Optimization of the Complexation and Extraction of Chromium(VI) with Cationic Yellow 42 Dye Reagent*

[a]V. ANDRUCH**, [b]I. S. BALOGH, [a]M. TELEPČÁKOVÁ, and [a]N. URBANOVÁ

[a]*Department of Chemistry, Faculty of Natural Sciences, P. J. Šafárik University, SK-041 54 Košice*
e-mail: andruch@kosice.upjs.sk

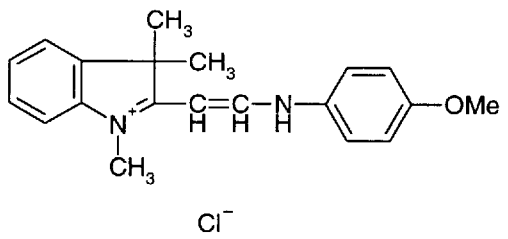
[b]*Department of Chemistry, University of Nyíregyháza, HU-4400 Nyíregyháza, Hungary*

Received 16 October 2002

The complex formation and extraction of chromium(VI) with Cationic Yellow 42 dye reagent has been investigated by the spectrophotometric method. The influence of the medium acidity, concentration of the ligand, and of the dye reagent on the absorbance of the coloured extract has been studied. The optimum conditions have been found: 0.3—0.9 mol dm^{-3} H_2SO_4, 0.6 mol dm^{-3} NaBr, (2.2—2.6) × 10^{-4} mol dm^{-3} CY 42.

Chromium is an interesting element owing to its biological activity, which depends on the oxidation state. The chromium natural abundance in the Earth's crust is 8.3 × 10^{-3} %. The several reactions of the chromium metal are well known. Chromium can form complexes with some organic reagents such as diphenylcarbazide or 3,3-diaminobenzidine [1—3]. It is commonly known that complexation ability of chromium depends on the oxidation state of this element. This fact is usually used for the spectrophotometric determination of the species of this element, for example with some cyanine dyes [4]. Speciation of an element is the determination of the individual physicochemical forms of that element, which by summation make up its total concentration in a sample [5].

The preliminary experiments suggest that chromium(VI) forms complexes with Cationic Yellow 42 (CY 42) basic dye reagent. The aim of this work was to investigate the complex formation and extraction of chromium(VI) with the above-mentioned basic dye reagent and to find the optimum conditions.



EXPERIMENTAL

All chemicals and solvents used were of anal. grade. Distilled water was used throughout the experiment. A 0.1 mol dm^{-3} stock solution of chromium dichromate was prepared by dissolution of 2.9418 g of $K_2Cr_2O_7$ in 100 cm^3 of water. The 1 × 10^{-3} mol dm^{-3} working solution of $K_2Cr_2O_7$ was prepared by corresponding dilution of the stock solution. A 1 × 10^{-3} mol dm^{-3} aqueous solution of dye was prepared by dissolution of its chloride salt. A 3 mol dm^{-3} NaBr solution was used for the set of required concentrations of ligand. The necessary acidity of the medium was adjusted by sulfuric acid. Toluene was used as extractant.

The extraction was realized in the test tube at room temperature. The volumes of phases were 5 cm^3. Into the test tube 0.5 cm^3 of 1×10^{-3} mol dm^{-3} solution of chromium(VI), necessary amount of ligand and basic dye were added. This volume was diluted by water to 5 cm^3 and extracted by 5 cm^3 of toluene for 30 s. After the extraction, the organic phase was separated and the absorbance was measured at 430 nm against the extract of blank test, which was prepared similarly but without chromium. A Zeiss Spekol-11 spectrophotometer with 2 mm glass cells was used for the absorbance measurements. All visible spectral measurements were realized at 430 nm wavelength where the maximum absorbance value was reached.

*Presented at the XVIth Slovak Spectroscopic Conference, Košice, 23—27 June 2002.
**The author to whom the correspondence should be addressed.

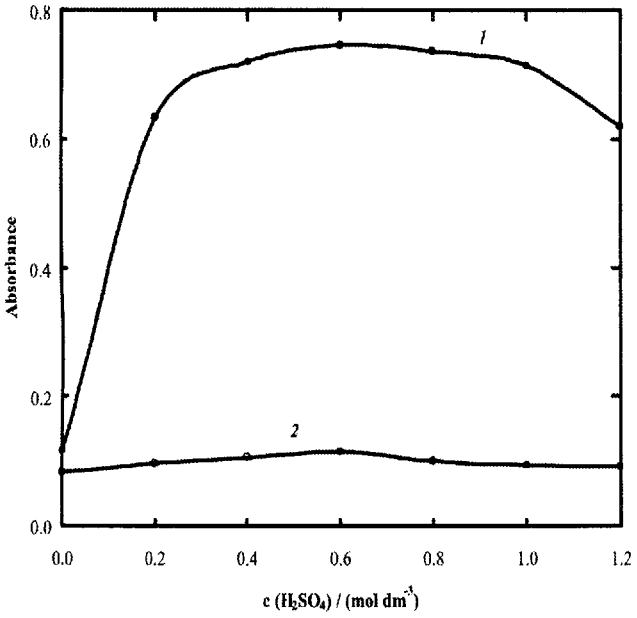


Fig. 1. Influence of the medium acidity on the absorbance of chromium(VI) complex. 1×10^{-4} mol dm^{-3} $Cr_2O_7^{2-}$, 0.6 mol dm^{-3} NaBr, 2.2×10^{-4} mol dm^{-3} CY 42. *1*. Complex, *2*. blank test.

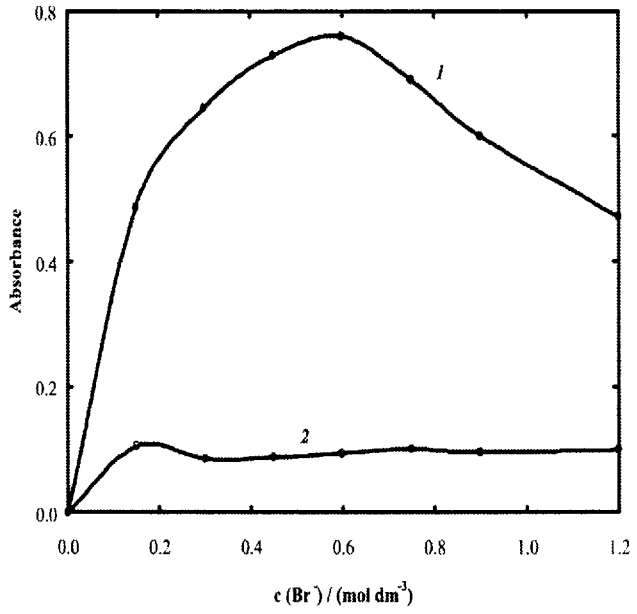


Fig. 2. Effect of the bromide concentration on the extraction of chromium(VI) complex with CY 42 by toluene. 1×10^{-4} mol dm^{-3} $Cr_2O_7^{2-}$, 0.4 mol dm^{-3} H_2SO_4, 2.2×10^{-4} mol dm^{-3} CY 42. *1*. Complex, *2*. blank test.

DISCUSSION

The complexation and extraction of chromium complexes with basic dyes are influenced by medium acidity, concentrations of the ligand and dye reagent. The influence of these factors on the absorbance of coloured extract has been investigated.

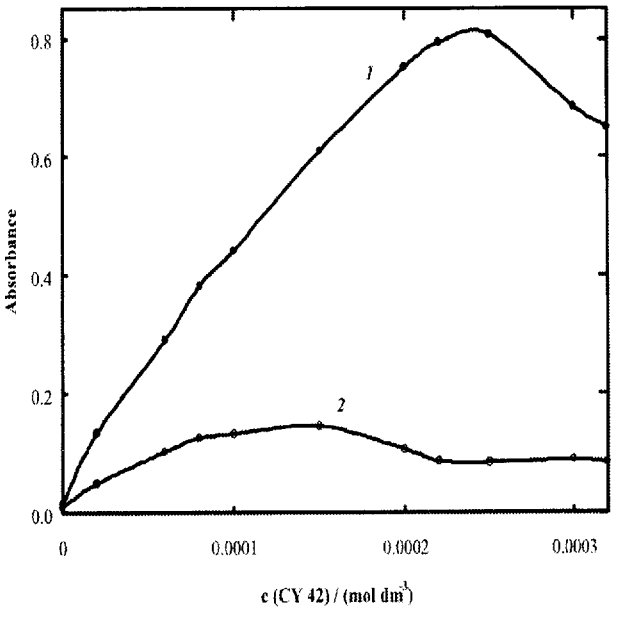


Fig. 3. Influence of the CY 42 dye reagent concentration on the absorbance of investigated complexes. 1×10^{-4} mol dm^{-3} $Cr_2O_7^{2-}$, 0.4 mol dm^{-3} H_2SO_4, 0.6 mol dm^{-3} NaBr. *1*. Complex, *2*. blank test.

The chromium(VI) complexes are extractable in the presence of various acids such as H_2SO_4, HCl, H_3PO_4. However, the absorbance of the extract is the highest if the necessary medium acidity is set by H_2SO_4. Hence, sulfuric acid was selected for the further investigations. As seen from Fig. 1, the appropriate acidity range for the extraction of chromium(VI) complex with CY 42 basic dye reagent is 0.3—0.9 mol dm^{-3} H_2SO_4.

The effect of the bromide ion concentration on the absorbance of coloured complexes was studied (Fig. 2). The optimum concentration was found to be 0.6 mol dm^{-3}.

The influence of the CY 42 dye concentration on the extraction of the chromium(VI) complexes is presented in Fig. 3. The highest absorbance of the extracts was at $(2.2—2.6) \times 10^{-4}$ mol dm^{-3} CY 42 dye.

It is intended that $[CrO_3Br]^-$ $(CY\ 42)^+$ complex is formed. The extraction equilibrium was established in 30 s and the absorbance of the extracts was stable for 6 h. The calibration plot obeys the Beer's law in the concentration range 2.1—14.5 μg cm^{-3} of Cr(VI). The obtained results allow developing a new procedure for the chromium determination.

Acknowledgements. The authors wish to express thanks to the Scientific Grant Agency of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences (Grant No. 1/7460/20) for partial financial support of this study. The preparation of the revised version of manuscript was supported by Grant No. 1/0448/03. V. A. would like to thank Domus Hungarica Scientiarum et Artium for the award of a two-month fellowship.

REFERENCES

1. Shinde, V. M. and Khopkar, S., *Fresenius Z. Anal. Chem. 249*, 239 (1970).
2. Pobozy, E., Wojasinska, E., and Trojanowicz, M., *J. Chromatogr., A 736*, 141 (1996).
3. Jamshid, L. M., Mohammad, H. S., and Farzaneh, S., *Anal. Lett. 29*, 2007 (1996).
4. Balogh, I. S., Maga, I. M., Hargitai-Tóth, Á., and Andruch, V., *Talanta* 53, 543 (2000).
5. Florence, T. M., *Talanta 29*, 345 (1982).