Colorimetric Estimation of Ni(II) Ions in Aqueous Solution

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Abstract: A rapid and accurate colorimetric method has been proposed for the estimation of nickel(II) in aqueous solution. It is found that nickel(II) ions have maximum absorbance at 393 nm in distilled water and in aqueous sucrose solution (0.3 mol dm^{-3}). In both case, the Beer's law was obeyed over the range from 0.04 to 0.08 mol dm^{-3} of nickel(II). The value of molar absorptivity was constant $5.13 \pm 0.03 \text{ mol dm}^{-3}$. This method is more rapid than the existing spectrophotometric methods for the estimation of nickel(II). The variation in the results obtained by the method is $\pm 2.1\%$.

Keywords: Colorimetry, Estimation of nickel (II), Molar absorptivity.

Introduction

Nickel is extensively used in electroplating, the manufacturing of steel, electronic devices, ceramics and colored glasses. It plays a vital role in many processes of applied sciences and fundamental sciences. It necessitates development of rapid methods for estimation of nickel.

In colorimetric methods colored solutions can absorb light more or less depending upon wavelength of radiation and concentration of colored species present in solution. If the wavelength at which the maximum absorbance of other ions present in solution is different from the maximum wavelength of nickel(II) ions, we can estimate the nickel(II) ions with the colorimetric method in presence of other ions.

Various attempts have been made for the colorimetric determination of nickel through mixed legend complex formation, surfactant sensitized systems and ion association systems. The reported ion association system are 1-10-phenanthroline – rosebangel¹, eriochromered B², – eosine³ and 4-chloro – 2- nitroso-1-nepthole- crystal violet⁴.

The complexing agents reported for the determination of nickel(II) are 2 hydroxy-3 methoxy benzaldehyde thiosemicarbazone⁵, cadion⁶, rubeanic acid-quinoline⁷ and xanthates⁸. The xylenol orange-CTAB (cetyltrimethylammonium bromide)⁹ and chromeazurol-CTAB¹⁰ surfactant sensitized systems has been used for the estimation of nickel(II).

Although these methods are more sensitive having less interference of foreign ions but these methods requires considerable time for colorimetric estimation with certain tolerance limits.

The results reported in this study clearly indicate that the direct colorimetric method can be recommended for the rapid spectrophotometric determination of nickel(II) ions in aqueous solution in absence of foreign ions or foreign ions having different wavelength absorbance ($\lambda_{\max}$) from nickel(II) ions. This method may be useful for many studies like kinetic, adsorption *etc.*

Experimental

The nickel sulphate used for the work was of Qualigens grade L R. The solution of known concentration of nickel was prepared by dissolving an accurate weight of sample in deionized water distilled twice with a small quantity of alkaline potassium permanganate. The specific conductance of water used for the study was of the order $2 \times 10^{-6} \Omega \text{ cm}^{-1}$. The solution of different concentrations were prepared by diluting a stock solution of appropriate concentration. All absorbance measurements were made on an Elico mini spectrophotometer S L 177 with 10 mm matched quartz cells.

Results and Discussion

The colorimetric method gives more accurate results at low concentrations range where the absorbance and concentration satisfies the Beer-Lambert law. In this study we have taken the concentration range of solution 0.04 to 0.08 mol dm⁻³. The absorbance of each solution was measured at different wave length in the wave length range 340 to 440 nm. The values of absorbance for each solution against distilled water blank are given in Table 1. The same processor was applied for the measurement of absorbance in aqueous sucrose solution using aqueous sucrose solution as blank.

The absorbance data obtained for each concentration showed maximum absorbance at 393 nm. The values of molar absorptivity at each concentration was obtained which are listed in the last row of the Table 1. In the all cases the constant value of molar absorptivity clearly indicate the validity of fundamental laws which governs the spectrophotometric analysis to test the validity of Beer-Lambert law. The absorbance of different solutions were measured at 393 nm, the result obtained were utilized to prepare a calibration curve by plotting the absorbance *versus* the concentration of nickel sulphate. The calibration curve is given in Figure 1.

The calibration curve was used to estimate the concentration of nickel solution as sample model (0.045 mol dm⁻³) which gives the value of optical density equal to 0.225. The concentration of model sample was also estimated from the reported method¹¹. The estimated values of concentration from standard method and proposed method was 0.046 mol dm⁻³ and 0.044 mol dm⁻³ respectively with the percentage error of $\pm 2.2\%$. The absorbance of nickel(II) ions was also observed in aqueous sucrose solution 0.3 mol dm⁻³ in this case the maximum absorbance was same at 393 nm. It confirms that method is accurate in absence of foreign colored ions and non ionic colorless foreign solute.

Table 1. Optical densities of Ni(II) ions at different concentrations with change in wavelength.

S.No.	Wave length, nm	Absorbance at				
		Con 0.04 mol dm ⁻³	Con 0.05 mol dm ⁻³	Con 0.06 mol dm ⁻³	Con 0.07 mol dm ⁻³	Con 0.08 mol dm ⁻³
1	340	0.05	0.053	0.057	0.071	0.086
2	350	0.057	0.063	0.069	0.084	0.092
3	360	0.086	0.09	0.098	0.119	0.123
4	370	0.116	0.132	0.159	0.187	0.205
5	380	0.172	0.203	0.233	0.275	0.309
6	385	0.180	0.229	0.27	0.324	0.358
7	390	0.185	0.245	0.295	0.347	0.395
8	391	0.197	0.242	0.304	0.356	0.392
9	392	0.20	0.24	0.292	0.357	0.404
10	393	0.204	0.258	0.306	0.361	0.410
11	394	0.19	0.244	0.298	0.36	0.404
12	395	0.188	0.215	0.249	0.295	0.322
13	400	0.185	0.213	0.248	0.292	0.322
14	410	0.156	0.179	0.208	0.248	0.272
15	420	0.112	0.129	0.15	0.178	0.195
16	430	0.072	0.081	0.093	0.109	0.12
17	440	0.048	0.053	0.06	0.069	0.075
Molar absorptivity mol ⁻¹ dm ³ cm ⁻¹		5.10	5.16	5.10	5.15	5.13

Figure 1. Concentration of nickel sulphate, mol dm⁻³.

Conclusions

The proposed method for estimation of nickel(II) in aqueous solution is within the limit of experimental accuracy and is more useful due to the rapidity in comparison to the methods in use. This method can be employed for the routine analysis of the nickel in the sample of similar solvent conditions.

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