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Removal of Heavy Metals from Water by using Organic acid

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ABSTRACT

Removal of heavy metal ions (Cu(II), Ni(II), Zn(II) and Pb(II)) by organic acid is likely to be representative research of complexation process. In this research, the potential of the organic acid to remove the heavy metal ions from the water and the effect of pH and temperature on the removal efficiency was also investigated. Results showed that the percentage removal order of copper, nickel, zinc and lead is as Cu^{2+} (75%) >Zn^{2+} (47%) >Ni^{2+} (40%) >Pb^{2+} (17.2%). During the removal process four different colored metal complexes were obtained. The metal complexes obtained were spectroscopically confirmed and characterized on the basis of UV-Visible, FT-IR and fluorescence. However, it was found that the removal efficiency increases up to a certain temperature and then decreases with increase in temperature. While as, with increase in pH the removal efficiency remains almost same.

I.INTRODUCTION

Pollution of the water environment by toxic heavy metals and metalloids is one of the growing problems all over the world. The majority of the metal pollutants are of anthropogenic origin and erosion of natural deposits, which poses adverse effects on aquatic life, humans and animal life [1,2].

The majority of metal contaminants behaves as inorganic ions in the water environment and thereby creates serious ecotoxicity. Large proportion of heavy metals released into aquatic systems are suggested to be associated with suspended solids in water or partitioned to the solid phase of sediments, and these particulate-bound metals can be the secondary pollutant to agricultural soils via irrigation water and floods. Conventional physicochemical techniques for removal of toxic metals from water include coagulation–precipitation, ion exchange, electrochemical treatments, and reverse osmosis [3-7].

The aim of the present work is to remove Cu(II), Ni(II), Zn(II) and Pb(II) metal ions from waste water by the acid, an economical and easily available method which proves an alternative for costly and cumbersome processes.

II. MATERIALS AND METHODS

Materials

Succinic acid was purchased from Loba Chemie. The Nickel Nitrate [$Ni(No_3)_2$.$6H_2O$], Cupric Nitrate [$Cu(NO_3)_2$.$3H_2O$], Lead Nitrate [$Pb(NO_3)_2$] and Zinc Nitrate [$Zn(NO_3)_2$.$6H_2O$] were purchased from CDH respectively.

Methods

Synthesis of complexes

To an aqueous solution (50ml) of complexing agent [0.002M], the aqueous solutions (25ml) of metal ions [0.001M] were added slowly with constant stirring over a period of 30 min. The pH was adjusted to the desired value by adding NaOH 10% solution. After that, the solution was filtered by Whatman filter paper No.41 to remove the metal complexes. The collected filtrate was used for the analysis of residual metal ions. Moreover, coloured metal complexes were obtained in good yield. The metal complexes obtained were dried over $CaCl_2$ in vacuum desiccators and were soluble in DMSO.

Physical measurements

The UV-VIS spectra of the samples were recorded on a double-beam spectrophotometer. Fourier Transform infrared (FTIR) spectra of the acid and metal complexes were recorded by Perkin Elmer FTIR spectrophotometer using KBr pellets. The residual metal ion measurement was done by using an Atomic Absorption Spectrophotometer. The solubility of the metal complexes was checked at room as well as at different temperature in different solvents. Molar conductance measurement was conducted using 10^{-3} M solution of the complexes in DMSO at room temperature with a Systronics model 304 digital conductivity meter.

Residual metal ion analysis

After the filtration of the complexes, the residual metal ion content in the filtrate was measured by using an Atomic absorption Spectrophotometer.

Calculation of removal % of metal ions by succinic acid:

Removal percentage was expressed as a percentage of complexed metal compared to initial metal ion concentration:

Removal (%) = $(C_o - C_f) / C_o \times 100$

Where C_0 and C_f are the initial and residual concentrations of metal ions respectively.

III. RESULTS AND DISCUSSION

All the metal complexes obtained during removal process are coloured solids, stable towards air and found in good yield (Table). All the complexes are slightly soluble in coordinating solvent i.e. dimethylsulfoxide

(DMSO). The molar conductivity of complexes in DMSO solutions (10^{-3}M) at room temperature indicates that they are non-electrolytes [8].

Table : Analytical data and other details of complexing agent and its metal complexes.

Compound	Colour	Yield	Molar conductance[a]
Succinic acid	White	-	-
Nickel Complex	Green	72	11.9
Copper Complex	Blue	73	14.2
Zinc complex	Greyish white	66	8.8
Lead complex	White	64	4.8

[a] $\Omega^{-1}cm^2\ mol^{-1}$ in 10^{-3} M DM

Absorption and emission spectra

The spectra of the compounds of pure acid, nickel and lead complexes exhibit bands in the region 200-230, 257, 250-260 nm respectively. However, in nickel and lead complexes the bathochromic shift of ~30 nm has been observed due to the ligand metal charge transfer interaction. The peaks of these complexes at 257 nm and 250-260 nm are also present.

However, in all metal complexes there is a gradual increase in the relative emission intensity due to the gradual decrease in the size of the metal ions viz $Zn^{2+} > Cu^{2+} > Ni^{2+}$.

IV. CONCLUSION

Organic acids are attractive complexing agents because complexation of the heavy metal ions can be performed at mildly acidic conditions and they are biologically degradable. In the present study, we have used the succinic acid as the complexing agent (ligand). The metal complexes synthesized during metal removal process were characterized by various spectroscopic techniques (UV-Vis, Fluorescence and FT-IR). Moreover, the removal efficiency was found to be Cu^{2+} (75%) >Zn^{2+} (47%) >Ni^{2+} (40%) >Pb^{2+} (17.2%).The removal efficiency of the succinic acid was extensively revealed and confirmed by the spectral characterization of the metal complexes formed during metal removal process, besides the optimum temperature and pH for the removal process comes out to be 75 ^{o}C and 6.5 respectively.

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