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ORIGINAL PAPER

Removal of Fe(III) using a polystyrene anchored Schiff base

Girish Kumar Krishnapillai · Saji John Konnully

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Abstract Salicylaldehyde Schiff base of amino-methylated polystyrene has been developed as a novel reagent for the removal of Fe(III) from solutions. The selectivity of the metal ion uptake over a wide range of different concentrations of metal ion, effect of pH, ligand concentration and the influence of other foreign ions were studied. A very good selectivity was achieved for the removal of the ion. It was found that 0.01 g of the ligand was sufficient to achieve about 96% removal of the metal ion in terms of concentration (ppm) from a 30 ppm solution in acidic pH.

Keywords Ion removal · Salicylaldehyde · Polymeric Schiff base

Introduction

Polymer-supported metal possess enough flexibility to permit interaction of polymer bound anchoring groups with the metal complex. High selectivity of chelating sorbents together with advantageous sorption kinetics enable the extraction of trace metals from their complex solutions. The sorbents are also used for the separation of metal ion by ion exchange chromatography. The chelate forming polymeric ligands are widely investigated and applied for metal ion separation from dilute solution (Samal et al. 2003; Warshawsky et al. 2001), in which various chelating groups have been incorporated and are attached to the polymer matrix. The main advantages of these polymeric resins are high chemical and mechanical stability. In continuation of our studies on metal removal (Krishnapillai et al. 2005), herein we report the ion removal studies of the salicylaldehyde Schiff base of amino-methylated polystyrene for Fe(III). Optimum conditions have been developed by varying time of reflux, metal ion concentration, pH, ligand concentration and interference studies of other ions.

G. K. Krishnapillai (✉) · S. J. Konnully
Department of Applied Chemistry, Cochin University of Science and Technology,
Kochi 682 022 India
e-mail: giri@cusat.ac.in
Tel.: +91-0484-2575804

Experimental

Reagents

All reagents were of analytical reagent grade and were used without further purification. Amino-methylated polystyrene (2% cross linked with divinyl benzene) was obtained from Thermax India Ltd., Mumbai, as a gift sample. Salicylaldehyde, ferric chloride and the organic solvents like dimethylformamide (DMF), methanol, etc., were all products of Merck.

Procedure for the metal ion removal

The ligand was prepared as reported in the literature (Syamal et al. 1994) by soaking amino-methylated polystyrene (1×10^{-3} mol dm^{-3}) in DMF for 1 h and refluxing with a DMF solution of salicylaldehyde (2×10^{-3} mol dm^{-3}) for 15 h. The resulting solution was allowed to cool and then filtered. It was then washed with DMF, methanol, distilled water and diethyl ether and finally dried in vacuo. A weighed amount of this polymer ligand was soaked in DMF for 1 h and ferric chloride solution was added to this suspension. The mixture was then refluxed on an electric mantle for 20 min and was filtered using a Whatmann 41 filter paper. The filtrate was diluted to a definite volume and

Table 1 Optimum conditions for the removal of Fe(III)

Amount of ligand (g)	0.01
Time of reflux (min)	20
pH	2–7
Percentage removal	96
Metal ion concentration (ppm)	30
Volume of metal ion solution taken (ml)	5

the exact amount of metal ion present was determined by the spectrophotometric method using KCNS (Jeffery et al. 1990). Optimum conditions have been developed for the effective removal of Fe(III) by varying time, metal ion concentration, ligand concentration and pH. The selectivity of Fe(III) over other ions such as Co(II), Ni(II), Cu(II), Zn(II), U(VI), Na^+, K^+, NH_4^+, Ca^{2+}, Cl^-, Br^-, NO_3^-, NO_2^-, and CH_3COO^- were also studied.

Results and discussion

Removal of Iron(III) using salicylaldehyde Schiff base supported on amino-methylated polystyrene

Following studies were conducted and optimum conditions were developed for the removal of Fe(III) using the ligand. The data are presented in Table 1.

Effect of time

Standard iron(III) solution (30 ppm) was refluxed with a DMF (5 ml) suspension of the polymeric ligand (0.01 g) at different time intervals. The concentration of iron(III) was determined spectrophotometrically (Jeffery et al. 1990). As expected, the metal ion removal capacity of the ligand increases as the time of reflux increases. About 96% removal was obtained within a time span of 20 min.

Effect of pH

The pH of the mixture was changed using buffer solutions and then determinations were carried out. It was found that the most effective removal happened in the pH range 2–7. This is an advantage of the method, as most of the metal ion removal studies takes place at acidic pH range. A graph is plotted to show the effect of pH on the removal of Fe(III) (Fig. 1).

Effect of metal ion concentration

The effect of metal ion concentration on the removal capacity of the reagent was studied. For a fixed amount of the ligand (0.01 g), the removal was monitored for a set of the

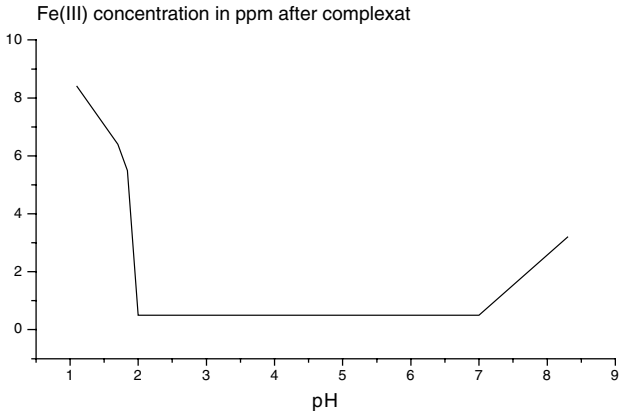

Fig. 1 Effect of pH on the studies based on the removal of Fe(III) using salicylaldehyde Schiff base supported on amino-methylated polystyrene; Concentration of Fe(III) is 30 ppm

metal ion solutions of varying concentrations. At lower concentrations of the metal ion (10–30 ppm), the removal was almost complete, about 85% when the concentration of the metal ion solution taken was 50 ppm. Thereafter, the percentage removal was decreased, due to insufficient amount of the ligand, as expected. It can be concluded from the above discussions that an amount of 0.01 g of the ligand is only needed to achieve about 96% removal of the metal ion, if the concentration of the original solution is 30 ppm.

Effect of ligand concentration

The effect of ligand concentration was studied in the range 0.0005–0.05 g for a solution of metal ion concentration of 30 ppm. As is clear from the results that for a 30 ppm Fe^{3+} solution, the minimum amount of ligand required for about 96% removal was 0.0075 g. But on safer side, 0.01 g was used uniformly.

Interference due to other ions

For studying the interference due to other ions (Co(II), Ni(II), Cu(II), Zn(II), U(VI), Na^+, K^+, NH_4^+, Ca^{2+}, Cl^-, Br^-, NO_3^-, NO_2^-, and CH_3COO^-), the Fe(III) solution (30 ppm) was mixed with a definite concentration of foreign ion (10–50 ppm) and salicylaldehyde Schiff base of amino-methylated polystyrene (0.01 g) soaked in DMF was added to this mixture and the removal experiment was repeated. The experiment was repeated with different concentrations of foreign ion keeping other factors same.

Conclusion

On the basis of results, it can be concluded that the polystyrene anchored salicylaldehyde Schiff base is an

excellent reagent for the removal of Fe(III) from solutions. About 96% removal was achieved in an acidic pH range. The selectivity of the ligand for Fe(III) over other ions is also found to be excellent. The method can claim the advantage of easy preparation of the reagent, comparatively lesser time of heating and high metal-removing capacity. Further, the metal can be regenerated from the resin by simple acid treatment.

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