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SCIENCE DIRECT

Dyes and Pigments 67 (2005) 77–79

DYES and PIGMENTS

www.elsevier.com/locate/dyepig

Short communication

Photometric studies of the complex formation of Cu^{2+} and Cr^{3+} ions with Sudan Red B

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Received 13 June 2004; received in revised form 22 August 2004; accepted 20 October 2004

Abstract

Photometric method was used to study the complex formation of Sudan Red B with Cu^{2+} and Cr^{3+} ions. 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 constants) of the metal–dye complex were calculated using Job's method and these were of the order of 11 and 11.6 for Cr^{3+} and Cu^{2+} complex, respectively.

Keywords: Photometric; Complexation; Sudan Red B

1. Introduction

Many organic reagents can react with metal ions in a variety of ways and are generally transformed into a colored complex. Such complexes can be easily formed and can also be monitored in terms of their metal to ligand ratio by using various methods [1–5]. The stability constants of these complexes can be of significance in order to predict different chemical processes such as isolation, extraction or preconcentration methods [6,7]. Additionally, many elements present in trace amounts can also be isolated from aqueous or nonaqueous media by using these organic reagents. Many well known examples of the complexation of Eirochrome Black T, *o*-Phenanthroline and Malachite Green etc. with various metals are available in the literature. In addition to these commonly occurring organic reagents, some organic dyes can also act as ligands towards complex formation. Azo dyes form a representative class of organic compounds which can act as chelating reagents for metal ions [8]. The present study concerns with the complexation of Sudan Red B {benzene(3′-methyl) azo-*p*-phenyl(3-methyl)azo-2 napthol} with Cu^{2+} and Cr^{3+}. The conditions favorable to the complex were optimized and the stability constants of the complexes were obtained. The effect of foreign ions was also studied.

2. Experimental

All the chemicals used in the present work acquired from E. Merck were of analytical grade and were used as such from freshly opened bottles. No attempt was made to purify them further. Molecular sieves number 5A was added to acetone to keep it in the dried form. Triple distilled water was used for making aqueous preparations. Stock solutions of the metal and the dye (both 1×10^{-3} M) were prepared in triple distilled water and acetone, respectively, by dissolving appropriate amounts of these chemicals. Buffer solutions of various pH were

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doi:10.1016/j.dyepig.2004.10.009

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

Metal ions	Stoichiometry (M/L)	Molar absorptivity (L/mol cm)	Stability constant[a]
Cu^{+2}	1:2	1.4×10^5	11.6
Cr^{+3}	1:2	1.4×10^5	11.0

[a] Log value.

prepared as per reported methods [9]. The pH was monitored on a Horriba pH meter. Absorption spectra 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 absorption spectra of Sudan Red B dye with Cu^{+2} and Cr^{3+} showed their maxima at 530 and 525 nm, respectively. Their spectra were obtained against a standard blank solution of acetone and water, the solvents in which the dye and the metal ions were, respectively, soluble. 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–Cu complex was formed at pH 2.0, whereas, the dye–Cr complex was formed at pH 5.5. The stoichiometry of the complexes in both the cases was obtained by Job's method [10]. The stability constants of the complexes were also calculated. The results are shown in Table 1.

Further observations concerning the stability of the absorption intensity of the complex with respect to time were made. It was found that dye–Cu complex was stable up to 24 h after which the absorption started decreasing. The dye–Cr complex was stable up to 23 h.

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

Added cation/anion	Limiting concentration (mmol)	% Decrease in absorption
Barium(II)	1.1	34
Calcium(II)	8.7	42
Magnesium(II)	7.5	60
Potassium(I)	0.1	76
Aluminium(III)	1.4	60
Strontium(II)	2.2	68
Lead(II)	6.6	58
Sulphate(II)	3.0	70
Iodide(I)	5.2	34
Chloride(I)	0.1	70
Iodate(I)	6.8	86
Bromide(I)	7.5	74
Cyanide(I)	0.1	45
Nitrate(I)	2.5	50

Cations were added as nitrates and anions as potassium salts.

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

Added cation/anion	Limiting concentration (mmol)	% Decrease in absorption
Barium(II)	1.1	50
Calcium(II)	3.3	52
Magnesium(II)	8.0	84
Potassium(I)	0.1	77
Aluminium(III)	2.5	75
Strontium(II)	4.2	82
Lead(II)	8.8	77
Sulphate(II)	0.1	67
Iodide(I)	8.2	64
Chloride(I)	7.7	77
Cyanide(I)	0.1	50
Nitrate(I)	2.3	77

Cations were added as nitrates and anions as potassium salts.

The magnitude of the stability constant indicates the particular level of tolerance towards the interference by other species. By applying 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 $\log \beta$ (stability constant) were computed. Table 1 shows such values as calculated in this work. One can see that the complex formed between the dye and Cu^{2+} ion is slightly more stable as compared to the one formed between the dye and Cr^{3+} 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].

We have also evaluated the effect of foreign ions (both cations and anions) on the complexation of the dye with the metal ions. 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 the metal and the dye. Limiting concentrations of these ions were obtained, at which these ions start interfering with the complexes formed. Such values along with the percentage change in absorption spectra are shown in Tables 2 and 3. From these tables one can see that the maximum interference occurs in the case of K^+, Sr^{+2}, Br^- and iodate ions when added to dye–Cu 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 potassium and aluminium ions. In the case of the dye–Cr complex, pronounced effects were observed with small added concentrations of K^+, Mg^{+2}, Sr^{+2}, chloride, sulphate and nitrate 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 the solution prior to complexation of Sudan Red B with Cu^{+2} and Cr^{+3} ions.

4. Conclusion

Sudan Red B was used as a complexing reagent for Cu^{2+} and Cr^{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 $\log \beta$ (stability constants) values computed by using Job's method revealed that the Cu complex is slightly more stable than the Cr complex.

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