Chapter 12

Estimation of Fluoride in Ground Water by Spectrophotometric Technique

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Abstract

The current study intends to highlight the technique of fluoride estimation by spectrophotometric method. Flavonoid chrysin, xylenol orange, alizarin red-s are widely used as ligands for complextation with metal ions like Al^{3+} to estimate amount of fluoride in a mixture of elements. But to avoid these extensive toxic chemicals, a comparatively less toxic and economical friendly agent Eriochrome Black T (EBT), the well-known azo dye, is used in the present study for complexometric titration. Herein, we have allowed EBT dye to get complaxation with Al^{3+}. This Al-EBT complex acts here as mettalo-ligand and catches the fluoride resulting in pink color. By using UV-Vis spectrophometric method, then the amount of fluoride has been determined present in ground water. This proposed method has been successfully applied to the determination of fluoride in the drinking water samples of Bhupatinagar, in the district of Purba Medinipur, West Bengal, India. The results show that the concentration of fluoride in the ground water of said region is 0.295 mg/L which is much below in comparison to WHO's maximum contamination limit. This implies that the ground water of the concerned area is free from fluoride contamination.

Keywords: Complexometric titration, fluoride estimation, Spectrophotometric method.

12.1 Introduction

Fluoride, the 13th most common element and mostly found in geogenic sources, is a severe groundwater pollutant. It is extensively found in several minerals like fluorite (CaF_2), cryolite (Na_3AlF_6), monofluorophosphate and fluoroapatite [$Ca_5(PO_4)_3F$] present in Earth's crust. Extensive use of fluoride is pronounced in fields including pharmaceuticals, water

fluoridation, dental care, agrochemical use and even in chemical industries including nuclear reactors. Human intake of fluoride can take place from different sources including food, drug, cosmetics etc. Although the consumption of fluoride mostly happened from ground water as the presence of fluoride is most abundant in water resources than any other geogenic sources. To prevent the health risks, World Health Organization (WHO) has set a maximum contamination limit value of 1.5 mg/L. A low level (0.5–1.5 mg/L) of fluoride is also assumed to be an essential component of human health in preventing dental caries.

In general, ground waters contain more fluoride than surface water resources due to its maximum interaction with fluoride-bearing minerals in rock. Excessive fluoride via drinking water exerts endemic ill effects including dental fluorosis and skeletal fluorosis. Hence to assess the quality of drinking water, the estimation of fluoride is important for human beings. Several techniques have been employed in the determination of fluoride from various sources.

Fluoride analysis techniques covering electrochemical, chromatographic, titrimetric, capillary zone electrophoresis, fluorescence sensing, and spectroscopic methods have been developed throughout [1-5]. Ion chromatography is expensive while ion-selective method is economical and sensitive in relation to UV-Vis spectroscopy. Although ion-selective electrode method is widely used and suitable for industrial and field monitoring, there are several disadvantages associated with it. It requires advanced cautions and buffer systems that require extra care in the steps of chemical preparation. Buffer system during fluoride analysis using the ion-selective electrode involves citrate, cyclohexane diamine tetra acetic acid (CDTA), total ionic strength adjustment buffer (TISAB), diethylenetriamine penta acetate (DTPA), and ethylene diamine tetra acetic acid (EDTA), effect of coexisting ions in water that form complexes with fluoride has been another challenge in potentiometric/ion-selective determination of fluoride

Some chromophor ligands are widely used for spectrophotometric determination of fluoride. Flavonoid chrysin, xylenol orange, alizarin red-s are widely used ligands employed for complextation with metal ions like Al^{3+} to estimate amount of fluoride in a mixture of elements. But to avoid these extensive toxic chemicals, a comparatively less toxic and economical friendly agent Eriochrome Black T (EBT), the well-known azo dye, is being used in complexometric titration [6,7]. Herein, we have also adopted this method and allowed EBT dye to get complaxation with Al^{3+}. This Al-EBT complex acts here as mettalo-ligand and catches the fluoride forming pink color. By using UV-Vis spectrophometric method then the amount of fluoride has been determined present in ground water.

12.2 Materials and Methods

12.2.1 Chemical reagents: All the reagents were purchased in pure form of AR grade from Sigma Aldrich. For the synthesis of Al-EBT complex, Al $(NO_3)_3$ and EBT were used and for fluoride complexation, NaF was used. H_2O was used as solvent.

12.2.2 Instrument: All the absorption measurements were performed using Systronics 2202 UV- Vis spectrophometer under room temperature.

12.2.3 Preparations of Solutions

12.2.3.1 Stock NaF Solution of 1000 mg /L: 0.22 g of NaF was dissolved in 100 ml of distilled water.

12.2.3.2 Al-EBT Complex Formation: $1x10^{-3}$ M solutions for both $Al(NO_3)_3$ and EBT were prepared. Then on 1:1 mixing of both the solutions produces Al-EBT complex of concentration $1x10^{-5}$ M.

12.2.4 Analytical Procedure: From the stock solution of Al-EBT complex, 2 ml was first taken. Then on gradual addition of fluoride solutions (0.2 ml to 1 ml), the change in absorptions were recorded at λ_{max} 450 nm in UV -Vis spectrophotometer. The standard straight-line curve obtained from plotting of absorption vs. concentration of fluoride was used for determination of molar extinction coefficients. To find the concentration of fluoride in the tested water, 2 mL of water was mixed with 2 mL of Al-EBT metallo-ligand and absorption was measured at 450 nm. Then by using the following equation, concentration has been determined.

$$\text{Concentration of fluoride} = \text{Slope} / \text{Absorption of the solution} \qquad (1)$$

12.3 Result and Discussion

The standard plot, absorption vs. concentration of fluoride is straight line with slope 0.004 L $mg^{-1}cm^{-1}$(Figure 12.1). Using this data of slope and absorption (0.00118) of the tested samples, concentration of fluoride is determined with the help of above equation 1. It is found that the concentration of fluoride in the tested water collected from Bhupatinagar block is 0.295 mg/L which is much below in comparison to WHO's maximum contamination limit. This implies that the ground water of the concerned area is free from fluoride contamination.

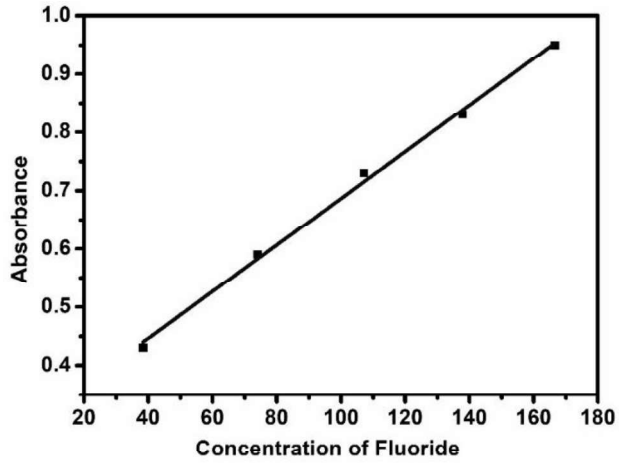

Figure 12.1 Absorption vs. concentration of fluoride plot

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12.5 References

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