Spectrophotometric Determination of Micro Concentration of Strontium with Xylenol Orange

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Summary: A rapid and sensitive spectrophotometric method is developed for the determination of strontium. The method is based on the colour reaction between strontium and xylanol orange. The complex formed is measured for its adsorption at 570 nm. Intereference for 20 cations is also investigated.

Introduction

The determination of strontium is of great interest because of its salts have been used at various times, ranging from the use of strontium bromide N.F.X. as a sedative to strontium lactate used in the treatment of osteoporosis [1]. Early work indicated that strontium caused the formation of a rachitic bone. Later work showed that if vitamin D, estrogens, and androgens were also administered with strontium, functional bone would be produced. The above two observations, can be rationalised by the recent report that strontium may inhibit the synthesis of 1, 25 - dihydro-xycholecalciferol from cholecalciferol (vitamin D_3), which would prevent proper calcium absorption from the intestinal tract [2], Horr [3] in 1959, had made a survey of analytical methods for the determination of strontium that have been reported in the literature over the last 40 years. Wade and Seim [4] separated calcium and strontium by (ethylenedinitro) tetraacetic and complexation - ion exchange chromatography and then determined the strontium using flame photometry. Their method is laborious. Hinsvark, Wittwer and Sell [5] determined strontium by flame photometry in the presence of barium and calcium. However, concentration of strontium measured was greater than 200 μg per ml, this method could not be used for the determination of micro amount of strontium in the sample of water etc. The direct method [6] for the determination of strontium contents in the samples by neutron - activation analysis has some advantages but it required neutron reactor and is time consuming. Gravimetrically [7], strontium can be estimated by precipitating it with oxalate in alcoholic media. This method is not only time consuming but also can not be used in the presence of trace amount of chromium present in the sample. Odum [8] determined strontium in clarnshells flame photometrically by the use of synthetic standards. However, the limits of detection of this method for strontium was 1.7 μg per ml; he was unable to detect strontium in tap water and in calcium containing reagents. In our earlier work, the xylenol orange was reported to be preferred reagent for the determination of zirconium [9] and molybdinum [10] and was expected to be useful reagent for the spectrophotometric determination of other elements. In the present work, the xylenol orange is proposed to be used as chromogenic reagent for the determination of strontium. Effect of pH, time, temperature, concentration of the reagent and solute and interference have also been reported.

Results and Discussion

The reaction between strontium and xylenol orange was very quick. A violet colour was immediately produced on mixing of the reactant and attained full intensity when warmed at 45°C and remained stable for more than 48 hours. Spectrometric measurements were made at 570 nm wavelength at which the absorbance was maximum (Fig. 2).

Effect of pH

Complex formation is pH dependent and the most stable complex was formed when 2 ml buffer solution of pH 9.5 per 100 ml was used. Under this condition, reaction mixture showed maximum absorbance (Fig. 3).

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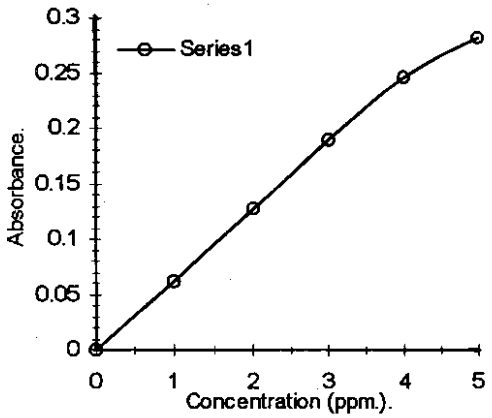

Fig. 1: Calibration curve for the determination of strontium.

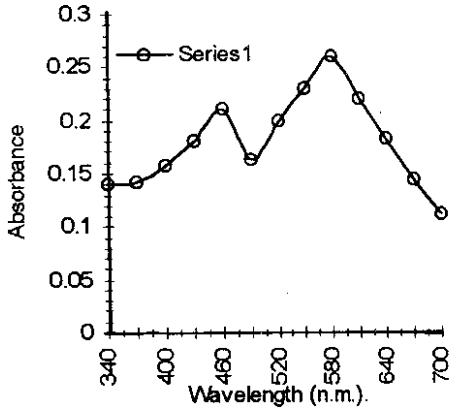

Fig. 2: Absorbance spectra of strontium xylenol orange complex.

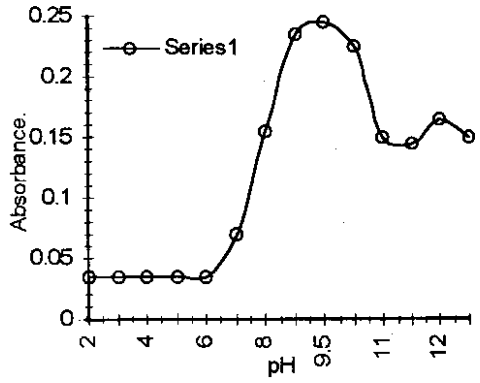

Fig. 3: Absorbance spectra of strontium xylenol orange by adding buffer solution of different pH.

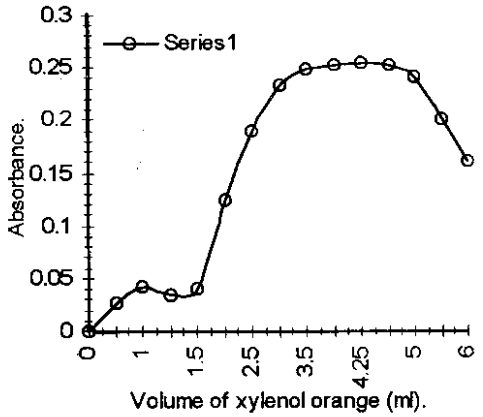

Fig. 4: Effect of xylenol orange concentration.

Effect of reagent concentration

The reaction was studied with xylenol orange concentration effect. Varying quantities of xylenol orange were used and it was observed that its 3-5 ml (0.05 % w/v) per 50 ml solution were quite sufficient for complete complex formation upto 4 ppm (Fig. 4).

Effect of temperature

The reaction is temperature dependent and the best results were achieved at 45-50°C.

Effect of solute concentration

The effect of strontium concentration was also checked at 570 nm and observed that reaction followed the Beer's law from 1 ppm to 4 ppm of strontium (Fig. 1).

Effect of time

The complex is time independent. It is stable for more than 48 hours. After 48 hours no study was carried out.

Interference study

Almost all the transition metals form strongly coloured complexes with xylenol orange at different pH and wavelengths. To see the effect, foreign metal ions were added in the strontium solution with equal concentration and the absorbance of these solutions were recorded under similar experimental condition. Table-1 lists the percentage error calculated for the strontium ion

Table-1: Effect of interfering cations on the determination of strontium

S.No.	Strontium taken (ppm)	Interferring cation added (ppm)	Strontium found	%age Error
1.	2.5	In (2.5)	2.5	0.00
2.	2.8	Na (2.8)	2.8	00.00
3.	2.5	K (2.5)	2.5	00.00
4.	2.7	Ca (2.7)	4.3	59.00
5.	2.6	Mg (2.6)	2.5	03.85
6.	2.9	Ba (2.9)	2.0	31.03
7.	2.7	Cr (2.7)	3.8	40.74
8.	2.5	Cu (2.6)	1.9	27.00
9.	2.6	Ni (2.6)	3.4	30.77
10.	2.8	Sn (2.8)	2.9	03.57
11.	2.5	Mn (2.5)	2.4	04.00
12.	2.7	Co (2.7)	2.8	03.70
13.	2.5	Zn (2.5)	0.8	68.00
14.	2.8	Ag (2.8)	2.8	00.00
15.	2.6	Bi (2.6)	4.3	65.38
16.	3.0	Nb (3.0)	4.8	60.00
17	3.1	Pb (3.1)	3.2	03.22
18.	2.5	Se (2.5)	1.0	60.00
19.	2.4	Cd (2.4)	2.4	00.00
20	2.8	Fe (2.8)	3.0	28.57

determination in the presence of various interfering ions.

The study indicated that metals in the neighbourhood of strontium in the periodic table interfered severely. This is due to the close resemblance in their chemical behaviour with that of strontium. This suggests that the sample should be free from calcium and barium etc. However other ions behave normally except nickel, bismuth etc., which increase the absorbance. In contrast to this copper, zinc and slenium depressed the absorbance of the sample.

Experimental

Reagents

All the reagents were of analytical grade or comparable purity supplied by Merck, Fluka or BDH. Deionized water was used throughout. The stock strontium solution (1000 ppm) was prepared by dissolving 3.042 g of $SrCl_2$. $6H_2O$ in some water and diluting to 100 ml with water. The working concentration (100 ppm) was prepared by diluting 50 ml of 1000 ppm solution to 500 ml with deionized water.

Apparatus

All absorbance measurements for the determination of strontium were made either by U.V. Spectrophotometer, "Hitachi Japan" or by Spectronic-20, "Milton Roy Company". The pH meter was a Pye Unicam. Graduated pipettes accurate to ± 0.005 ml were used. All other volumetric glassware used was of analytical grade calibration.

Buffer solutions

Buffer solution of pH range 2-13 pH was prepared by mixing ammonium chloride and concentrated solution using standard method given in literature [11].

Xylenol orange

A 0.05 % solution of the reagent was prepared in deionized water.

Procedure

5 ml of the test solution containing less than 20 μg of strontium, 4 ml of 0.05 % xylenol orange solution and 2 ml buffer solution of 9.5 pH per 100 ml was mixed thoroughly in a beaker and warmed upto 45-50°C. It was cooled and transferred to 100 ml measuring flask and volume was made upto mark with distilled water. The absorbance was measured at 570 nm against a reagent blank (containing all the reagents except strontium) using a paired 1 cm cylinderical glass cuvettes. The sequence was repeated by taking different concentration of strontium (0.5 - 1.0 ppm) and a calibration curve was prepared (Fig. 1).

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