SPECTROPHOTOMETRIC STUDY OF THE URANYL-NEOMYCIN COMPLEX

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Spectrophotometric studies of the yellow coloured complex of uranyl ion with neomycin have been carried out. The complex absorbs maximum at 420 mu and at a pH value 4.5 The composition of the complex has been determined employing Job's method and mole ratio method and the metal to ligand ratio in the complex molecule is found to be 1:1. The apparent stability constant (log K) and free energy of formation ($\triangle F$) of the complex at 40°C have been found to be 3.32 and —4.76 kcal per mole of the complex respectively.

INTRODUCTION

Aminoglycoside antibiotics have been found to complex with certain metal ions of biological importance by Foye and Lange (1955), Zhan and Eisenbrandt (1964) and the present authors (1975*a, b, c*). Neomycin, a member of this family of antibiotics, has been found to influence the electro-chromatographic migration of certain cations including uranyl ion (Unterman & Mioroneanu 1962). The present paper describes the spectrophotometric investigations of uranyl-neomycin complex. The complex absorbs maximum at $\lambda_{max} = 420$ mu in the acidic medium. The composition of the complex was determined by Job's method (Job 1928) and mole ratio method (Yoe & Jones 1944). Spectrophotometric data were used to compute the apparent stability constant (log K) and free energy of formation ($\triangle F$) at 40°C.

MATERIALS AND METHODS

All the chemicals used were of analytical grade. Neomycin sulphate (B.P. grade) was obtained from Unichem Laboratories, Bombay.

Spectrophotometric measurements were done with a Beckman spectrophotometer model DU-2400. A Beckman pH meter with glass and calomel electrode assembly was used for all pH measurements. All the solutions were prepared in double distilled water.

Absorption spectra of the complex—Absorption of the uranyl nitrate solution ($M/75$) was recorded in the presence and absence of equimolar quantity of neomycin sulphate solution, varying the wavelength from 350 mu to 500 mu. The absorbency of the two solutions at various wavelengths gave a maximum absorption difference at $\lambda_{max} = 420$ mu.

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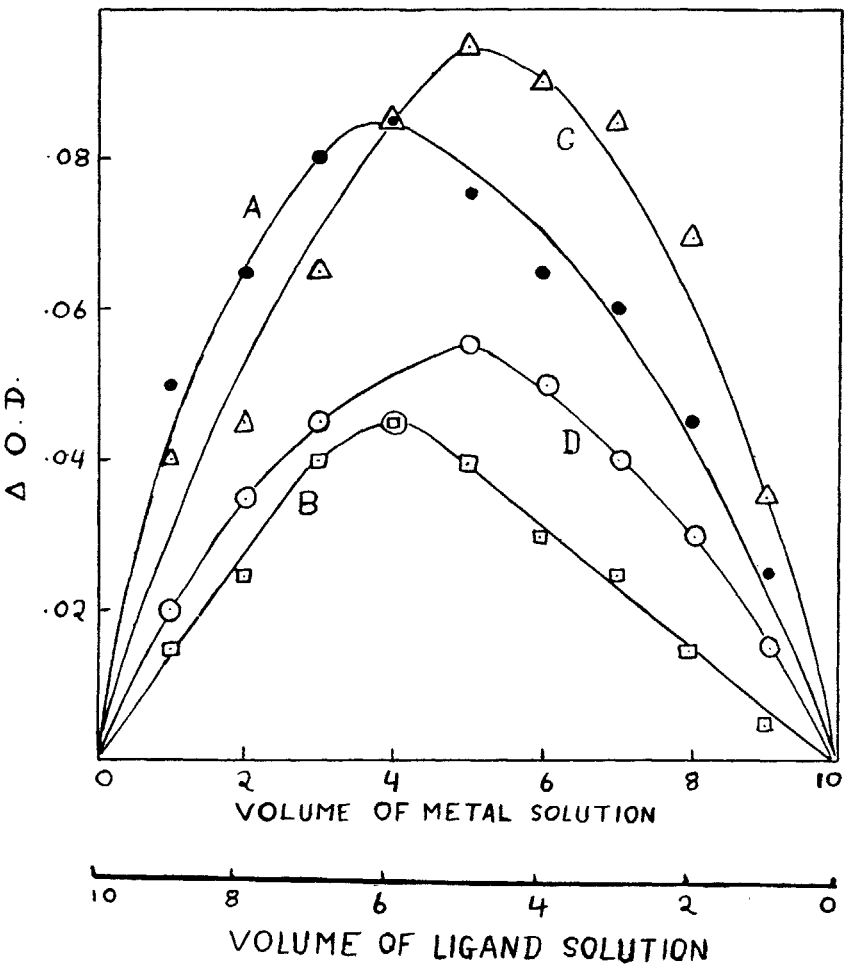

FIG. 1. Job's curves. Curve A (nonequimolar): M=M/25, L=M/50; Curve B (nonequimolar): M=M/40, L=M/80; Curve C (equimolar): M=L=M/25; and Curve D (equimolar): M=L=M/35.

Effect of pH—The absorbency of the complex was tested at different pH and was found to increase up to pH 4.5. Thereafter precipitation occurred.

Composition of the complex—Composition of the complex was determined by employing two different methods: (*i*) Job's method of continuous variation; and (*ii*) mole ratio method. All absorbencies were measured at 420 mu using a metal solution as blank at pH 4.0.

Job's method of continuous variation was performed by mixing different proportions of the equimolar and nonequimolar solutions of metal salt and the ligand. The final volume in each series was maintained constant. Optical density of each mixture was recorded against an appropriate metal blank and plotted against the volume of the variable component (Fig. 1).

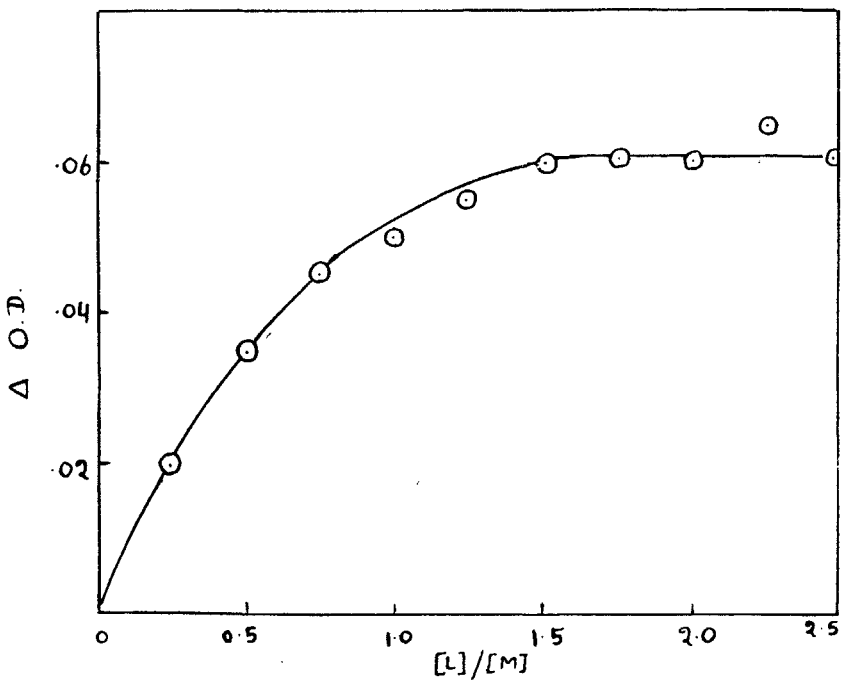

FIG. 2. Mole ratio curve. Final concentration of the metal = M/100.

Mole ratio method was employed by preparing a series of mixtures by adding a constant volume of uranyl nitrate solution with varying amount of equimolar solution of the ligand keeping the final volume constant and adjusting the pH at 4.0. The optical densities were then measured as in the Job's method and plotted against the mole ratio of the ligand in the mixture (Fig. 2).

Stability Constant—Stability constant was calculated from Job's curves (equimolar) by the method of Mukherji and Dey (1958) using the following formula:

$$K = \frac{x}{(a-x)\ (b-x)} \qquad \ldots (1)$$

where x is the molar concentration of the complex formed and a and b are the initial concentrations of the metal and the ligand solutions. The value of x was obtained from the following relation:

$$x = \frac{a_1 b_1 - a_2 b_2}{(a_1+b_1) - (a_2+b_2)} \qquad \ldots (2)$$

where the terms a_1, b_1, a_2 and b_2 have the same meanings as mentioned above.

From the log K value, free energy of formation (ΔF) was calculated by the following formula:

$$\Delta F = 2.303\ RT \log\ (1/K).$$

Results and Discussion

All the Job's curves show only one peak and the mole ratio curve only one break, all corresponding to the formation of a 1 : 1 complex between uranyl ion and neomycin. The values of apparent stability constant (log K) and free energy of formation ($\triangle F$) at 40°C were found to be 3.32 and −4.76 kcal per mole respectively.

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