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Short Communication

Extraction Studies of Scandium(III) Metal Ion Using Cyanex-923

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ABSTRACT

The present paper deals with the extraction of Scandium(III) from Sodium salicylate medium using trialkyl phosphine oxide Cyanex-923 extractant dissolved in toluene. The Sc(III) metal ion was quantitatively extracted at pH 9.0 with Cyanex-923. The extracted Sc(III) was stripped with 4.0 M HCl solution. On Sc(III) extraction, the influence of various parameters like pH, Cyanex-923 reagent concentration and sodium salicylate concentration, stripping agent, diluents and equilibration period were studied. The probable species extracted in the organic phase is [Sc (HSal)$_3$. 2Cyanex-923] which were proposed based on slope analysis method.

Keywords: Extraction, Scandium(III), Cyanex923, Sodium salicylate, Separation.

INTRODUCTION

Scandium is obtained as a byproduct in the processing of Uranium ores which contain only about 0.02% Sc_2O_3 [1]. Scandium is used in nuclear reactor, its alloys in manufacturing of sports goods and as seed germinating agent [2]. Scandium metal is associated with many cations in the minerals; hence its separation is of importance. The paper deals with extraction of the scandium(III) metal ion from sodium salicylate medium using Cyanex-923 extractant. Various extractants are used for the extraction of Sc(III) metal ion which are as follows.

The extraction of Sc(III), Y(III), La(III) and Gd(III) have been investigated using Cyanex 302 in heptane from hydrochloric acid solution [3]. The extraction of Sc(III) and divalent metal ions were studied from HCl solution using sec-nonylphenoxy acetic acid [4]. Scandium (III) was extracted from SO_4^{2-} solution by methyltrialkyl ammonium sulfate and methyl cyclohexyl dioctyl ammonium sulfate in toluene [5]. The extraction equilibrium of Sc (III) was studied from sulfuric acid media by Cyanex 272 and Cyanex-302 [6-7]. The extraction of various metal ions like Sc(III), Zr(IV), Ti(IV), Th(IV), Fe(III) and Lu(III) were studied by Cyanex923 and Cyanex925 from H_2SO_4/HCl [8]. Sc (III)-hexafluoro acetyl acetone chelate was extracted into chloroform in the presence of tetrabutyl ammonium ion [9]. The extraction behavior of Sc (III), Y(III), Pr(III), Eu(III) and Yb(III) were carried out using N-octanoyl-N-phenyl hydroxylamine, N-(2-propyl pentanoyl)-N-phenyl hydroxylamine and N-(2-hexyl decanoyl)-N-phenyl hydroxylamine in carbon

tetrachloride [10]. The extraction behavior of Sc(III) was investigated in the presence of 3,5-dichlorophenol with acetyl acetone [11]. Sc(III) was separated from some transition and lanthanides metal ions by solvent extraction using mesityl oxide [12]. Extraction studies of scandium(III) were done using triphenyl phosphine oxide [13]. Extraction and separation of Sc (III) and Y(III) from rare earth metals was also proposed using Cyanex-302 extractant [14].

MATERIALS AND METHODS

The extractant, Cyanex-923 supplied by Cytec Industries Inc. Canada, were used directly for extraction purpose. A 100 ppm stock solution of Sc(III) is prepared by dissolving known amount of scandium Oxide in minimum quantity of concentrated hydrochloric acid and then diluted with double distilled water. 4-(2-pyridylazo) resorcinol (PAR), sodium salicylate, acids and metal salts used were of Analytical grade. Instrument used for adjusting pH is Elico model LI 120 pH meter and for absorbance measurement Shimadzu UV-Visible Recording spectrophotometer model UV-2401PC.

General Extraction Condition: A solution containing 20µg of Sc(III) and sodium salicylate was taken and its pH is maintain to 9.0 with dilute HCl and NH_4OH solution. The solution is diluted to 10 mL with distilled water and then it is transferred into the separating funnel containing cyanex-923 diluted in toluene. The two immiscible phases were shaken for 10 min and then it is allowed to separate. After separation of two phases, the organic phase containing extracted metal ion is stripped back into the aqueous phase by 4.0 M HCl. The amount of scandium(III) in the aqueous solution was determined spectrophotometrically by PAR method [15].

RESULTS AND DISCUSSION

Influence of pH: Extraction of Sc(III) was carried out in the presence of sodium salicylate in the pH range from 1.0 to 9.0 with Cyanex-923 diluted in toluene. As the pH increases, the extraction increases and it becomes quantitative at pH 9.0 (Fig.1). Hence all the extractions of Scandium(III) was carried out at pH 9.0.

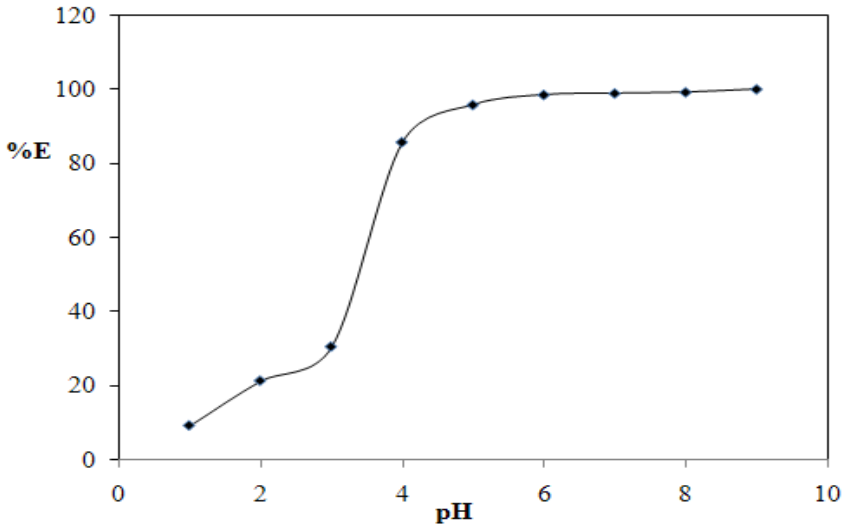

Fig:1 Effect of pH on percentage extraction of Sc(III) with Cyanex-923 in toluene.

Influence of Cyanex-923 Reagent concentration: The extraction of Sc(III) was carried out by varying the Cyanex-923 reagent concentration from 5×10^{-4} to 1×10^{-2} M. It was observed that the extraction

increased with the increasing concentration of Cyanex-923 and becomes quantitative in the range of 5.0×10^{-3} M to 1.0×10^{-2} M Cyanex-923. Hence all the extractions were carried out at 5×10^{-3} M Cyanex-923.

Influence of Sodium salicylate concentration: The effect of Sodium salicylate concentration on the percentage extraction of Sc(III) was studied with $5x10^{-3}$ M Cyanex-923 at fix pH of 9.0 in the sodium salicylate range of 1.0×10^{-5} M - 1.0×10^{-3} M. As the concentration of sodium salicylate increases the extraction goes on increasing and becomes quantitative in the range 1.0×10^{-4} M to 1×10^{-3} M. Hence the extractions were carried out at fix 1.0×10^{-4} M Sodium salicylate concentration.

Influence of stripping agents

The Scandium(III) metal ion which was extracted in the organic phase during the extraction process is brought back into the aqueous phase using various acids like HCl, HNO_3 and H_2SO_4. The Sc(III) ion is quantitatively recovered from metal loaded organic phase of Cyanex-923 with 4.0 M HCl/ HNO_3 and 1-2 M H_2SO_4 (Table-1).

Table-1: Effect of stripping agent on percentage recovery of Scandium(III) from metal loaded organic phase of Cyanex-923 in toluene.

Acids (Molarity)	Percentage Recovery (%R) of Sc(III) with various strippants		
	HCl	**HNO_3**	**H_2SO_4**
1.0	5.1	0.0	99.9
2.0	24.8	16.1	99.9
3.0	49.7	31.4	-
4.0	99.9	99.9	-

Influence of diluents and equilibration period: The extraction of Sc(III) at pH 9 and 1.0×10^{-4} M sodium salicylate was carried out using different organic diluents like toluene, chloroform, xylene, n-hexane and cyclohexane. It was observed that quantitative extraction of Sc (III) is seen with all the above diluents except that of xylene (97.9%). For all the further experiments, toluene is used as diluent.

Extraction of Sc (III) was studied for different periods of shaking from 1-30 min. It was found that 5 min of shaking period was sufficient for quantitative extraction of Sc(III) metal ion. However there was no effect by increasing the extraction period upto 30 min.

Nature of the extracted Species: In order to determine the probable nature of the extracted species, a graph of log D versus log R [R=Cyanex-923] at fixed pH of 9.0 was plotted (Fig.2). The slope obtained was 2.2, indicating that two molecules of Cyanex-923 react with one molecule of Sc(III) ion. Another plot of log D versus log [$HSal^-$] gave the slope of 3.2 which indicates three salicylate ions reacts with one Sc(III) ion. Hence the probable species extracted in the organic phase is $Sc(HSal)_3$.2Cyanex-923, which is similar to the earlier reported with triphenyl phosphine oxide (TPPO) [15] (Fig.3). The probable mechanism is given below,

$$Sc^{3+}{}_{(aq)} + 3\,HSal^-{}_{(aq)} \rightleftharpoons Sc(HSal)_{3\,(aq)}$$

$$Sc(HSal)_{3\,(aq)} + 2Cyanex\text{-}923_{\,(org)} \rightleftharpoons [Sc(HSal)_3].2Cyanex\text{-}923_{\,(org)}$$

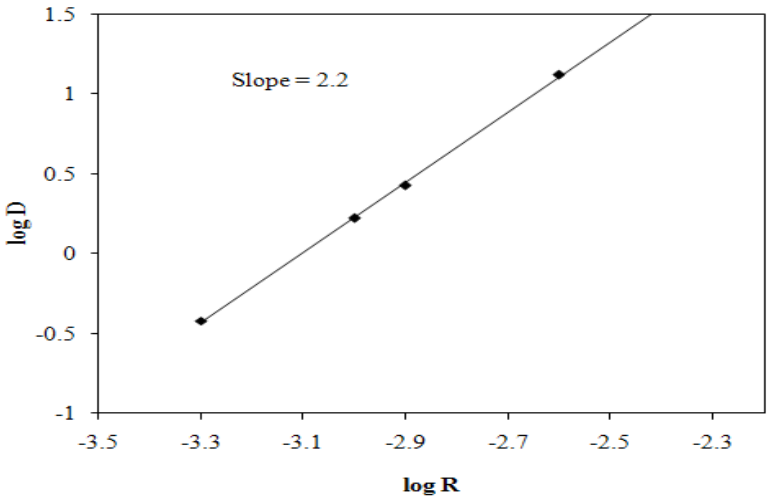

Fig:2 Effect of reagent concentration on Distribution ratio of Sc(III).

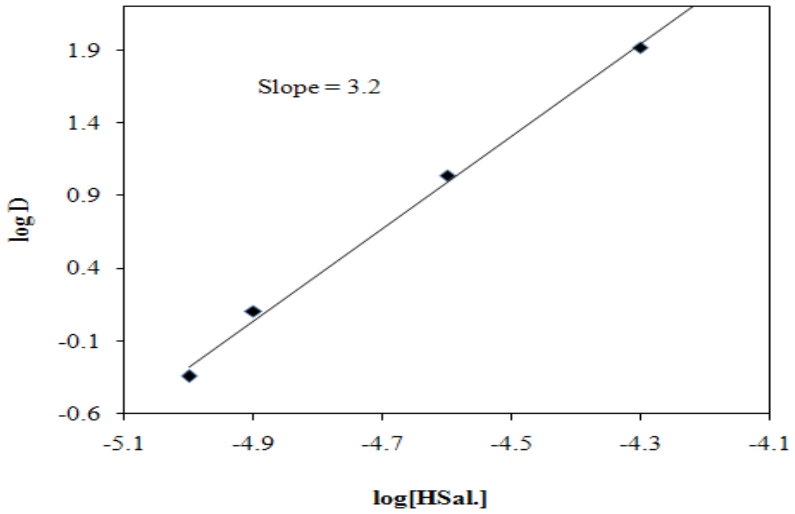

Fig:3 Effect of Sodium Salicylate concentration on distribution ratio of Sc(III).

APPLICATIONS

Scandium (III) metal ion is separated from the other associated metal ions by taking into consideration the difference in their extraction conditions. A mixture of 20 µg Sc(III) and 40 µg U(VI) is taken and its pH is adjusted to 9.0 and 5.0 x 10^{-4} M concentration of sodium salicylate. The solution is then extracted with 5.0 x 10^{-3} M Cyanex-923 dissolved in toluene, whereby only Sc(III) gets extracted while U(VI) remains unextracted. The extracted Sc(III) is stripped with 4.0 M HCl solution. Similarly metal like zinc(II), titanium(IV), lanthanum(III) and yttrium(III) are separated from Scandium(III) metal ion (Table-2).

Table-2: Separation of Sc(III) from multicomponent mixtures with Cyanex-923 in toluene.

Sr. No.	Metal ions	Amount taken (µg)	pH	Sodium salicylate (M)	Extractant Cyanex - 923	Stripping Agents	Recovery (%)
1.	Sc(III)	20	9.0	5.0×10^{-4}M	5.0×10^{-3}M	4.0 M HCl	99.6
	U(VI)	40	-	-	-	Unextracted	99.4
2.	Sc(III)	20	9.0	5.0×10^{-4}M	5.0×10^{-3}M	4.0 M HCl	99.6
	Ti (IV)	50	-	-	-	Unextracted	99.2
3.	Zn (II)	20	9.0	5.0×10^{-4}M	5.0×10^{-3}M	1.0 M HCl	98.9
	Sc(III)	20	-	-	-	4.0 M HCl	99.7
4.	Sc(III)	20	9.0	5.0×10^{-4}M	5.0×10^{-3}M	4.0 M HNO_3	99.4
	La (III)	40		-	-	2.0 M HCl	99.1
5.	Y(III)	50	9.0	5.0×10^{-4}M	5.0×10^{-3}M	1.0 M HCl	99.2
	Sc(III)	20	-	-	-	4.0 M HCl	99.8

CONCLUSIONS

Cyanex-923 can be effectively used for quantitative extraction of Sc(III) from sodium salicylate media at pH 9.0. The concentrations of Cyanex-923 and sodium salicylate required for the quantitative extraction of Sc(III) are 5.0×10^{-3} M and 5.0×10^{-4}M respectively. Sc(III) can be effectively separated from other associated metal ions like U(VI), Zn(II), Ti(IV), La(III) and Y(III).

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