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Short communication

Photometric studies of the complexation of Sudan Red B with Mn^{+2} and Fe^{+3} ions

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Abstract

A representative azo dye by the name of Sudan Red B, was used as a complexing reagent for Ni and Co ions. Photometric method was used to monitor the metal to ligand formation. The absorption spectra were monitored and the conditions were optimized in terms of dye and metal concentration, pH, and cationic and anionic effects. The log β (stability constant) of the metal–dye complex was calculated using Job's method and this was of the order of 7.52 and 8.28 for Mn and Fe complex, respectively.

Keywords: Complexation studies; Azo dyes; Sudan Red B

1. Introduction

Metal ions can react with different types of organic reagents to form colored complexes. Such complexes, which are stable to quite an extent, can be formed easily and also be monitored in terms of their metal to ligand ratio by using various instrumental techniques [1–5]. Their stability constants can be of importance in order to predict various chemical processes such as isolation, extraction, or preconcentration methods [6,7]. In many different types of matrices, elements which are present in trace amounts can be isolated by suitable complexing reagents which also include some dyes such as Eirochrome Black T, Pyrocatechol Violet, Malchite Green, etc. Azo dyes form a representative class of organic compounds which can act as chelating reagents for metal ions [8]. The present paper deals with the photometric study of complexation of one such representative azo dye named Sudan Red B {Benzene(30-methyl)azo-*p*-phenyl(3-methyl)azo-2 napthol} with Mn^{+2} and Fe^{+3}. The conditions favorable to complex formation were optimized and the stability constants of the complexes were obtained. The effect of foreign ions was also investigated.

2. Experimental

Analytical grade chemicals were procured from E. Merck and were used in the present work.

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Freshly opened bottles were used in every case and no attempt was made to purify them further. Molecular sieves number 5A were added to acetone to keep it in the dried form. Triply distilled water was used for making aqueous preparations. Metal and dye stock solutions (both 1×10^{-3} M) were prepared in triply distilled water and acetone, respectively, by dissolving appropriate amounts of these chemicals. Buffer solutions of various pH were prepared as per reported methods [9]. The pH was monitored by using a Horriba pH meter. Spectral studies in the absorption mode were obtained using a 1.0 cm matched quartz cell against a standard blank cell on a Shimadzu spectrophotometer model number 1601.

3. Results and discussion

The recorded spectra of the complex formed by Sudan Red B dye with Mn^{+2} and Fe^{+3} showed their absorption maxima at 523 and 518 nm, respectively. A solution of acetone and water was used as a blank standard to obtain the spectra against the mixture of the dye and the metal ion solution. The aqueous solution was adjusted to various pH values with buffer solutions, and the best conditions at which the complexation took place were identified. The dye–Mn complex was formed at 3.0 pH, whereas, the dye–Fe complex was formed at pH 5.0. Job's method was used to calculate the stoichiometry of the complexes in both the cases [10]. The stability constants of the complexes were also calculated. The results are shown in Table 1. Further observations were made concerning the stability of the absorption intensity of the complex with respect to time. It was found that dye–Mn complex was stable up to 1 h after which the absorption started decreasing. The dye–Fe complex was stable up to 1.5 h.

The magnitude of stability constant indicates the particular level of tolerance to the interference by other species. By applying the equilibrium conditions, one can easily obtain the value of stability constants.

The concentration of the species in the above equation was determined photometrically and the values of log β (stability constant) were computed.

Table 1
Various properties of the complexes formed between Sudan Red B and the metal ions

Metal ions	Stoichiometry (M/L)	Molar absorptivity[a]	Stability constant[b]
Mn^{+2}	1:2	1.2×10^5	7.52
Fe^{+3}	1:2	1.4×10^5	8.28

[a] L/mol cm.
[b] Log value.

Table 1 shows such values as calculated in this work. Based on the stability constant values, one can see that the complex formed between the dye and Fe^{+3} ion is slightly more stable as compared to the one formed between the dye and Mn^{+2} ion. This may be due to several reasons such as the electronegativity of the ligand and the ionic radii of the metal ion and its atomic number [11]. Structures for similar types of diazo dye with metal ions have been proposed in the literature [12].

The effect of foreign ions (both cations and anions) on the complexation of the dye with the metal ions was also investigated. These ions were added as nitrates (for cations) and as potassium salts for anions. The effect was studied at optimal conditions of concentrations of both metal and dye. Limiting concentrations of these ions were obtained, at which these ions start interfering with the complexes formed. Tables 2 and 3 outline such

Table 2
Effect of foreign ions on the complex of Sudan Red B with Mn^{+2} ion

Added cation/anion	Limiting concentration (mmol)	% Decrease in absorption
Barium(II)	1.5	74
Calcium(II)	3.3	70
Magnesium(II)	5.2	74
Potassium(I)	2.0	60
Aluminium(III)	1.8	68
Strontium(II)	2.2	60
Lead(II)	4.2	70
Sulphate(II)	0.1	58
Iodide(I)	8.8	70
Chloride(I)	1.5	58
Iodate(I)	6.6	68
Bromide(I)	9.5	68
Cyanide(I)	0.1	54
Nitrate(I)	1.3	76

Cations were added as nitrates and anions as potassium salts.

Table 3
Effect of foreign ions on the complex of Sudan Red B with Fe^{+3} ion

Added cation/anion	Limiting concentration (mmol)	% Decrease in absorption
Barium(II)	3.5	95
Calcium(II)	3.5	93
Magnesium(II)	5.2	90
Potassium(I)	2.4	93
Aluminium(III)	5.2	90
Strontium(II)	1.1	88
Lead(II)	6.6	94
Sulphate(II)	2.6	87
Iodide(I)	5.7	88
Chloride(I)	0.1	88
Iodate(I)	0.2	93
Cyanide(I)	8.0	86
Nitrate(I)	0.1	85

Cations were added as nitrates and anions as potassium salts.

values along with the percentage change in absorption spectra. From these tables one can see that the maximum interference occurs in the case of Ba^{+2}, Ca^{+2}, Mg^{+2}, and nitrate ions when added to dye–Mn complex.

In this case a very small amount of these ions causes a substantial change in the absorption spectra. A pronounced effect is also observed in the case of lead and iodide ions. In the case of the dye–Fe complex, pronounced effects were observed with small added concentrations of Ba^{+2}, Pb^{+2}, Ca^{+2} and iodate ions. The reduction in absorption intensity is a direct indicator of the interference of the added ions in a particular process. Thus these ions must be removed from solution prior to complexation of Sudan Red B with Mn^{+2} and Fe^{+3} ions.

4. Conclusion

Sudan Red B was used as a complexing reagent towards Mn^{+2} and Fe^{+3} ions. The investigations were carried out photometrically. Absorption spectra of the complexes were monitored and the conditions were optimized in terms of dye and metal concentration, pH, and cationic and anionic effects. The log β (stability constant) values computed by using Job's method revealed that the Fe complex is slightly more stable than the Mn complex.

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