

ID 3031

Solvent Extraction Studies of Copper (II) by Capric Acid from Sodium Sulfate Solution

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ABSTRACT

This work focuses on the study of the extraction of copper(II) in sulfate medium by capric acid in large range of concentration from 0.005 to 2M dissolved in chloroform at 25°C. The stoichiometry of the extracted organometallic complexes was determined by the graphical method of slopes. Copper(II) complex exists as a monomeric (mononuclear) species $\text{CuL}_2 \cdot 2\text{HL}$ in the lower concentration range of capric acid and as a dimeric (binuclear) species $(\text{CuL}_2 \cdot \text{HL})_2$ in the higher concentration range, while both monomer and dimer were extracted, which are in equilibrium in the organic phase, at a total capric acid concentration of 0.1–0.2 M. The extraction constants for each species were determined. UV-visible and infrared spectroscopy have also been performed for the study of the ligand and their complexes. Electronic and infrared spectrum of these metallic species suggests the octahedral geometry.

Keywords: capric acid, complex, concentration effect, copper(II), dimerization, spectroscopy, stoichiometry.

1. Introduction

Solvent extraction is used in numerous chemical industries to produce pure chemical compounds ranging from pharmaceuticals and biomedical to heavy organics and metals, in analytical chemistry and in environmental waste purification [1]. In the present paper the extraction of copper(II) from sulphate medium with large range of capric acid concentrations using chloroform was performed. The aim of this work is to determine the structure of the extracted species and their extraction constants. UV-Visible and FT-IR spectroscopy have been also used to determine the structure and types of bonding of the extracted copper(II) complexes, respectively.

2. Experimental

2.1 Reagents

Capric acid ($\geq 98\%$, SAFC) was used without further purification. Chloroform, donated by Biochem, Montreal (Quebec), Canada was washed successively with dilute sodium sulfate solution. Copper(II) sulfate, sodium sulfate, and sodium hydroxide were supplied by Biochem. The initial composition of the phases was as follows:

Aqueous phase: $[\text{Cu}^{2+}]_i = 1.57 \cdot 10^{-3} \text{ mol dm}^{-3}$; $[\text{Na}_2\text{SO}_4] = 0.33 \text{ mol dm}^{-3}$;

Organic phase: $[\text{HL}]_{i,\text{org}} = 0.005\text{--}2 \text{ mol dm}^{-3}$ in chloroform.

2.2 Extraction and analytical procedures

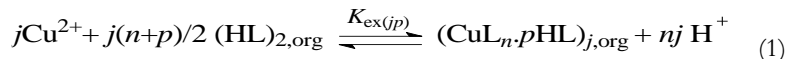
Equal volumes (30 ml) of organic and aqueous phases of known concentrations were magnetically shaken in thermostatic bath kept at $25 \pm 1^\circ\text{C}$ and allowed to attain equilibrium. The equilibrated pH was measured by glass electrode (pH meter OHAUS, model STARTER 3100-B, Ohaus Corporation, Parsippany, USA). After phase separation, copper(II) concentration in the aqueous phase was determined photometrically at 810 nm using a SECOMAM type prim number 3618. A Photo Lab® 6100 VIS (Spectro Flex 6100, Wissenschaftlich-Technische Werkstätten (WTW) GmbH, Weilheim, Germany) (320–1100 nm) was used for recording the visible spectra of the organic phases. FTIR spectra of capric acid and copper (II) caprate



complex were recorded with FTIR spectrophotometer (SHIMADZU model 8400 S) using KBr disk technique.

3. Results and Discussion

The extraction equilibrium of divalent metals such as copper (II) by carboxylic acids is represented in general form as [2, 3]:



Equation (1) gives the following relationship:

$$\log C_{\text{Cu,org}} - j(\log C_{\text{Cu,aq}} + n \text{pH} - \log \beta_{\text{Cu}}) = j(n+p)/2 \log [(\text{HL})_2]_{\text{org}} + \log K_{\text{ex}(jp)} + \log j \quad (2)$$

From equation (2), values of the stoichiometric coefficient (n, p and j) for the extracted copper(II) complex and their extraction constants were obtained by graphical method.

Table 1:

Metal	C_{HL} (M)	Stoichiometric Coefficients (n, j, p)	Extraction equilibria	$\log K_{\text{ex}(jp)}$
Cu(II)	0.005-0.08	2, 1, 2	$\text{Cu}^{2+} + 2 (\text{HL})_{2,\text{org}} \xrightleftharpoons{K_{\text{ex}(12)}} (\text{CuL}_2 \cdot 2\text{HL})_{\text{org}} + 2\text{H}^+$	- 7.33
	0.4-2	2, 2, 1	$2 \text{Cu}^{2+} + 3 (\text{HL})_{2,\text{org}} \xrightleftharpoons{K_{\text{ex}(21)}} (\text{CuL}_2 \cdot \text{HL})_{2,\text{org}} + 4\text{H}^+$	- 13.96

4. Conclusions

In the solvent extraction of copper (II) from aqueous sodium sulphate solution with capric acid in chloroform was carried out under the present experimental conditions, it was found that:

- The extraction of copper (II) increases with increase in pH and capric acid concentration of 0.005–2 mol dm⁻³.
- By using the slope analysis method, the structure of the extracted copper(II) complexes was determined. Copper(II) is extracted into the organic phase as a monomeric complex, CuL₂·2HL, in the region of lower capric acid concentrations, and as a dimeric complex, (CuL₂·HL)₂, in the region of higher capric acid concentrations.
- The visible spectra of the extracted copper (II) complexes indicated the octahedral geometry in low and high ligand concentrations.
- FTIR spectroscopy confirms the dimeric nature of capric acid, the extractant dissolved in chloroform phase.

References

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