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Extraction of Copper(II) from Sulphate Aqueous Medium with N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine Polydentate Schiff Base in Aqueous Two-phase Micellar of Non-Ionic Surfactant

The present paper outlines the use of the novel polydentate Schiff's base extractant, N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine (H₂L), for copper(II) extraction in aqueous two-phase micellar of non-ionic surfactant from sulphate media. The extraction process is based on the formation of the hydrophobic complex of copper(II)-H₂L, which is subsequently extracted into the non-ionic surfactant-rich phase of p-octylpolyethyleneglycolphenylether (Triton X-100) at a temperature above the cloud point temperature (CPT). The phase diagrams of the binary system, water-surfactant (Triton X-100), and of the ternary systems, water-surfactant-salt (Na₂SO₄), were examined. The effects of the main experimental parameters such as pH, extractant concentration and non-ionic surfactant concentration on the extraction process of copper(II) were studied. The extraction yield was found to be significantly depending on the aqueous solution pH. Copper(II) was extracted with H₂L and Triton X-100 in the pH range of (3 – 12). From the equilibrium slope analysis method, it was suggested that the stoichiometry of the extracted complexes have a composition of 1 : 1 (Cu : H₂L). The optimum conditions of the extraction of copper(II) have been established as the following: (1) 2×10^{-3} M extractant; (2) 5 % (m/v) surfactant; (3) pH of 7.2; (4) 7 % (m/v) Na₂SO₄ and (5) temperature of 65 °C.

Key words: Aqueous two-phase micellar extraction; copper(II); polydentate Schiff base extractant; N,N′-bis (2-hydroxy-1-naphthalideneaminoethyl) amine; non-ionic surfactant

Extraktion von Kupfer(II)-Sulfat aus wässrigem Medium mit N,N′-bis(2-hydroxy-1-naphthalidenaminoethyl)amin als mehrzähnige Schiff'sche Base in wässrigen Zweiphasen-Mizellen nichtionischer Tenside. Die vorliegende Arbeit behandelt den Einsatz der neuartigen mehrzähnigen Schiff'schen Base, N,N′-bis(2-hydroxy-1-naphthalidenaminoethyl)amin (H₂L), als Extraktionsmittel für die Kupfer(II)-Extraktion in wässrigen Zweiphasen-Mizellen nichtionischer Tenside aus einem Sulfatmedium. Der Extraktionsprozess basiert auf der Entstehung eines Kupfer(II)-H₂L-Komplexes, der anschließend in einer tensidreichen Phase aus nichtionischem p-Octylpolyethylenglycolphenylether (Triton X-100) bei einer Temperatur oberhalb des Trübungspunktes (CPT) extrahiert wird. Es wurden das Phasendiagramm des binären Systems, Wasser-Tensid (Triton X-100) und das des ternären Systems, Wasser-Tensid-Salz (Na₂SO₄) untersucht. Der Einfluss der experimentellen Hauptparameter, wie pH, Extraktionsmittelkonzentration und nichtionische Tensidkonzentration auf den Extraktionsprozess von Kupfer(II) wurden untersucht. Die Extraktionsausbeute war signifikant abhängig vom pH der wässrigen Lösung. Kupfer(II) wurde mit H₂L und Triton X-100 in einem pH-Bereich von 3 – 12 extrahiert. Die Steigung der Geraden aus der Auftragung der Verteilungsgleichgewichtskonzentrationen ergab für die Stöchiometrie der extrahierten Komplexe eine Zusammensetzung von 1 : 1 (Cu : H₂L). Die optimalen Konditionen für die Extraktion von Kupfer(II) wurden wie folgt festgestellt: (1) 2×10^{-3} M Extraktionsmittel – (2) 5 % (m/v) Tensid – (3) pH von 7.2 – (4) 7 % (m/v) Na₂SO₄ und (5) Temperatur von 65 °C.

Stichwörter: Wässrige mizellare Zweiphasen-Extraktion, Kupfer(II), mehrzähnige Schiff'sche-Base als Extraktionsmittel, N,N′-bis(2-hydroxy-1-naphthalidenaminoethyl)amin, nichtionisches Tensid

1 Introduction

Extraction in aqueous two-phase micellar of non-ionic surfactants is one of the most important applications of surfactants in separation chemistry [1]. At first, this technique was mainly used for the purification of biological species and separating hydrophobic from hydrophilic proteins [2].

Aqueous micellar solutions of polyoxyethylenated non-ionic surfactants become turbid on being heated above a certain temperature defined as the cloud point (T_{cp}). At a higher temperature than the cloud point (T_{cp}) the solutions separate into two distinct aqueous phases [3]: a surfactant-rich phase (coacervate), and a dilute phase, in which the concentration of the surfactant is close to its critical micelle concentration (cmc). Hence, any hydrophobic species or organometallic complexes which are solubilized in the micellar solutions of the non-ionic surfactants will be favourably extracted to the surfactant-rich phase after increasing the temperature above T_{cp}.

The use of aqueous two-phase micellar extraction of metals was firstly reported by Miuar et al., who studied the extraction of Ni(II) with 1-(2-thiazolylazo)-2-naphtol extractant (TAN) in TX-100 micellar solutions [4]. Later on, several extractants such as dithizone (HDz) [5 – 6], 1-(2-pyridylazo)-2-naphthol (PAN) [7 – 8], diethyldithiocarbamate (DDTC) [9], 8-hydroxyquinoline (HQ) [10], di-(2-ethylhexyl)phosphoric acid (D2EHPA) [11] and calixarenes [12] have been used to extract different metal ions in many processes [13 – 14].

The Schiff bases constitute another family of powerful extractants. Indeed, they are well known as extractants that are easy to be synthesized and have structural rigidity. Furthermore, they are used also in solvent extraction of several kinds of metal cations [15 – 19]. However, they have
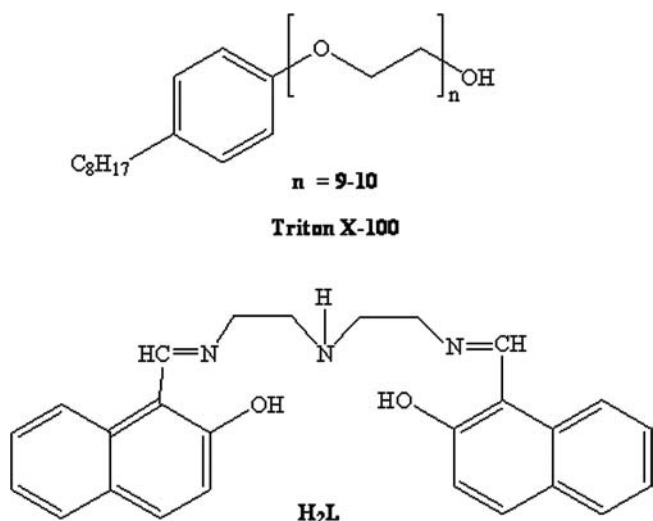
Figure 1   Structures of chelating extractant and surfactant used

been rarely utilized in aqueous two-phase micellar extraction [20]. Therefore, in this present paper, we aimed to investigate the aqueous two-phase micellar extraction of copper(II) employing a polydentate Schiff base, N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine (H_2L), as extractant and Triton X100 as non-ionic surfactant (Fig. 1). The pentadentate Schiff base (H_2L), which contain in its structure mixed donor atoms $O-N$ type, was chosen as chelating extractant because it forms more stable complexes than either $O-O$ or $N-N$ types [21]. Another advantage to select this extractant is its stability in dilute acidic solutions and high hydrophobicity. The copper(II) metallic ion was used as example because it constitutes a perpetual toxic threat to the environment and represents waste resources. Besides, the extraction-recovery of this metal coincides with the goals of the waste management strategy since it could provide some economical revenue and solve a pollution problem.

In addition to the optimisation of the use of N,N′-bis-(2-hydroxy-1-naphthalideneaminoethyl)amine extractant in aqueous two-phase micellar extraction of Cu(II), the effects of some parameters such as pH, extractant concentration and surfactant concentration on the extraction process were investigated. The results are used to assess the conditions for the maximum extraction of copper(II) from sulphate aqueous media.

As far as we know, no such study has been reported on this extractant for copper(II) extraction.

2 Experimental

2.1 Materials and solutions

All reagents used were at least of the highest available purity and analytical grade. The non ionic surfactant polyethylene glycol p-isooctyl phenyl ether (Triton X-100) with $9-10$ oxyethylene units was purchased from Alfa Aesar. This surfactant was chosen for the formation of the surfactant-rich phase because it had many advantages. After settling, the two phases were easy to separate without cooling by an ice bath. What is more, this reagent was not very expensive. The initial concentration of analyte, $[Cu^{2+}] = 1.57 \times 10^{-3}$ M, was prepared by dissolving $CuSO_4 \cdot 5H_2O$ (Fluka) in distilled water. Na_2SO_4 (Prolabo) was used to aid the phase separation

($[Na_2SO_4] = 7\%$ (m/v)) and H_2SO_4 (Merck) and NaOH (Prolabo) to adjust the pH. A chelating extractant (2×10^{-3} M) was prepared by dissolving appropriate amounts of a Schiff base in absolute ethanol. The Schiff's base N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine was synthesized and purified as described in the "synthesis of extractant section".

2.2 Synthesis of extractant

The quinquedentate extractant Schiff base N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine (H_2L) was prepared according to the literature through a well known method, as follows [22]: Diethylenetriamine (0.2 mole) was mixed with 2-hydroxy-1-naphthaldehyde (0.4 mole) in 100 ml of ethanol. The stirred mixture was kept reacting for 120 min at 60 °C under reflux, and then cooled to room temperature for precipitation.

The solid product was filtered, and then recrystallized from ethanol and dried for 24 hours. The purity was checked by IR and ^{1}H-NMR spectra.

H_2L: yield 75%; IR (KBr pellet, cm^{-1}) : 1629 (C=N); ^{1}H-NMR (CDCl$_3$, δ ppm): 13.4 (s, 2H, OH), 8.78 (s, 2H, CH=N), 6.88–7.86 (m, 12H, aromatic-H), 3.03 (t, 4H, =N−C−CH$_2$−), 3.70 (t, 4H, =N−CH$_2$−C−).

This extractant is very stable in the solid state and in ethanol. It has three nitrogen atoms and two hydroxyl groups in complexation with copper (Fig. 1).

2.3 Instrumentation

A Schimadzu 1202 model UV-Visible spectrophotometer with 10 mm-quartz cells was used for the determination of the concentration of metal. The pH values were measured using a Schott-Gerate model CG820 pH-meter, equipped with a glass-combination electrode. A thermostatted bath maintained at the desired temperatures was employed for cloud point temperature experiments.

2.4 Analytical procedures

2.4.1 Cloud point temperature determination of micellar solution

The temperature at which the cloud point phenomenon occurs was determined by the method reported by Carvalbo et al. [23]. The method is based on the visual observation of the separation of phases in the micellar solution. The initial aqueous solution (25 mL) was heated in a thermostatted vessel at a specific temperature which was well above its cloud point (turbid solution). Then the solution was cooled gradually. The cloud point was considered as the temperature at which the solution became clear. To verify the results, the opposite process was carried out by gradually heating the clear solution until turbidity appeared. The reported value was the average of these two determinations. In most cases, these two temperatures were identical, within 0.5 °C.

2.4.2 Typical cloud-point extraction

For the aqueous two-phase micellar extraction, aliquots of 25 mL of a solution containing the analyte, Triton X-100, Na_2SO_4 and Schiff base extractant were adjusted at suitable pH. Then, the mixture was stirred for 5 min in a shaker and kept in the thermostatic bath maintained at 65 °C for 6 hrs. The copper concentration was determined spectrophotometrically in the water phase. The overall procedure can be visualized as Scheme 1.
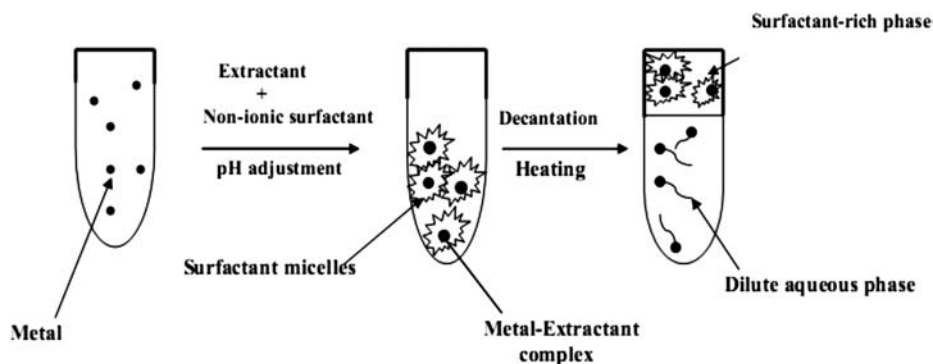
Scheme 1 Schematic representation of typical aqueous two-phase micellar extraction process

3 Results and discussion

3.1 Calculations

The distribution coefficient parameter used to describe the degree of metal partitioning from the aqueous to the surfactant-rich phase, is given by:

$$D_M = \frac{[M]_s}{[M]_w} \tag{1}$$

Where $[M]_s$ and $[M]_w$ are the final metal concentrations in the surfactant-rich phase and in the dilute aqueous phase, respectively.

The percentage of extraction of metal (yield), R %, and the efficiency of process, E %, can be expressed as:

$$R = 100 \; \frac{[M]_0 - [M]_w}{[M]_0} \tag{2}$$

$$E = 100 \; \frac{D_M}{D_M + \frac{V_w}{V_s}} \tag{3}$$

Where, $[M]_0$ refers to the metal concentration in the original aqueous solution prior to the extraction step, and V_w and V_s are the volumes of dilute aqueous solution and surfactant-rich phase obtained after the extraction step, respectively.

Finally, the concentration factor and the volume fraction of surfactant-rich phase are given by:

$$C_f = \frac{E}{100 \; \varphi_s} \tag{4}$$

$$\varphi_s = \frac{V_s}{V_0} \tag{5}$$

Where V_0 is the volume of the original aqueous solution prior to the extraction step.

3.2 Phase diagrams of binary systems

3.2.1 Characterization of phase diagram of Triton X-100-water micellar system

The phase diagram of the non-ionic Triton X-100 obtained in this study at different aqueous concentrations, ranging from 0.1 to 5 % (m/v) is shown in Fig. 2. The shape of the curve coincides with that expected for a typical non-ionic surfactant [24]. Below the curve, they are micellar solutions (1L), while two-phase regions co-exist above the curve (2L).

It has been mentioned by several authors that solutions of non-ionic surfactants generally can show different critical temperatures at similar concentrations depending upon the
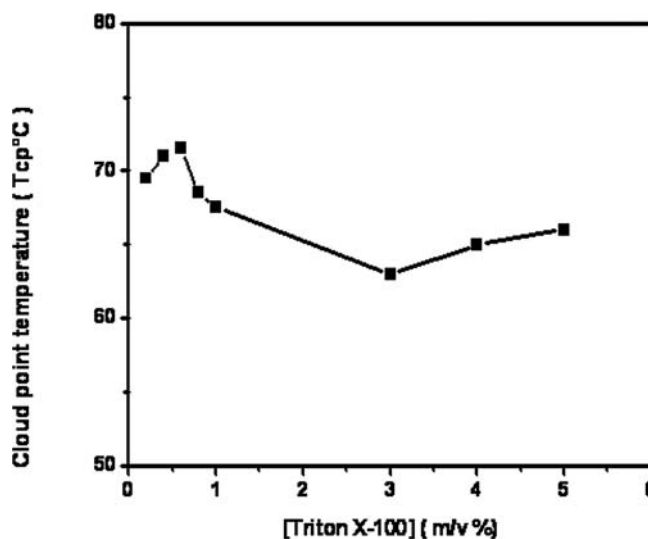

Figure 2 Phase diagram of Triton X-100 − water binary micellar system. L: one phase, 2 L: two phases

experimental conditions and purity of the amphiphiles [25]. Non-ionic polyoxylene surfactants are usually synthesized as a mixture of oligomers characterized by an average number of oxyethylene units. Furthermore, the presence or addition of other compounds to the amphiphile solution can lead to change in the clouding process. Thus, one should expect complete agreement among the results obtained by different researchers unless the experiments have been carefully controlled and all operating conditions are exactly repeated.

As evident from the phase diagram given in Fig. 2, the highest cloud point temperature (Tcp) value determined for Triton X-100 was 71.5 °C at the concentration of 0.6 % (m/v), whereas the lowest cloud point temperature was 63 °C at the concentration of 3 % (m/v). Moreover, the cloud point temperature, Tcp = 67 °C, found at the surfactant concentration of 1 % (m/v) was in good agreement with that reported by J. P. Mata [26], for micellar solution of Triton X-100 without any additives.

3.2.2 Effect of sodium sulphate

The influence of added Na_2SO_4 (1 − 7 % m/v) on the cloud point temperatures of the Triton X-100 micellar solutions were examined at various surfactant concentrations. Fig. 3 clearly demonstrates that the addition of sodium sulphate lowers the cloud point curve. This phenomenon can be conveniently explained in terms of a faster dehydration of the ethoxylated chains due to the presence of inorganic ions (sodium sulphate in this case: Na^+ and SO_4^{2-}) competing for
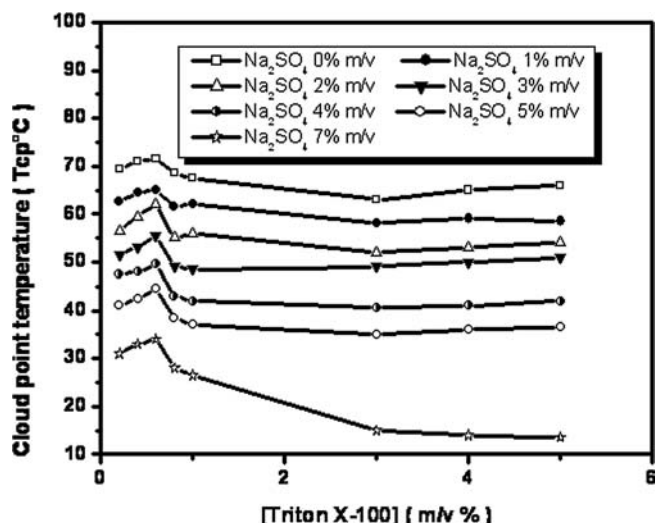
Figure 3 Phase diagram of Triton X-100 – water-Na$_2$SO$_4$ ternary micellar systems

Figure 4 Effect of the pH on the extraction yield of copper(II). [Cu^{2+}] = 1.57×10^{-3} M. [H$_2$L] = 2×10^{-3} M. [Na$_2$SO$_4$] = 7% (m/v). [S] = 5% (m/v). T = 65 °C

the interaction with the water molecules, i. e. a "salting-out" effect.

Also, it seems that, the sodium sulphate lowers the cloud point by a continuous medium change, more than by direct interaction with the ethoxy groups of the surfactant [24, 27–28].

Fig. 3. shows how 7% (m/v) of Na$_2$SO$_4$ is able to lower the cloud point of 5% (m/v) Triton X-100 solution from 66 °C to 13.5 °C. Therefore, it is possible to adjust the cloud point to room temperature and facilitate the cloud point extraction process by simply controlling surfactant and salt concentrations. Salt addition can also increase the density of the dilute phase; this makes the separation of both dilute and surfactant rich phases easy in some non-ionic surfactant systems [29–30].

3.3   Optimization of the aqueous two-phase micellar extraction process

The dependence of the extraction efficiency upon changes in some experimental parameters was studied. These included solution pH, concentration of the extractant, and concentration of the surfactant. In these studies, extraction process parameters were investigated in order to find optimal operation conditions.

3.3.1   Effect of solution pH

For ionisable solutes, the charge of the solute can greatly influence its extent of binding to a micellar assembly [31]. The ionic form of a molecule normally does not interact with and bind the micellar aggregate as strongly as does its neutral form. Indeed, adjustment of the micellar solution pH is the key-parameter when controlling experimental variables in cloud point extraction process.

An interesting result was obtained in the study of the influence of solution pH on extraction recovery of studied cation. In this series of experiments, the solution pH was varied over the range of 3 to 12. The Triton X-100, N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl) amine, copper, and Na$_2$SO$_4$ concentrations were kept constant at 5% (m/v), 2×10^{-3} M, 1.57×10^{-3} M, and 7% (m/v) respectively. The experiments were carried out at the separation temperature
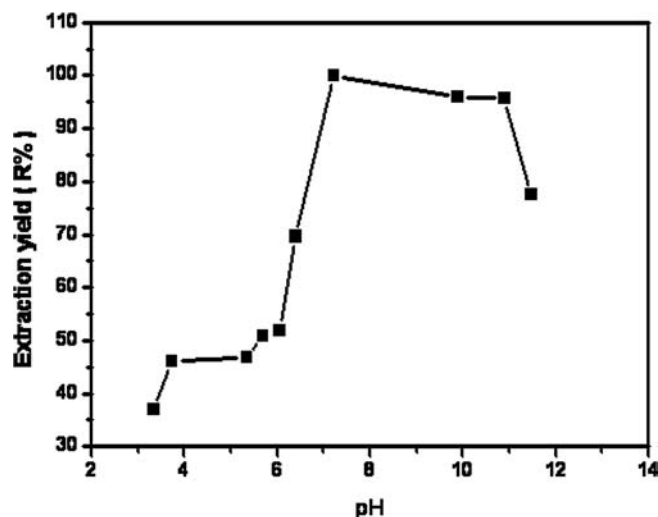
of 65 °C. The extraction yield depends on the pH at which complex formation between copper and ligand occurs. It is evident that the Cu–H$_2$L system is reasonably influenced by the pH, as shown in Fig. 4.

The extraction yield reaches the highest amount at pH = 7.2 for Cu(II). At lower pH values, the formation of complexes is not quantitative, and at higher pH values, the extraction starts to decrease. Therefore, a pH of 7.2 was selected to perform further extractions.

3.3.2   Effect of extractant concentration

In order to achieve the total extraction and preconcentration of copper(II), a series of experiments were carried out in which the other experimental variables, except extractant concentration, remained constant. The yield of the extraction as a function of the concentration of the extractant (over the range (10^{-4} M – 5×10^{-3} M)) is presented in Fig. 5.

It is shown that the yield of the extraction of copper increases with the increasing the concentration of the extractant, N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine (H$_2$L). An extractant concentration of 2×10^{-3} M permitted to reach 100% extraction efficiency and to raise the total formation of the Cu–H$_2$L complex. On the other hand, when an excess of extractant was used (4×10^{-3} M), a very slight decrease in the yield was observed (99%). This behaviour can be explained because the molecules of extractant are presumably trapped into the micelles, thus reducing the concentration of the complex.

3.3.3   Effect of surfactant concentration

The concentration of surfactant that is used in aqueous two-phase micellar extraction is critical factor. A successful cloud point extraction would be that which maximizes the yield of extraction through minimizing the phase volume ratio, and thus maximizing its concentrating factor. To obtain the optimal concentration of Triton X-100, the effect of surfactant concentration on the extraction efficiency of the system was investigated over the range of 1% (m/v) to 7% (m/v). The results are shown in Fig. 6. The optimum concentration of Triton X-100 falls in the range 4–6% (m/v). A concentration of 5% (m/v) was selected as the optimum concentration for
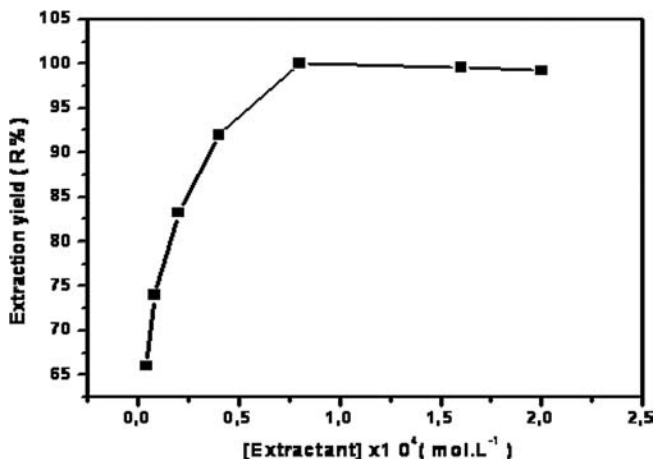
Figure 5 Effect of the extractant concentration on the extraction yield of copper(II). $[Cu^{2+}] = 1.57 \times 10^{-3}$ M. pH = 7.20. $[Na_2SO_4] = 7\%$ (m/v). $[S] = 5\%$ (m/v). T = 65 °C
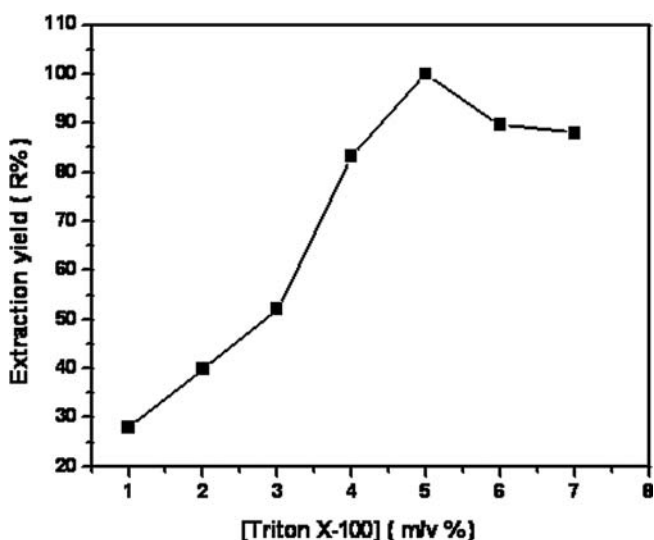

Figure 6 Effect of the Triton X-100 surfactant concentration on the extraction yield of copper(II). $[Cu^{2+}] = 1.57 \times 10^{-3}$ M. $[H_2L] = 2 \times 10^{-3}$ M. pH = 7.20. $[Na_2SO_4] = 7\%$. (m/v). T = 65 °C

[S] % (m/v)	E %	C_f	φ_s
1	30.16	10.05	0.03
2	42.40	10.60	0.04
3	54.40	10.88	0.05
4	84.30	12.95	0.065
5	100.00	14.29	0.07
6	90.43	11.30	0.08
7	89.20	08.92	0.10

Table 1 Effect of the surfactant concentration on the concentration factor (C_f) and surfactant-rich phase volume fraction (φ_s) of the aqueous two-phase micellar extraction process performance: $[H_2L] = 0.002$ M, $[Na_2SO_4] = 7\%$ (m/v), pH = 7.20, T = 65 °C

the extraction of copper. At lower concentration, the yield of the extraction of the complexes was low because there are few molecules of the surfactant to entrap the $Cu-H_2L$ complex quantitatively. At higher concentrations of Triton X-100 the yields decrease because of the increment in the volumes and the viscosity of the surfactant phase.

3.3.4 Preconcontration factor, C_f and phase volume fraction, f_s

Performance of an aqueous two-phase extraction process can be also assessed by its surfactant rich-phase volume fraction, f_s and preconcentration factor, C_f. These two parameters are defined in the "Calculation section". Tab. 1 illustrates the variation of φ_s, C_f, and extraction efficiency (% E) of copper(II) of the Triton X-100/Na_2SO_4/H_2L aqueous two-phase micellar extraction process with respect to concentration of non-ionic surfactant. At a fixed sample volume, C_f initially increases and then decreases as the concentration of the non ionic surfactant increased.

In general, with less surfactant in the solution, the volume of the surfactant-rich phase thus formed becomes

smaller and, hence, the concentration of the extracted analyte in the surfactant-rich phase increases. However, further reduction of surfactant concentration will eventually lead to insufficient surfactant in the surfactant-rich phase to efficiently extract the analyte, causing a drop in analyte extraction. From Tab. 1, it is seen that a concentration of non-ionic surfactant of 5 % (m/v) provides a high preconcentration factor ($C_f = 14.29$) and extraction efficiency (E % = 100 %) with an acceptable surfactant-rich phase volume fraction of $f_s = 0.07$. On the other hand, the results show that the volume fraction (f_s) of the surfactant increases with increasing concentration of the surfactant TX-100. Similar behaviour was observed in other aqueous two-phase micellar extraction processes using non-ionic and ionic surfactants [32–34].

3.4 Composition of the extracted species

The extraction of a divalent metal ion (M^{2+}) with H_2L in the system can be described, in general, according to Eq.(6),

$$M_{(w)}{}^{2+} + (n+m)H_2L_{(w)} \rightleftharpoons ML_n(H_2L)_{m_{(w)}} + 2nH \qquad (6)$$

$$\downarrow\uparrow$$
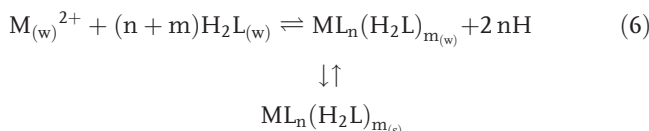
$$ML_n(H_2L)_{m_{(s)}}$$

where $M_{(w)}{}^{2+}$ and $H_2L_{(w)}$ are the metallic solute and the extractant in the aqueous phase, respectively. $ML_n(H_2L)_{(m)(w)}$ is the complex in the aqueous phase and $ML_n(H_2L)_{(m)(s)}$ is the complex in the surfactant-rich phase.

The extraction constant, K_{ex}, is expressed by Eq. (7):

$$K_{ex} = \frac{[ML_n(H_2L)_m]_{(s)}[H^+]^{2n}}{[M^{2+}]_{(w)}[H_2L]_{(w)}^{n+m}} \qquad (7)$$

The distribution ratio, D_M, of the metal ion between the two phases can be given by

$$D_M = \frac{[M]_s}{[M]_w} = \frac{[ML_n(H_2L)_m]_{(s)}}{[M^{2+}]_{(w)} + [ML_n(H_2L)_m]_{(w)}} \qquad (8)$$

Assuming that $[M^{2+}]_w \gg [ML_n(H_2L)_m]_w$, the distribution ratio becomes:

$$D_M = \frac{[ML_n(H_2L)_m]_{(s)}}{[M^{2+}]_{(w)}} \qquad (9)$$

Thus, Eq. (7) is reduced to a logarithmic form as Eq. (10):

$$\text{Log } D_M = \text{Log } K_{ex} + (n+m)\,\text{Log}[H_2L] + 2n\,\text{pH} \qquad (10)$$
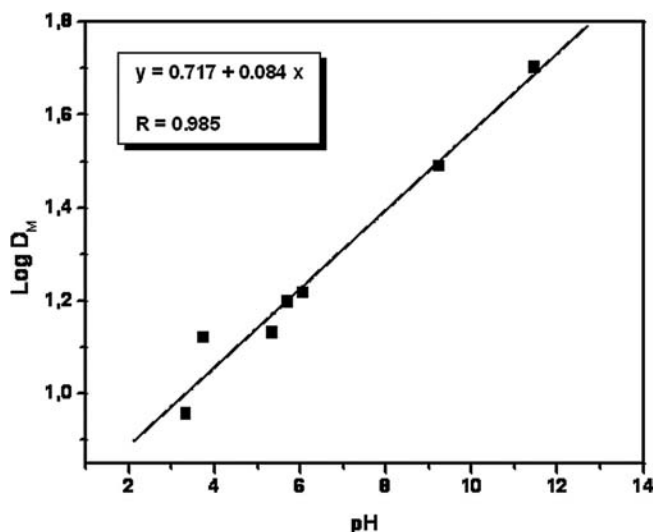
Figure 7 Variation of the distribution ratio, D_M, of copper(II) as a function of the pH. $[H_2L] = 2 \times 10^{-3}$ M. $[Na_2SO_4] = 7\%$ (m/v). $[S] = 5\%$ (m/v). $T = 65\,°C$
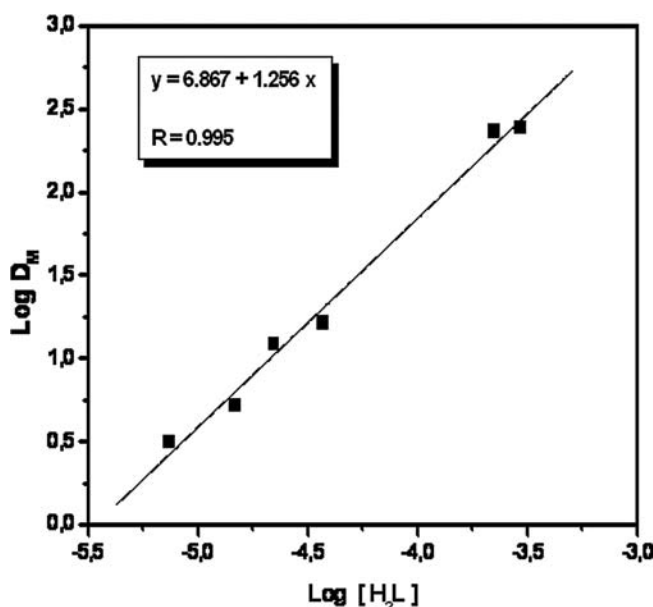

Figure 8 Variation of the distribution ratio, D_M, of copper(II) as a function of the extractant concentration (H_2L). pH = 7.20. $[Na_2SO_4] = 7\%$ (m/v). $[S] = 5\%$ (m/v). $T = 65\,°C$

Equation (10) expresses D_M as a function of the extractant concentration $[H_2L]$, and pH of the aqueous phase.

To determine the composition of the extracted species, the slope analysis method was carried out by plotting Log $D_M = f$ (pH) and Log $D_M = f$ (Log $[H_2L]$) using the developed equation (10).

For both curves in Fig. 7 and Fig. 8, the slopes are $2n = 0.084$ and $n + m = 1.256$ respectively (i.e. $n \approx 0$ and $m \approx 1$), indicating that the copper(II) should be extracted as the complex of 1:1 (metal:extractant). Hence, the probable composition of extractable species is $[Cu(H_2L)]^{2+}X$ (X: anion as SO_4^{2-}).

From the results obtained above the mechanism extraction process can be described by the following reaction:

$$Cu_{(w)}^{2+} + H_2L_{(w)} \rightleftharpoons [Cu(H_2L)]_{(s)}^{2+} \text{ (micelles)}$$

4 Conclusion

In this study, the combined advantages of the aqueous two-phase micellar extraction technique and the use of polydentate Schiff base N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine as extractant were utilized for extraction of copper(II) in aqueous solutions. From the results obtained it can be considered that N,N′-bis(2-hydroxy-1-naphthalideneaminoethyl)amine is an efficient extractant for quantitative aqueous two-phase micellar extraction of copper. The simple synthesis, the formation of stable complexes and consistency with the aqueous two-phase micellar extraction technique are the major advantages of the use of this type of extractant in aqueous two-phase micellar extraction of copper.

The extent extraction is markedly influenced by the pH of the aqueous solution, the concentration of the extractant and non-ionic surfactant. Moreover, the proposed technique offers a simple, sensitive, inexpensive and non polluting alternative to other separation extraction techniques.

Finally, further work is underway in our laboratory to increase the selectivity of the aqueous two-phase micellar extraction technique with this type of polydentate Schiff base extractant in order to accomplish extraction of copper from multimetal solution.

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