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Research Article

Recovery of Heavy Metals from a Polyethoxylated Alcohol

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Abstract – Metals often appears in very high concentrations in many solid, and liquid industrial discharges. The storage of such waste in controlled landfill site does not justify the absence of any risk of contamination. Lead and copper are a heavy metals that have been widely used in metallurgy since ancient times and was rediscovered during the industrial revolution.

The could point process is a technic that uses non-ionic surfactants as metal extractant based on there could point temperature. In recent years, ionic liquid known as a green solvent, wish also have surfactants properties, have become interesting tool in hydrometallurgical process for separating metal ions, where they are beginning to replace many expensive, toxic and non-biodegradable organic solvents.

This technic has made it possible to recover 82 % of lead and 74% of copper.

Keywords – Could Point, Lead, Copper, Extraction, Green Solvent.

I. INTRODUCTION

Lead and copper are present in the earth's crust and in all the compartments of the biosphere. It has interesting properties, such as flexibility, resistance to corrosion and certain types of radiation, and high density, which make it useful for a variety of uses.

The problem of environmental pollution is still very much with us today, as many industrial activities continue to generate a wide range of pollutants, particularly organic substances and heavy metals, which can cause major nuisances.

Faced with increasingly restrictive regulations, industries are obliged to treat their effluents before reintroducing them into the natural environment: various conventional purification techniques are used for this purpose. However, the development of clean technologies is becoming increasingly important in order to protect the environment. With this in mind, our laboratory has set itself the objective of developing a simple, effective and environmentally-friendly extraction depollution technique.

Conventional techniques for extracting metal ions from environmental matrices include the following processes: Precipitation, solvent extraction, ion exchange, adsorption and electrochemical recovery. The latter, which are currently the most widely used treatment techniques, may be ineffective due to legislative, technical or economic constraints.

Surfactants have properties that enable them to be used in a number of unit operations and processes, such as two-phase aqueous liquid-liquid extraction, also known as Cloud Point Extraction (CPE), the effectiveness of which has been demonstrated in numerous previous studies.

Polyethoxylated alcohols (PEAs) also have satisfactory toxicological and ecotoxicological properties. This makes it possible to move towards ‘green’ chemistry, which involves designing processes that are non-polluting and inexpensive in terms of energy.

In addition to their adsorption and association properties (which are at the origin of micellar solubilisation, for example), polyethoxylated alcohols (AE, abbreviated formula: CiEj), possibly propoxylated with less than four propylene oxide units, and even derived from the OXO synthesis, are easily biodegradable and inexpensive.

II. MATERIALS AND METHOD

1- Extraction Procedure

A suitable quantity of a polyethoxylated alcohol surfactant was brought into contact with a mixture of lead (II) metal solution, the whole is heated to 69°C for a period of time to allow complete decantation of the two phases (coacervate and dilute phase) and stabilisation of their composition (establishment of equilibrium).

Once the extraction is complete, the metallic phase is collected and analysed by atomic absorption.

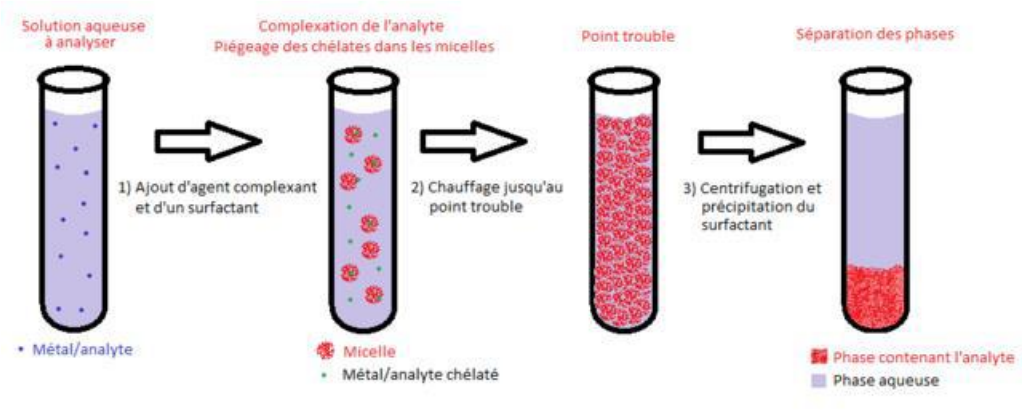

Figure 1: Cloud point extraction procedure

III. RESULTS AND DISCUSSIONS

1- Effect Of Surfactant Concentration On Cloud Point Temperature

The decomposition curve for water/surfactant binary systems was plotted by increasing the temperature at a rate of 1°C/min. We observed that the cloud point is strongly influenced by the hydrophobic nature of the surfactant [1]. According to Figure 1, the cloud point is 69°C. The decrease in cloud point at lower surfactant concentrations (0-2 wt%) could be attributed to the increase in micelle density present in the surfactant solution. Thus, phase separation results mainly from the attractive interaction between micelles in this dilute regime.

On the other hand, the relative increase in cloud point temperature at higher surfactant concentrations is due to the more structured water/surfactant system [1,2].

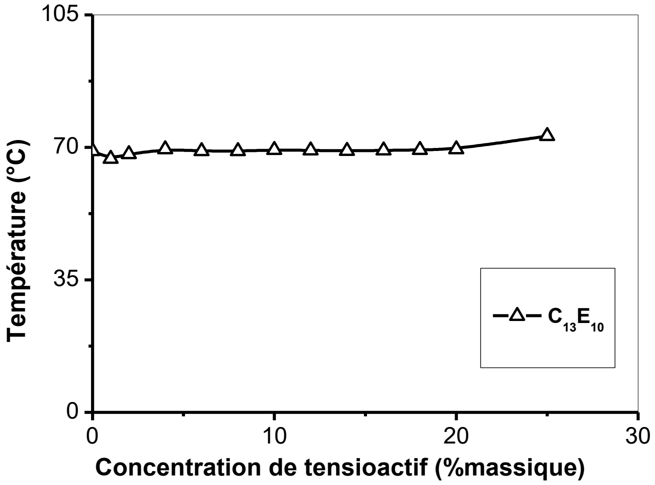

Figure 2. Change in cloud temperature as a function of $C_{13}E_{10}$ surfactant concentration

2- Effect Of Equilibrium Time On Extraction Through The Cloud Point

For the process to be hydrodynamically viable and therefore feasible, it is imperative that the phases separate within suitable incubation times. By adjusting the parameters, i.e. surfactant content or temperature, phase separation may not be a a limiting stage in the process. The driving force behind phase separation is the difference between their densities [3]. The results of the influence of incubation time on the extraction yield of metal ions, are given in figure 3. According to this figure, extraction yields increase with incubation time up to 180 min. The latter corresponds to 35.47% and 7.23% respectively for Pb(II) and Cu(II). Yields then decrease after 180 min. We note that the minimum time required for the start of coacervate formation was 5 min. The coacervate is already clear, while the dilute phase is still opaque due to the presence of a few droplets of coacervate. This was in agreement with previous experimental findings [1,4].

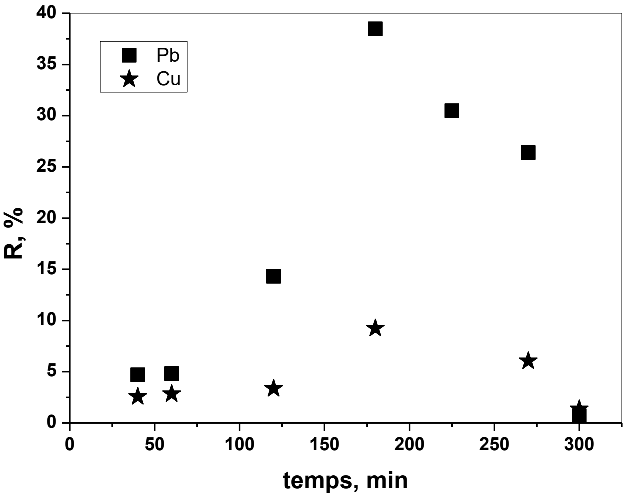

Figure 3. Evolution of metal ion extraction yield as a function of time.

3- Effect Of Surfactant Concentration

The results of the study of the influence of the concentration of the $C_{13}E_{10}$ non-ionic surfactant on the extraction yield of lead and copper ions, are shown in Figure 4. we note that Pb(II) and Cu(II) ions were extracted from their equimolar mixture respectively at 38.13% and 9.14%. This was achieved in the presence of 5% m/m surfactant in the aqueous metal phase.

It can be seen that the extraction power increases as the concentration of oxo-$C_{13}E_{10}$ alcohol increases, reaching a slight maximum of 5%. w/w.

This is because this density is much greater when working at low alcohol concentrations, the addition of more alcohol lowers the charge density and, consequently, the extraction yield, and even a change in the cloud point [4].

Extraction yields become practically constant above 5% m/m alcohol due to the nature of polyethoxylated non-ionic surfactants, which do not modify the charge of the micelle [1,4,5].

It can be seen that doubling the quantity of surfactant will only increase the extraction yield by 4.47% and 1.56% for lead and copper ions respectively.

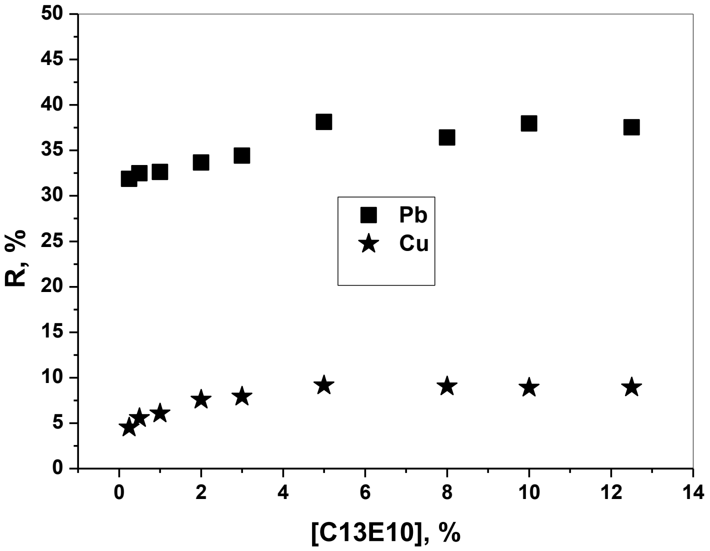

Figure 4. Evolution of extraction yield as a function of time.

4- Effect Of Feed Phase Concentration

The variation in the initial concentration of the metal, in the feed phase, constitutes the concentration gradient that can influence mass transfer during extraction by the cloud point technique [4].

The concentration of Pb(II) and Cu(II) ions in the range 20 to 500 ppm while keeping the concentration of APE constant and equal to 5% m/m. The results are shown in Figure 5.

It can be seen that extraction yields increase as the concentration of metal ions in the feed phase increases. Maximum yields of 79.34% and 58.08% respectively for Pb(II) and Cu(II), at a concentration of 100 ppm. Extraction yields decrease above this concentration in the feed phase. It was found that 59.31% and 47.41% were lost for lead and copper respectively when the feed phase was concentrated five times.

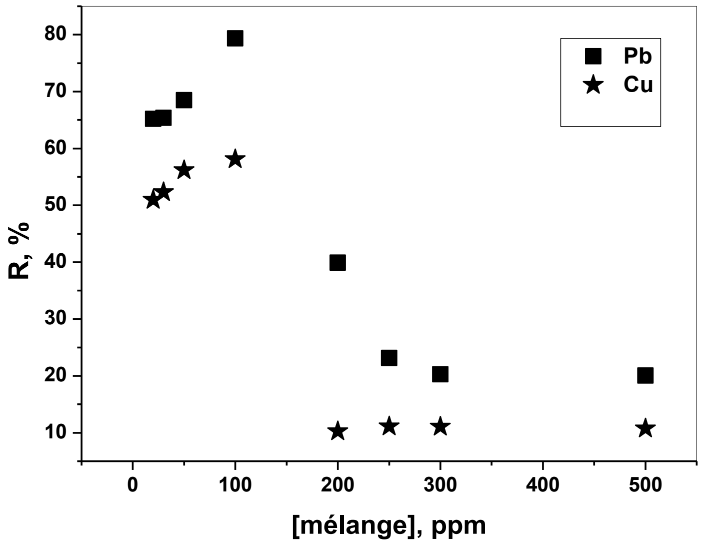

Figure 5. Evolution of extraction yield as a function of mixture concentration.

It is important to understand why and how certain metal cations adsorb more readily than others onto charged micellar surfaces.

According to Coulomb's law, the exchange affinity increases with the valency of the ion and, at equal charge, the cation with the largest non-hydrated radius (RI) is preferentially adsorbed to the surface. It is important to note that surfactants also have a hydration sphere, which can hinder the approach of cations to the micellar surface.

This justifies the differences in extraction yields obtained for lead and copper ions.

These results are in agreement with previous work [4].

5- Effect Of The Initial Ph Of The Feed Solution

The pH is a very critical parameter for the coacervation of micelles and the complexation of the ligand with metal ions [174]. It is one of the key factors in the coacervate extraction technique [6].

The influence of the initial pH of the metal solution on cloud point

cloud point extraction was carried out for the two metal ions Pb2+and Cu2+ using their synthetic mixture and in the pH range 0.57 to 5.28.

The results are shown in Figure 6. According to this figure, the extraction of ions increases as the initial pH of the metal solution increases, reaching maximum yields of 84.98% and 74.09% for lead and copper respectively at pH=1.19, then decreases.

The decrease in yields is more noticeable in the case of copper, since it is closer to its precipitation pH.

The extraction yield for Cu(II) therefore fell to 57.8%. The predominance of metal solutions as a function of their initial pH shows several forms of water-soluble metal species not chelated by alcohol.

These species do not interact with the polar head of the surfactant (outside micelles) and remain dissolved in aqueous solutions of polyethoxylated alcohols [5].

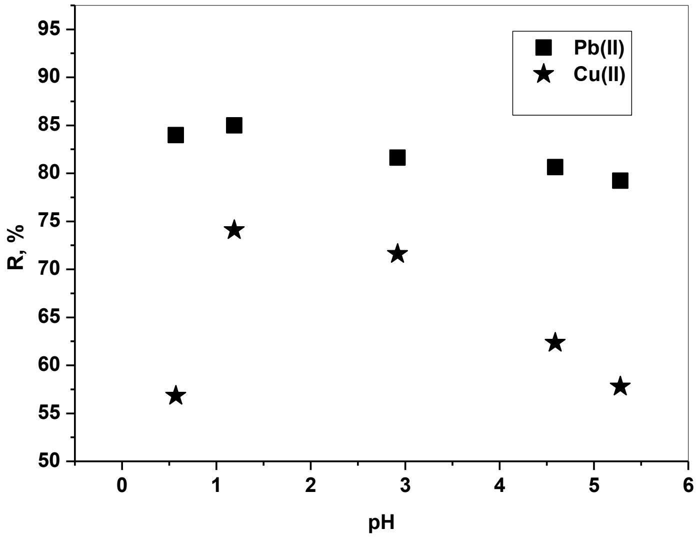

Figure 6. Evolution of extraction yield as a function of pH

IV. CONCLUSION

The separation of lead from copper using non-ionic liquids such as polyethoxylated alcohol $C_{13}E_{10}$ with the cloud point extraction technique was investigated.

Optimisation of the Pb(II) extraction process revealed that 84.98% of Pb(II) was extracted from a lead nitrate solution at pH 1.19 with 5% w/w polyethoxylated alcohol.

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