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Spectrophotometric study of the uranyl–streptomycin complex

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ABSTRACT

Spectrophotometric studies of the yellow coloured complex of uranyl ion with streptomycin have been carried out. The complex absorbs maximum at 420 mμ and at a pH value of 3·5. The composition of the complex has been ascertained employing Job's method, mole ratio method and slope ratio method and 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 3·37 and $-4{\cdot}83$K cal per mole respectively.

1. INTRODUCTION

METAL complexes of streptomycin, a well known antibiotic with certain metal ions of biological importance, have been studied by Foye and Lange (1955) and Zhan and Eisenbrandt (1964). The spectrophotometric investigation of uranyl–streptomycin complex has now been carried out by us. The complex absorbs maximum at $\lambda_{max} = 420$ mμ in the acidic medium. The composition of the complex was determined by Job's method (*see* Job 1928), mole ratio method (Yoe and Jone 1944) and slope ratio method (Harvey and Manning 1950). Spectrophotometric data were used to compute the stability constant ($\log K$) and free energy of formation ($\triangle F$) at 40° C.

2. MATERIALS AND METHODS

All chemicals used were of analytical grade. Streptomycin sulphate (B.P. grade) was obtained from Hindustan Antibiotics, Poona.

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Spectrophotometric measurements were made with a Beckman spectrophotometer model DU–2400. A Beckman pH meter was used for all pH measurements. All the solutions were prepared in double distilled water.

Absorption spectra of the complex.—Absorbance of uranyl nitrate solution (M/30) was recorded in the presence and absence of excess streptomycin sulphate (SMS) solution, varying the wavelength from 350 mμ to 500 mμ. The absorbance of the two solutions at various wavelengths gave a maximum absorption difference at $\lambda = 420$ mμ (figure 1).

Effect of pH.—Solution of various pH, ranging from 1·5 to 4·0 were prepared and their absorbance recorded at 420 mμ, using a metal salt solution, prepared under identical conditions except the addition of ligand as blank. The absorption which was maximum at pH 3·5 then fell.

Composition of the complex.—Composition of the complex was determined by employing three different methods (i) Job's method of continuous variation, (ii) mole ratio method and (iii) slope ratio method. All absorbances were measured at 420 mμ using a metal salt solution as blank at a pH 3·0.

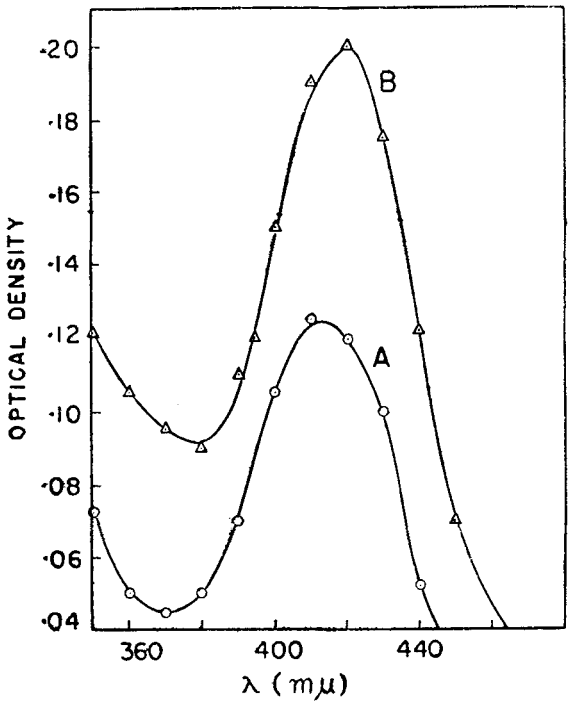

Figure 1. Absorption spectra of SMS—Uranyl complex.

Curve A: $1·66 \times 10^{-2}$ M uranyl nitrate.
Curve B: $1·66 \times 10^{-2}$ M uranyl nitrate + $1·66 \times 10^{-2}$ M SMS.

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 densities of each mixture at 420 mμ was recorded against an appropriate metal blank and plotted against the volume of the variable component (figure 2).

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 3·0. The absorbances were then measured according to Job's method using two different concentrations of the reactants and plotted against the mole ratio of the ligand in the solution (figure 3). The results thus obtained were further confirmed by employing slope ratio method.

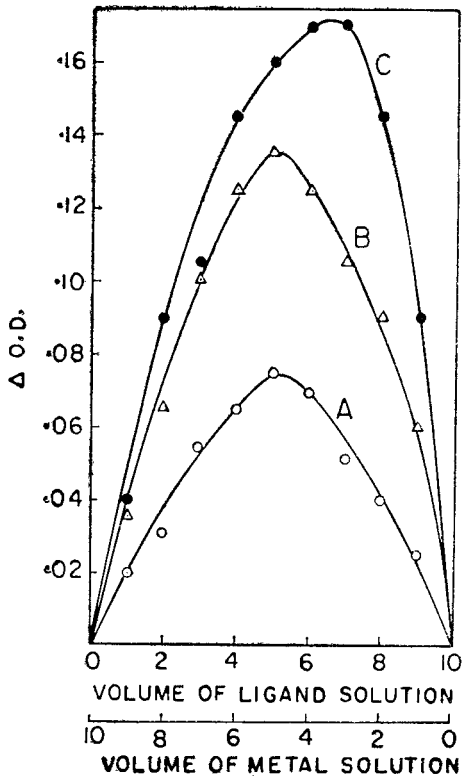

Figure 2. Job's curves.

Curve A (equimolar: M = L = M/30.
Curve B (equimolar): M = L = M/20.
Curve C (nonequimolar): M = M/10, L = M/20.

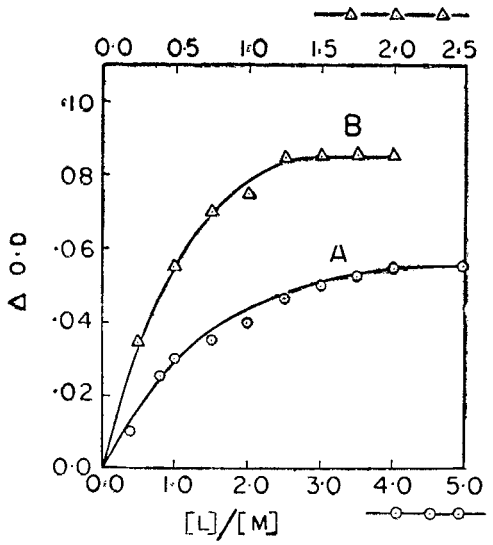

Figure 3. Mole ratio curves.

Curve A: Total concentration of the metal = M/140.
Curve B: Total concentration of the metal = M/60.

Stability constant.—Stability constant was calculated from Job's curves and mole ratio curves by Raghav Rao's method (*see* Subhrana and Raghav Rao 1955) employing the formula,

$$K = (1 - \alpha)/\alpha^2 \, C$$

α, the degree of dissociation was calculated by the formula

$$\alpha = E_m - E_s/E_m$$

where E_m and E_s have the usual meanings. From the log K value, free energy of formation ($\triangle F$) at 40° C was calculated by the formula

$$\triangle F = \mathrm{RT} \log (1/K).$$

3. Results and Discussion

All the Job's curves show only one peak and the mole ratio curves show one break, all corresponding to the formation of a 1:1 complex between uranyl ion and streptomycin. The values of apparent stability constant (log K) and free energy of formation (F) at 40° C were found to be 3·37 and − 4·38K cal per mole respectively.

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