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Determination of Indium (III) by Simple Spectrophotometric Technique Using Bromocresol Purple Dye

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ABSTRACT

A simple and sensitive spectrophotometric method has been developed for the determination of Indium (III) using Bromocresol purple dye as a reagent. Indium (III) forms an Orange Yellow coloured complex with the reagent in acidic medium at pH 4.0. The molar absorptivity and Sandell's sensitivity of coloured species are 1.6 x 10^5 dm^3mol^{-1} cm^{-1} and 0.00617 µg $cm^{3\,-1}$ respectively. Beer's law is obeyed in the range of 0.2296-2.2960 µg mL^{-1} of Indium(III) at λ_{max} 485 nm. Indium (III) forms a 1: 3 complex and the effect of interferences was studied. The merits and demerits of several other spectrophotometric methods for Indium (III) are also discussed.

Keywords: Spectrophotometric technique, Indium(III), Bromocresol Purple.

INTRODUCTION

Indium is classified as a rare element with an oxidation state of 3^+ and is quite stable to atmospheric exposure. One of the early uses of indium was in the coating of other elements to protect them against wear and corrosion. It also has uses in alloys, in semiconductors and as a solder to metal [1]. Stark et al. prepared an indium(III) chloride complex with 12-crown-4 and distinguished it by single X-ray diffraction [2]. Fujinawa et al. have prepared a support liquid membrane for indium and used it in metallurgic recovery of gallium and indium [3].

There are several determination methods of trace In^{3+} in solution, such as spectrophotometry, atomic absorption spectrometry, atomic emission spectrometry and polarography [4]. Among these methods, spectrophotometry is the most widely used one because of simple structure of instrument, low cost, and simple operation [5].

The present note deals with a sensitive and selective method for the spectrophotometric determination of Indium (III) at trace levels using Bromocresol purple as analytical reagents.

MATERIALS AND METHODS

An UV- visible spectrophotometer (ELICO, Model SL-159) with quartz cells of 1.0 cm path length was used for absorbance measurement. An ELICO digital pH (Model LI-120) with combined glass calomel electrode was used for pH measurements. All chemicals used were of AR grade (Merck). A stock solution of Indium nitrate, $In(NO_3)_3$ of 1.0×10^{-2} M was prepared by dissolving the requisite amount of Indium (III) in distilled water. The standard stock solution of Bromocresol purple of 1.0×10^{-2} M concentration was prepared in aqueous alcohol (40%v/v). The standard stock solutions of various salts (as source of diverse ions), each of 1.0×10^{-2} M, were prepared in doubly distilled water.

Recommended Procedure:
An aliquot of solution containing 2.296 µg mL^{-1} indium (III) was taken in a 10 mL measuring flask, 3 mL of 1.0×10^{-5} M of the reagent was added to it. The contents were diluted to the mark with aqueous alcohol (40%v/v), keeping the pH constant, the absorption spectrum of the resultant Orange yellow coloured Indium (III)- Bromocresol purple complex was recorded against blank from which the value of λ_{max} was obtained.
The optimum experimental conditions in regard to-
(1) the concentration of the reagent (Bromocresolpurple);
(2) the concentration of the Indium(III);
(3) the pH of the medium;
(4) ascertaining the λ_{max} of the indium (III)- Bromocresolpurple complex were established.

RESULTS AND DISCUSSION

The absorption spectrum of the indium (III)- Bromocresol purple complex in aqueous alcohol was studied over the wave length range 340-580 nm. The Orange yellow coloured complex exhibited absorption maximum at 485 nm(Fig.1), where reagents show negligible absorption at this wavelength. The effect of the quantity of the reagent on the intensity of colour was also studied. It was found that minimum 3 - fold excess of the reagent was required for full colour development. The colour develops instantaneously on mixing the two solutions and remains stable for 24 h. The optimum pH for the formation of this complex is 4.0.

The system adheres to Beer's law in the range $1.0 \times 10^{-6} - 1.0 \times 10^{-5}$ M of the Indium (III) with optimum range of 0.2296 - 2.296 µg mL^{-1} of the metal (Fig.2). The molar absorptivity calculated over the range studied was 1.6×10^{5} dm^3mol^{-1} cm^{-1}, while Sandell's sensitivity was 0.00617 µg $cm^{3\ -1}$. The standard deviation and coefficient of variance as determined of a series of measurements made according to the optimum conditions were 0.00063 and 0.40 respectively. This speaks the volume for the precision for the present spectrophotometric method for the determination of Indium(III) using Bromocresolpurple as the analytical reagents. It is worthwhile to mention here that this method has an edge over some recent spectrophotometric methods for the determination of Indium (III) using other reagents (Table 2). Further, the mole ratio method gives the composition of this Indium (III)- Bromocresolpurple complex as 1:3.

The effect of diverse ions on the spectrophotometric determination of Indium (III), using Bromocresolpurple as the reagent has been studied in the terms of tolerance limit which was set as the amount (µg ml^{-1}) of the diverse ions causing an error of ± 1% (refer to Table 1). It has been concluded that the following cations and anions do not interfere in the spectrophotometric determination of the Indium (III).

Table 1: Effect of diverse ions on the spectrophotometric determination of Indium (III) using Bromocresol Purple as the reagent Indium (III) = 0.2296 μg mL^{-1}

S. No.	Diverse ions	Added as	Amount of a diverse ion added (μg mL^{-1})	In (III) found (μg mL^{-1})	Relative error (%)
1	NO_2^-	$NaNO_2$	113.60	0.235	1.82
2	NO_3^-	$NaNO_3$	154.63	0.231	0.60
3	CH_3COO^-	CH_3COONa	147.97	0.232	1.23
4	Cl^-	KCl	173.34	0.228	-0.60
5	Br^-	KBr	212.29	0.231	0.62
6	I^-	KI	317.30	0.228	-0.61
7	CO_3^{2-}	Na_2CO_3	972.81	0.228	-0.60
8	SO_4^{2-}	K_2SO_4	240.80	0.227	-1.23
9	PO_4^{3-}	$Na_2HPO_4.12H_2O$	234.22	0.231	-0.60
10	NH_4^+	NH_4NO_3	898.92	0.228	-0.61
11	Na^+	$NaNO_3$	574.72	0.231	-0.60
12	Pb^{2+}	$Pb(NO_3)_2$	513.10	0.228	-0.62
13	Hg^{2+}	$HgCl_2$	495.96	0.227	-1.00
14	Cu^{2+}	$Cu(NO_3)_2.3H_2O$	158.90	0.229	-0.20
15	Cd^{2+}	$Cd(NO_3)_2$	281.71	0.227	-1.23
16	Al^{3+}	$Al_2(SO_4)_3.16H_2O$	128.00	0.229	-0.20
17	Fe^{3+}	$FeCl_3$	157.01	0.228	-0.61
18	Cr^{3+}	$CrCl_3.6H_2O$	251.20	0.227	-0.92
19	Zn^{2+}	$Zn(NO_3)_2$	487.22	0.231	0.62
20	Mn^{2+}	$MnSO_4.H_2O$	137.00	0.231	0.62
21	Ni^{2+}	$Ni(NO_3)_2.6H_2O$	147.04	0.231	0.61
22	Co^{2+}	$Co(NO_3)_2.6H_2O$	147.06	0.227	-1.23
23	Ba^{2+}	$BaCl_2.2H_2O$	342.82	0.231	0.60
24	Sr^{2+}	$Sr(NO_3)_2$	218.94	0.231	0.60
25	Ca^{2+}	$Ca(NO_3)_2$	997.20	0.228	-0.60
26	Mg^{2+}	$Mg(NO_3)_2.6H_2O$	592.83	0.228	-0.61
27	K^+	KCl	977.00	0.231	-0.62

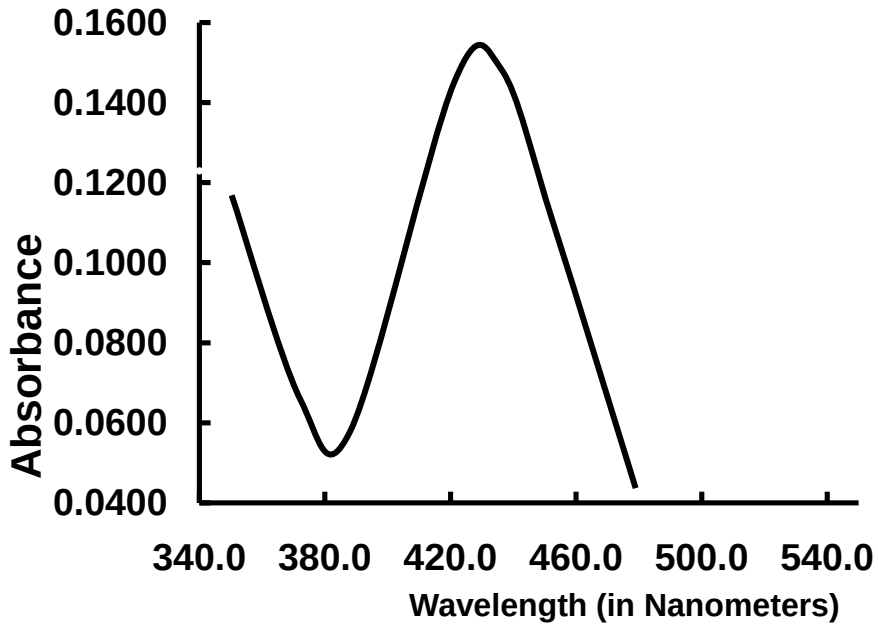

Figure 1: Absorption spectrum of Indium (III) – Bromocresol purple complex system In aqueous alcoholic medium (40%v/v)

Table 2: Comparison of the present method with some recent spectrophotometric methods for the determination of Indium (III)

Reagent	Sensitivity μgmL^{-1}	Linear range μgmL^{-1}	Molar absorptivity L $mol^{-1}cm^{-1}$	Ref. No.
Alizarine Green derivative	-	-	$3.03x\ 10^4$	6
Cetypyridinium ion 1-(2-Thiazolyl azo)-2-nepthol	8.6 ng cm^{-2}	0.1-3.2	$2.15\ x10^4$	7
7-(1-Phenylazo)-8-hydroxyquinoline-5-sulphonic acid and Triton X-100	-	0.0 – 0.6 ng/L	$7.33\ x\ 10^4$	8
Bromocresol Purple	0.00617 $\mu g/cm^3$	0.0 – 2.29	1.6 x 105	Present method

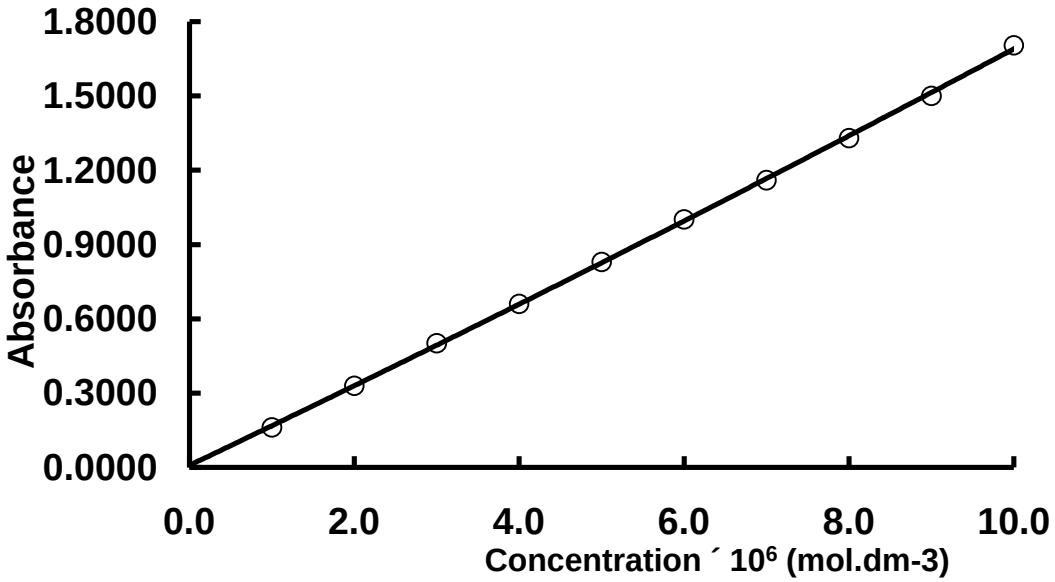

Figure 2. Plot of Absorbance vs Molar Concentration of Indium (III) in Indium (III) – Bromocresol Purple Complex System at λ_{max} =485 nm

APPLICATIONS

This method is applied for the determination of In(III) in presence of foreign ions successfully (Table 2)

CONCLUSIONS

The proposed method for the determination of indium(III) offers advantage of simplicity rapidity, sensitivity and reasonable selectivity over the other methods. The developed colour is stable for 24 h. The major advantage of the proposed method is that the maximum colour intensity is obtained instantaneously at room temperature without the need for heating and also a high tolerance limit for the interfering ions in Indium determination. Because no extraction step is required, the use of organic solvents, which are generally toxic pollutants, is avoided. The proposed method does not involve any stringent reaction conditions and can be favorably compared with other methods. The sensitivity in terms of the molar absorptivity and precision in terms of the standard deviation of the present method are very reliable for the determination of indium(III).

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