Determination of Dopamine by a Terbium-sensitized Spectrofluorimetric Method

Mohammad Kamruzzaman · Al-Mahmnur Alam · Sang Hak Lee† · Taslima Ferdous · Young Ho Kim*
Department of Chemistry, Kyungpook National University, Daegu 702-701, Korea,
*Research Institute of Advanced Energy Technology, Kyungpook National University, Daegu 702-701, Korea

Abstract

A terbium-sensitized spectrofluorimetric method was developed for the determination of dopamine (DA) using an anionic surfactant, sodium dodecyl benzene sulfonate (SDBS). This method is based on the sensitized fluorescence of terbium (III) when excited in the presence of DA because a Tb (III)–DA complex is formed. A pronounced enhancement of intensity was observed when SDBS was added to the Tb (III)–DA complex. Under the optimum conditions, the present method showed good stability and reproducibility within the range of $2.5 \times 10^{-9} - 1.0 \times 10^{-7}$ mol L$^{-1}$ of DA with a detection limit of $7.5 \times 10^{-10}$ mol L$^{-1}$. Therefore, the proposed method was applied satisfactorily to the determination of dopamine in pharmaceutical preparations and serum sample.

Keywords: Dopamine, Spectrofluorimetric, Terbium, SDBS

1. Introduction

Dopamine (4-(2-aminoethyl) benzene-1, 2-diol) (DA) is a catecholamine neurotransmitter that occurs in a wide variety of animals, including both vertebrates and invertebrates and serves as a chemical messenger in the nervous system and permits individual nerve fibers (neurons) to communicate with each other. Dopamine is produced in several areas of the brain, including the substantia nigra and the ventral tegmental area. Dopamine is also a neurohormone released by the hypothalamus. Its main function as a hormone is to inhibit the release of prolactin from the anterior lobe of the pituitary. Numerous analytical methods have been reported in the literature for the determination of dopamine in pharmaceutical as well as biological samples such as electrochemical[1], HPLC[2], flow-injection analysis[3] and spectrophotometry[4]. The fluorescence methods[5] have attracted many attentions because of its high sensitivity. Ethylene diamine[6], N-hydroxysuccinimidyl-3-indolyacetate[7] and 1, 2– bis (3-chlorophenyl) ethylenediamine[8] have been used as fluorescence derivation reagents for determining DA. In our present work, we reported a sensitive and simple spec–
trofluorimetric method for the determination of dopamine. Experimental results showed that
the characteristic peak of Tb$^{3+}$–DA system at 490 and 545 nm was greatly enhanced by
SDBS and the increasing effect is proportional to the concentration of DA. According to this,
a simple fluorescence method with high sensitivity and selectivity is established for the de-
termination of DA using Tb (III) in the presence of SDBS. The proposed method was suc-
cessfully applied for the determination of dopamine in pharmaceuticals and biological samples.

2. Experimental

2.1. Apparatus

Fluorescence intensity was measured using an F-4500 spectrofluorimeter (Hitachi, Japan)
equipped with a coiled glass flow cell (1.0 mm i.d., 20 mm total diameter). Xe Lamp (450 W)
was used as light source. Emission signal was measured and transduced to an electric signal
by a photomultiplier tube (voltage 950 V, Model R928, Hamamatsu, USA). A pH meter (Model
Orion 520A USA) was used for pH adjustment. The UV–1800 (Shimadzu, Japan) spectrophotometer
was used to record the absorption spectrum.

2.2. Reagents

All reagents used were of analytical reagent grade. A stock solution of dopamine (Sigma,
USA) was prepared in de–ionized water and stored at 4°C. The standard solution for the
experiment was freshly prepared daily before use. Stock solution of SDBS (0.1 mol L$^{-1}$) was
prepared in water. Doubly deionized water was used throughout the experiment.

2.3. Basic procedure

Appropriate amounts of dopamine, Tb$^{3+}$ and SDBS solutions were added to a fluorescence
cell (1 cm quartz cell) and the mixtures were stirred for 1 min before fluorescence measurement.
The fluorescence intensity was measured at $\lambda_{\text{ex}}/\lambda_{\text{em}}$ = 290/545 nm. The standard curve
method was used in the quantitative determination of DA in real samples. All fluorescence
measurements were made using 1 nm increment, 1 s integration time, S acquisition mode and
YES auto zero.

3. Results and Discussion

3.1. Spectral characteristics

The fluorescence emission and excitation spectra of Tb$^{3+}$, Tb$^{3+}$–DA and Tb$^{3+}$–DA–SDBS
are shown in Fig. 1. It was observed that the characteristic peaks of DA–Tb$^{3+}$ at 490 and
545 nm ($\lambda_{\text{ex}} = 290$ nm) increases several folds after the addition of SDBS. The intra–mo-
lecular energy transfer from DA to Tb$^{3+}$ in the presence of SDBS during the measurements
were might be responsible for the increments of fluorescence intensity.
3.2. Effect of Tb (III)

The effect of Tb (III) ion concentration on the fluorescence intensity of 545 nm in the range of $1.5 \times 10^{-5} - 4.0 \times 10^{-3} \text{ mol L}^{-1}$ was studied. The results are shown in Fig. 2. It can be seen that the maximum fluorescence intensity was obtained at $5 \times 10^{-4} \text{ mol L}^{-1}$ of Tb (III). Therefore, to achieve highest intensity, $5 \times 10^{-4} \text{ mol L}^{-1}$ of Tb (III) was selected as optimum for the whole experiment.

3.3. Effect of pH

The effect of pH in the range of 8-10 was studied and the intensity reached maximum at pH of 8.8. At the same time, the buffer solutions have also affected the intensity. Thus, the effect of buffers such as KH$_2$PO$_4$, Tris–HCl, NH$_4$Cl–NH$_3$, acetate buffers were examined and observed that Tris–HCl buffer gives highest intensity. Therefore, 0.01 mol L$^{-1}$ Tris–HCl buffers was used to maintain pH within the working range.

3.4. Effect of SDBS

Three types of surfactants, SDBS, SDS and CTAB were used to examine the effect of surfactants. It was observed that maximum intensities were obtained using SDBS. So the effect of SDBS concentration was studied in the range of 0.001~0.1 mol L$^{-1}$ and shown in Fig. 3. Enhanced fluorescence intensity was obtained at 0.025 mol L$^{-1}$ of SDBS and chosen for whole experiment.
3.5. **Calibration curve and detection limit**

Under the optimum conditions, calibration graphs for the determination of DA were established. The enhanced fluorescence intensity of the system showed a good linear relationship with the concentration of DA in the range of $2.5 \times 10^{-9} - 1.0 \times 10^{-7}$ mol L$^{-1}$; its correlation coefficient was 0.9997. The limit of detection was $7.5 \times 10^{-10}$ mol L$^{-1}$.

4. **Conclusion**

Dopamine can be determined by the proposed spectrofluorimetric method. The proposed method has advantages in sensitivity and accuracy which can be successfully applied for the determination of dopamine in pharmaceuticals and spiked human urine.

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