

Sensitization of Europium Luminescence in Complexes with Thiaprophenic Acid

A. Egorova¹ and S. Beltyukova^{1,2}

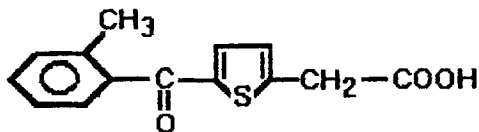
Received August 7, 1998; accepted December 29, 1998

The sensitized luminescence of europium ion in complexes with thiaprophenic acid has been investigated. It is shown that the luminescence intensity of the Eu (III) increases by 10^7 times as the result of intramolecular energy transfer from ligand to lanthanide ion. The luminescence properties of the complex have been studied in solutions and a highly sensitive luminescence method for the determination of thiaprophenic acid has been developed.

KEY WORDS: Luminescence; thiaprophenic acid; europium(III) ion; drug analysis.

INTRODUCTION

Thiaprophenic (5-benzoyl- α -methyl-2-thiophenacetic) acid is a sulfur-containing carboxylic acid used



in preparation "Surgam" as the active substance and it possesses antiinflammatory, analgetic, and febrifugal activity [1]. The extensive application of this preparation in medical practice necessitates its determination in various biological fluids (blood, urine, etc.).

We have demonstrated previously that for determination of some drugs (nalidixic acid and catecholamines), the luminescence sensitization of lanthanide ions taking place in their presence can be used [2,3]. The determination of a number of fluoroquinolones (perfloracin, ofloxacin, ciprofloxacin) by sensitized luminescence of terbium ions has also been described [4].

The purpose of this work was to study the optimum conditions of europium ion luminescence in the presence of thiaprophenic acid and to develop methods for its determination in both substances and biological fluids (urine).

EXPERIMENTAL

Apparatus. The luminescence measurements were obtained on an SDL-2 spectrophotometer (Leningrad Optomechanical Association, St. Petersburg, Russia). A xenon lamp was used as the excitation source. The pH values of solutions were measured using an OP-211/1 laboratory digital pH-meter (Radelkis, Budapest, Hungary).

Reagents. The europium chloride solution at a concentration of 1 mg/ml was prepared by dissolving europium oxide (99.99%) in hydrochloric acid (1:1), the excess of which was evaporated to a wet residue and diluted with distilled water. The metal concentrations were determined by complexometric titration with arsenazo I as the indicator. The solution of thiaprophenic acid was obtained by dissolution of an accurately weighed preparation in distilled water. The solution of trioctylphosphinoxide (TOPO) at a concentration of 1×10^{-2}

¹ A. V. Bogatsky Physicochemical Institute of the National Academy of Sciences of Ukraine, 86 Lustdorfskaya doroga, 270080, Odessa, Ukraine.

² To whom correspondence should be addressed. Fax: 38(0482)65-20-12. e-mail: physchem@paco.net

M was prepared by dissolution of an accurately weighed substance in ethanol. The pH of solutions was maintained at 6.5 with 8% aqueous solution of urothropine.

Methods. To choose the optimum conditions for Eu(III) luminescence in complexes with thiaprophenic acid, the assays were performed as follows: the europium chloride solution was added to the solution of thiaprophenic acid, the solution was adjusted to pH 6.5 with 0.4 ml, the volume was adjusted to 10 ml with distilled water, and the luminescence intensity (I_{lum}) of solutions was recorded at 612 nm.

The thiaprophenic acid content was calculated by the method of additives using the formula $C_x = C \times I_x / (I_{x+ad} - I_x)$, where I_x and I_{x+ad} are the luminescence intensity of the assay and the assay with thiaprophenic acid additive. C is the content of thiaprophenic acid in the additive.

The triplet level of the ligand was calculated from its phosphorescence spectra at 77K.

RESULTS AND DISCUSSION

Optical Characteristics of the Ligand and Complex. The absorption spectrum of an aqueous solution of the ligand considered is characterized by the presence of two bands in the ultraviolet region (Fig. 1). The molar extinction coefficients for the bands at 207 and 308 nm are 9.6×10^3 and 1.12×10^4 , respectively, giving the possibility of effective absorption of light energy. The energy of the triplet level of a reagent is $19,500 \text{ cm}^{-1}$,

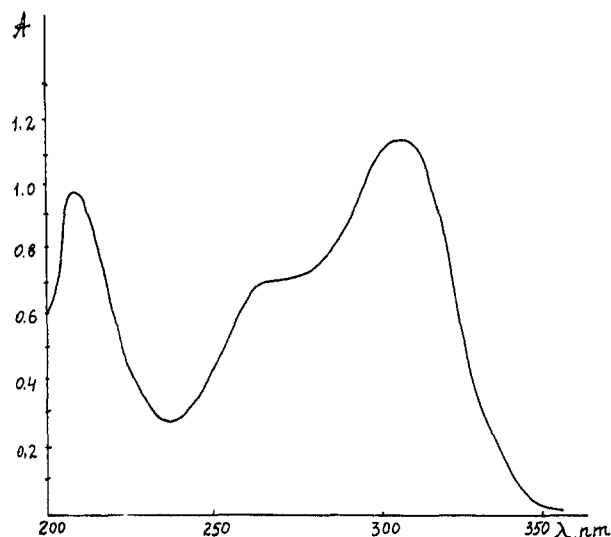


Fig. 1. Absorption spectrum of an aqueous solution of thiaprophenic acid (TPA). $C_{TPA} = 1 \times 10^{-4} M$; $l = 1 \text{ cm}$.

which is higher than the energy of the first excited state level of the Eu(III) ion, rendering the possible of energy transfer from the ligand to the lanthanide ion.

We have found that in aqueous solutions in the presence of thiaprophenic acid, a suspension of europium complex is formed in which the I_{lum} of Eu(III) ion increases by 10^7 times. The most intense in the europium luminescence spectrum is the band at 612 nm ($^5D_0 \rightarrow ^7F_2$ transition) (Fig. 2).

Influence of pH and Ligand Amount. The complexation of Eu(III) with the ligand occurs over a wide range of pH values, 2 to 9 (Fig. 3). The most luminescence intensity of the complex is observed at pH 5.5–6.5. At lower pH values (in acid solutions) the degree of complexation is very low. In alkaline solutions (pH > 8) decomposition of the complexes, with the formation of europium hydroxide, was observed.

It was found that the I_{lum} actually achieved a maximum immediately after preparation of the solutions and remained constant for 1 h.

The dependence of the Eu(III) I_{lum} on the ligand concentration is presented in Fig. 4. The highest I_{lum} is observed at a 10-fold excess of reagent.

Influence of the Solvent. The I_{lum} of the complex suspension depends on the kind of solvent present in the

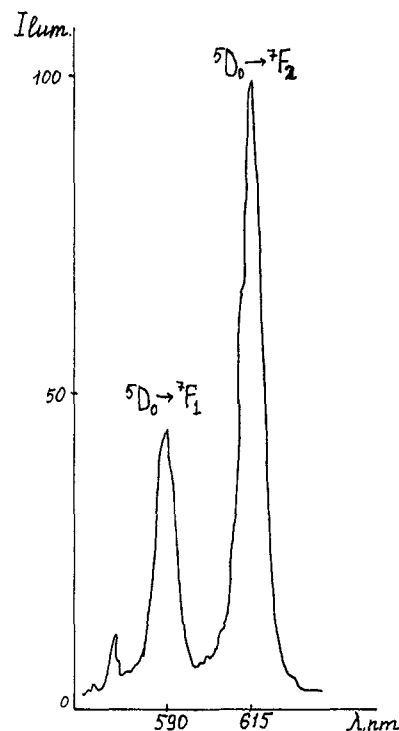


Fig. 2. Luminescence spectrum of Eu(III) in a complex with thiaprophenic acid. $C_{Eu} = 1 \times 10^{-4} M$.

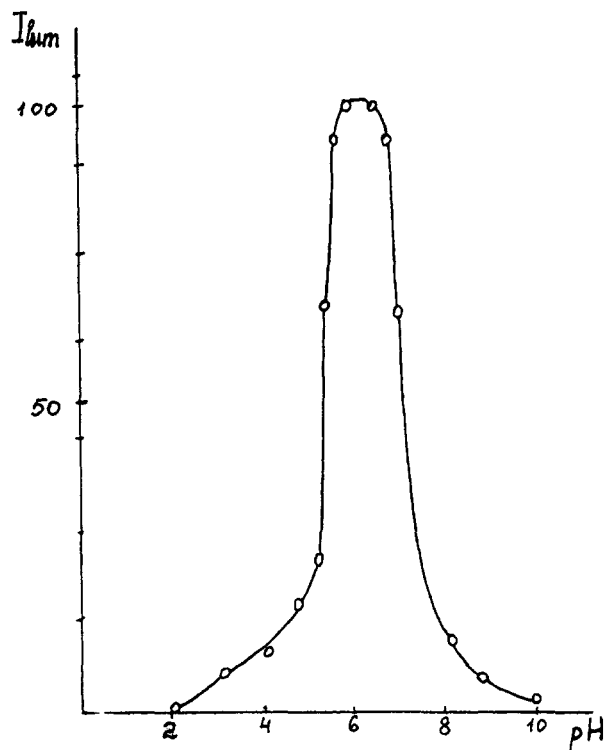


Fig. 3. Dependence of the I_{lum} of Eu(III) in complexes with thiapropionic acid on the pH of the solution. $C_{Eu} = 1 \times 10^{-4} M$.

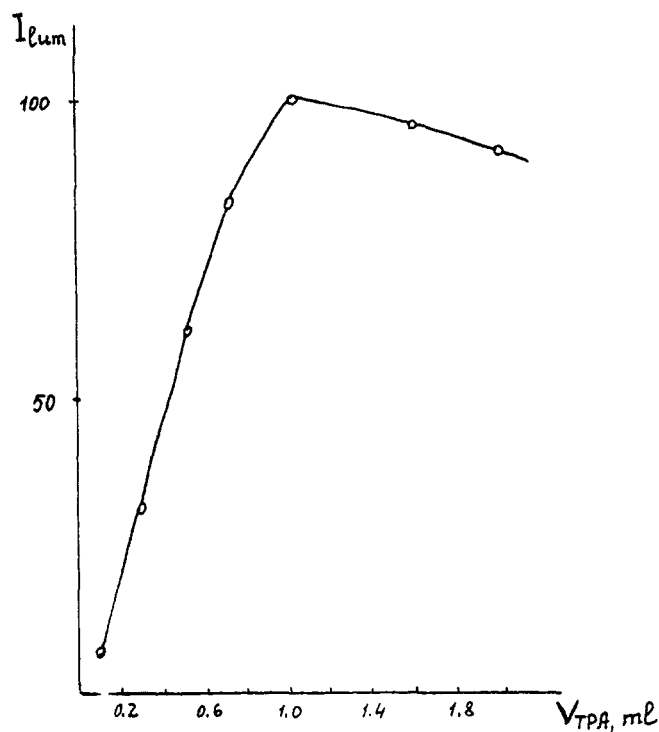


Fig. 4. Dependence of the I_{lum} of Eu(III) in complexes on the amount of thiapropionic acid. $C_{Eu} = 1 \times 10^{-4} M$.

solution. The influence of methanol, ethanol, isopropanol, acetone, dimethylformamide, and dimethylsulfoxide on I_{lum} has been studied. The highest I_{lum} was observed in aqueous solutions. The introduction into the solution of 50% (v/v) solvent leads to full quenching of the Eu(III) I_{lum} . This can be connected with the fact that, in the presence of solvents, complete dissolution of the complex suspension occurs, leading to a loss of rigidity of the molecular structure and an increase in nonradiative losses of excitation energy.

Influence of TOPO. A significant increase in the Eu(III) I_{lum} in complexes with thiapropionic acid was observed in the presence of the synergetic agent, trioctylphosphinoxide. The dependence of I_{lum} on the amount of TOPO added is shown in Fig. 5. An increase in the luminescence intensity by an order of value was observed upon the addition of 1 ml of a $1 \times 10^{-2} M$ ethanolic solution of TOPO. It could be supposed that in the presence of TOPO, there is an increase in the structure microrregulation and rigidity of the compound formed. The lowest amount of Eu(III) detected in the complexes with thiapropionic acid under optimum conditions is $1 \times 10^{-7} M$.

Influence of Various Components of Urine. To examine the possibility of determination of thiapropionic acid in urine, the influence of urea, sodium chloride, sulfates, phosphates, and oxalates, which are the main urine components, on the I_{lum} of europium in complexes with thiapropionic acid (Fig. 6). As shown in Fig. 6, oxalates and phosphates significantly reduce the luminescence intensity of europium ions. The presence of 0.3 mg of oxalates and 30 mg of phosphates in the solution

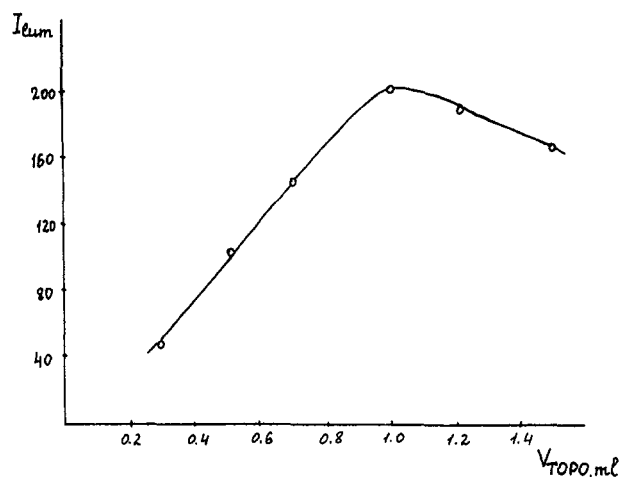


Fig. 5. Dependence of the I_{lum} of Eu(III) in complexes with thiapropionic acid on the amount of TOPO. $C_{Eu} = 1 \times 10^{-4} M$.

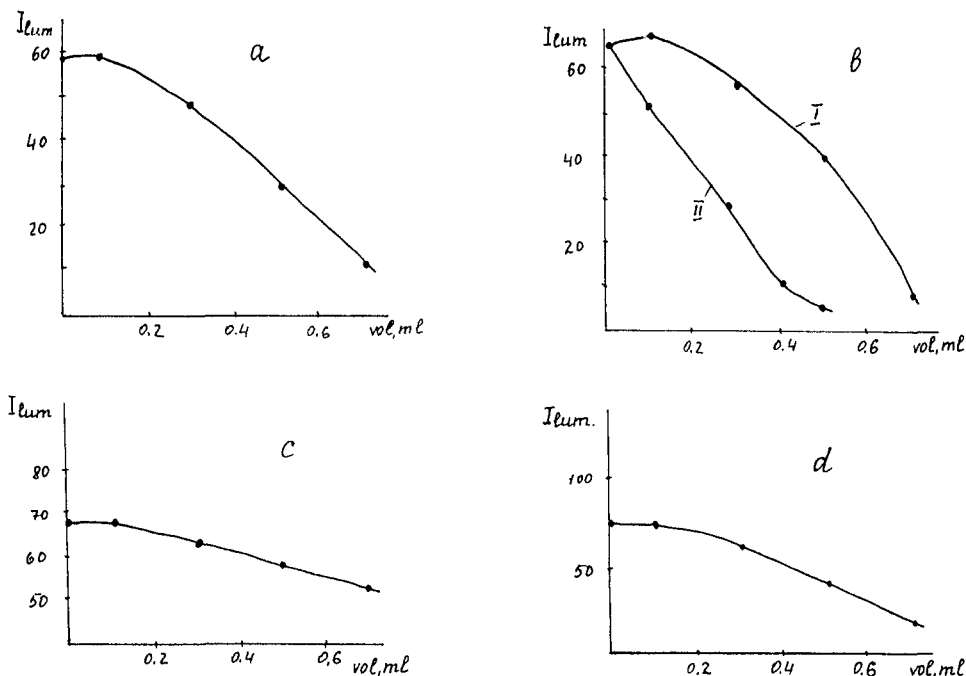


Fig. 6. Influence of various components of urine on the I_{lum} of Eu(III) in complexes with thiaprophenic acid: (a) urea, $C = 25$ mg/ml; (b) oxalate (I), $C_I = 1$ mg/ml, and phosphate (II), $C_{II} = 100$ mg/ml; (c) NaCl, $C_{NaCl} = 115$ mg/ml; (d) sulfate, $C = 96$ mg/ml.

reduces the I_{lum} of Eu(III) by 25 and 50%, respectively; 7.5 mg of urea decreases the I_{lum} by 15%. The presence of 30 mg of sulfates in the solution stimulates the same effect. NaCl slightly affects the I_{lum} . The investigations performed allow us to conclude that determination of thiaprophenic acid in the urine is possible.

Analytical Performance. The determination was performed in the following manner. Two hours after a personal dose of one tablet of the preparation Surgam, containing 300 mg of thiaprophenic acid, 100 ml of urine was collected. For the analysis 0.5 ml of the urine was selected.

One-half milliliter of the urine to be investigated was placed in each of three test tubes, then the additives of a thiaprophenic acid stock solution (1 mg/ml) were added in amounts such that the luminescence intensity of the assay with additives increased by two and four times, respectively. One milliliter of a europium chloride solution ($1 \times 10^{-2} M$), 1 ml of a TOPO ethanolic solution ($1 \times 10^{-2} M$), and 0.4 ml of an 8% solution of urothiopine were added to all the test tubes and the volume was adjusted to 10 ml. The assays were stirred, and after 5 min the I_{lum} was recorded at 612 nm. The thiaprophenic acid content was calculated by the additive method using the above formula. In the urine solution analyzed 0.05

mg/ml of thiaprophenic acid was detected. The standard deviation (SD) was 0.013.

The accuracy and precision of the method were checked in the urine solutions by the "added-found" procedure by means of the statistical treatment of determination data (Table I). For this, 0.5 ml of the urine was placed in the test tubes, the different contents of thiaprophenic acid and all the necessary reagents (as mentioned above) were introduced, the volume was adjusted to 10 ml, and the luminescence spectra were recorded. The thiaprophenic acid content was calculated by the additive method.

The detection limit of thiaprophenic acid by the proposed method is 0.0005 mg/ml in substance and 0.005 mg/ml in urine.

Table I. Results of the Determination of the Thiaprophenic Acid Content in Urine Solutions (mg/ml) ($n = 5$; $P = 0.95$)

Added	Found	SD
0.08	0.079	0.011
0.05	0.051	0.013
0.02	0.019	0.020

CONCLUSIONS

A highly sensitive method for the determination of thiaprophenic acid in substances and biological fluids (urine) using the luminescence sensitization of Eu(III) ion has been developed. The influence of the main components of urine (urea, phosphates, oxalates, sulfates, chlorides, and sodium ions) on the luminescence intensity of europium ion in complexes with thiaprophenic acid has been studied. The detection limit of thiaprophenic acid

is 0.0005 and 0.005 mg/ml in substance and urine, respectively.

REFERENCES

1. Vidal Handbook (1995) *Drugs in Russia* Astra Farm Service, Moscow.
2. S. V. Beltyukova, T. B. Kravchenko, N. S. Poluektov, and T. L. Gritsay (1983) *Doklady AN USSR Ser. B* **12**, 29–31.
3. T. B. Kravchenko, S. V. Beltyukova, L. I. Kononenko, and N. S. Poluektov (1982) *Ukrainsky Khim. Zh.* **1**, 68–70.
4. A. Rieutord, L. Vazquer, M. Soursac, P. Prognon, J. Blais, and Ph. Bourget (1994) *Anal. Chim. Acta* **290**, 215–225.