

Spectrophotometric Determination of Erbium(III) with Murexide in Synthetic Samples

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A sensitive, facile and simple method for the determination of trace amounts of erbium by spectrophotometry is described based on the formation of the erbium-murexide complex. Beer's law is obeyed from 0.1–5.0 mg/L of erbium at 463 nm as Er-murexide complex. Optimal conditions such as reagent amounts, pH for the erbium determination were reported. The effects of the foreign ions were also investigated. The proposed method was successfully applied to the determination of erbium contents in synthetic samples.

Key words: Spectrophotometry, determination, erbium(III), murexide, synthetic samples

INTRODUCTION

Erbium is a member of the lanthanide series in group IIIb of the periodic table. Erbium is used in experimental optical amplifiers that amplify light signals sent along fibre-optic cables. Erbium is finding nuclear and metallurgical uses. Most of the rare-earth oxides have sharp absorption bands in the visible, ultraviolet, and near infrared. This property, associated with the electronic structure, gives beautiful pastel colours to many of the rare-earth salts. Erbium oxide gives a pink colour and has been used as a colorant in glasses and porcelain enamel glazes^{1–3}.

Spectrophotometry is an important technique for the determination of the metal complexes^{4–7}. There are many spectrophotometric methods described for the determination of erbium(III) with various organic reagents^{8,9}. Murexide (MUR) is an organic colorimetric reagent which has some desirable characteristics such as high complex formation constants with metal ions, high molar absorptivities and selectivity of the complex formations with metal ions.

In the present work, a sensitive and simple method for the determination of trace amounts of erbium(III) by spectrophotometry is described based on the formation of the erbium(III)-murexide complex. The method was applied to the determination of erbium in synthetic samples.

EXPERIMENTAL

A Hitachi Model 150-20 UV-Vis double beam spectrophotometer with a 10 mm optical path cell was used for spectrophotometric measurements. The measurements for erbium(III)-(Er-MUR) were performed at 463 nm.

All chemicals obtained from commercial sources were of super pure grade unless otherwise stated. All aqueous solutions were prepared using doubly distilled water. The erbium stock solution, 1000 mg/L was prepared from Er_2O_3 (Sigma Chem. Co., St. Louis) in water. Portions were diluted daily for obtaining reference and working solutions.

Borax buffer solution (pH = 7.25): 0.1 M sodium hydroxide solution was added dropwise to 0.05 M sodium tetraborate solution (Merck-Darmstadt) to the required pH. Murexide (MUR) (Sigma Chem. Co., St. Louis) solution (0.2% (w/v)) was prepared daily by dissolving in water.

General procedure: Ten micrograms of erbium was transferred into a 25-mL calibrated flask and 1 mL of 0.2% MUR solution was added. The pH of the solution was adjusted with borate buffer to pH 7.5 and 1 mL of 0.2% CPC solution was added. Then the whole solution was mixed and diluted with distilled water to the mark. After 10 min, the absorbance of this solution was measured at 463 nm by spectrophotometer against a reagent blank.

RESULTS AND DISCUSSION

The absorption maxima was obtained for erbium-MUR complex in water at 463 nm. Reagent blank was used thereafter as a reference because it showed absorption at this wavelength.

Effect of pH: The effect of the pH on the formation of the erbium-MUR complex was examined, at 463 nm using various buffer solutions of different pH values. The results are given in Fig. 1. The erbium-MUR complex begins to form at approximately pH 5.0, with maximum absorbance being reached at pH values between 7.0 and 8.0. After pH 8.5, $\text{Er}(\text{OH})_3$ was formed under experimental conditions. In the light of these findings, all subsequent studies were carried out at pH 7.25 using borax buffer.

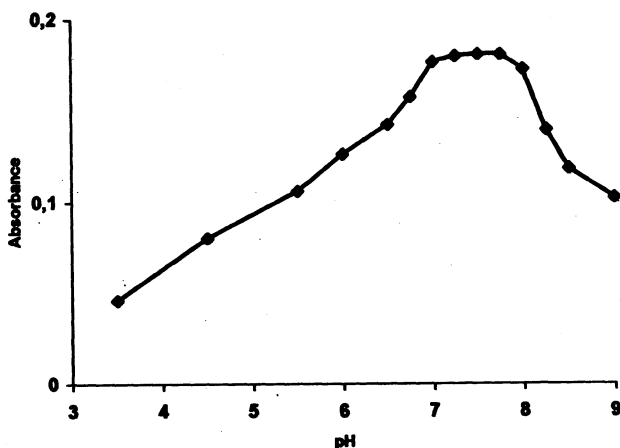


Fig. 1. Effect of pH on the formation of the erbium-murexide complex (Er: 1.0 $\mu\text{g}/\text{mL}$, 1000 μL of 0.2% MUR, pH 7.25)

Effect of reagent amount: The effect of murexide amounts on the formation of erbium-MUR complex was investigated at the optimum pH. It was found that maximum absorbance values were obtained for 0.2% MUR solution in the range of 800–1200 μL . In all studies, 1000 μL of reagent was used.

Influences of time on the complex formation: The influence of time on the formation of the erbium-MUR complex was also studied at the optimum conditions. The colour development of the complex is complete in 5 min and the colour is stable for at least 48 h.

Calibration graphs and detection limit: Calibration curve was constructed for erbium according to the general procedure described above. Beer's law is obeyed from 0.1–5.0 mg/L of erbium at 463 nm as Er-MUR complex. The detection limits based on three times the standard deviations of the blank were 42 $\mu\text{g/L}$ ($N = 21$). The relative standard deviations for the erbium determinations were 3% ($N = 10$) at 0.4 $\mu\text{g/mL}$ Er.

Effect of diverse ions: The interferic effects of some anions, cations and metal ions were examined by measuring the absorbance of solution containing 10 μg of erbium(III) in 25 mL of distilled water and various amounts of foreign ions. Tolerable limit was defined as the highest amount of foreign ions that produced an error not exceeding 5% in the determination of erbium. The results are summarized in Table-1. The formation of the Er-MUR complex was not influenced by alkaline earth or ions and some other anions.

Analysis of samples: In order to highlight the utility of the proposed method, it was used for the spectrophotometric determination of erbium contents of some synthetic samples. The results are given in Table-2. Erbium as MUR complex in the samples is successfully determined by the proposed method.

TABLE 1
TOLERABLE LIMITS OF THE FOREIGN IONS ON THE
DETERMINATION OF ERBIUM AS MUR COMPLEX ($N = 4$)

Foreign ion	Tolerable limit [ion]/[Er]
Bi^{3+}	1
Al^{3+}	2
Cr^{3+} , Cu^{2+} , PO_4^{3-}	5
Pb^{2+} , Co^{2+} , Ni^{2+}	10
Ca^{2+}	25
Zn^{2+} , Cd^{2+} , Fe^{3+}	60
Mn^{2+}	250
Na^+	12500
K^+ , CH_3COO^- , Mg^{2+} , NH_4^+ , Cl^-	30000
SO_4^{2-}	65000

TABLE 2
DETERMINATION OF ERBIUM IN SYNTHETIC SAMPLES
BY PROPOSED METHOD (N = 4)

Sample	Composition	Erbium content	Erbium found
NaCl	10000 mg/L	0.40 µg/mL	0.40 ± 0.02 µg/mL
(NH ₄) ₂ SO ₄	10000 mg/L		
NaCl	4000 mg/L	0.80 µg/mL	0.79 ± 0.02 µg/mL
(NH ₄) ₂ SO ₄	4000 mg/L		

x ± SS: mean ± standard deviation.

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