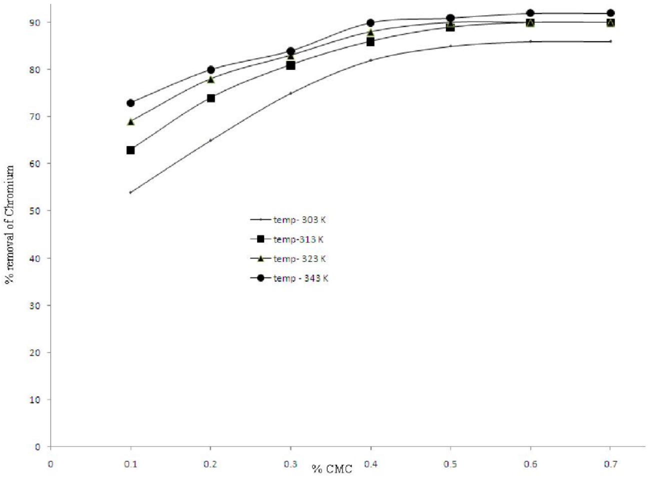

Figure 3 : Effect of carboxymethyl chitosan on removal of chromium for varying contact temperature

CONCLUSION

Carboxymethyl chitosan was made from chitosan. It was found that CMC has high adsorption properties for Cr^{+6} ions in solution. Furthermore, the adsorption capacity increases with increase in contact time, contact temperature and concentration of CMC. The use of CMC was limited to a maximum of 0.7 % to avoid the gel formation of product. The optimum experimental conditions were found to be 0.5 % CMC at 313 K with a contact time of 18 hours.

ACKNOWLEDGEMENT

The authors wish to acknowledge their gratitude to Director, Central Institute of Fisheries Technology, Cochin for providing Chitosan.

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