

# EXTRACTION PROCEDURE FOR COPPER (II) IN ACETATE MEDIUM BY NANOFILTRATION AND REVERSE OSMOSIS

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## Abstract

The retention of copper ions from a synthetic solution by nanofiltration and reverse osmosis has been shown to be a feasible process to achieve efficient copper extraction. In this study, we investigate the effect of varying pressure, pH, and copper acetate concentration.

The experimental results indicated that the retention of copper ions increase with increasing operating pressure, decrease with increasing concentration and were strongly influenced by the pH of the feed solution. Higher degrees of copper extraction were obtained for experiments carried out by reverse osmosis than those carried out by nanofiltration.

The results show that, the extraction efficiency of copper by reverse osmosis varied from 90% to 100 % for an initial feed concentration of 50 ppm, and by nanofiltration ranged from 49 % to 98% and from 24% to 73 % for an initial feed concentration of 50 and 75 ppm, respectively.

**Keywords:** Copper, Nanofiltration, Reverse osmosis, Retention, Extraction

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## I- INTRODUCTION

Copper is a widely used heavy metal in many engineering and chemical industries due to its electrical and thermal conductivity, the great difficulty being that heavy metals are not biodegradable and tend to accumulate in organisms [1]. For this, the treatment of aqueous effluents has become imperative.

Many processes are used to purify water contaminated with heavy metals; these methods are effective but have many drawbacks which require the use of organic solvents harmful to the environment.

Membrane processes were found to be feasible for the removal of heavy metals from an aqueous solution due to their relative ease of construction and control and the possible recovery of precious metals [2].

The aim of this work is to investigate the ability of the SNTE NF270-2540 nanofiltration membrane to remove Cu(II) ions from aqueous solutions and compared with the xle 2540 reverse osmosis. To this end, the effect of operating parameters (applied pressure, feed pH and concentration) on the membrane performance is systematically investigated.

## 2. EXPERIMENTAL

### 2.1. Reagent and solutions

Copper acetate salt was supplied by Carlo Erba (France), hydrochloric acid (38%) and 1-(2-Pyridylazo)-2-naphthol (PAN) were purchased from Sigma-Aldrich (Germany).

All solutions were prepared by dissolving the appropriate weight of the salt in water and made to a volume of 40 L.

### 2.2. Analyses

Copper ion concentration was measured by a UV-Visible spectrophotometer type (SPECORD 210/plus) purchased by Analytik Jena Specord (Germany), takings of 100  $\mu$ L of copper are measured by UV-VISIBLE after the addition of 2 mL of stamp solution with pH = 4.0 and 100  $\mu$ L of PAN.

### 2.3. Materials

A commercially nanofiltration membrane (SNTE NF270-2540) and reverse osmosis membrane (XLE- 2540) supplied by DOW FILMTEC™ Membranes (USA) was used in this study (Table 1).

The pH value was measured with a pH - meter AD 1030 (Adwa, Hungary).

The weighing was made with an electronic analytical balance type OHAUS (USA).

### Pilot equipment

Nanofiltration and reverse osmosis experiments was performed with tangential filtration unit (Fig.1), in this experiments the retained liquid the permeate is returned to the tank. For each admitted pressure, the experiment time was 15 minutes.

CA is the cartridge filter with activated carbon and 25  $\mu$ m of wound cartridge filter. S is the safety valve (14 bars). B1 is the feed tank (100 L). B2 is the permeate tank (20 L). C2 is the nanofiltration membrane. FI1 is the upstream flow meter (100–1000 l/h). FI2 is the downstream flow meter of retentive. FI3 is the downstream flow meter of permeate. PI1 & PI2 are the manometers at upstream and downstream of module (0–16 bars). PI3 & PI4 are the monitoring manometers of filters state (0–2.5 bars). LSL1 is the low

level sensor (pump safety). CE1 is the Sensor of permeate conductivity measuring. Y is the emptying, CIT1 to the electrical display cabinet. V1–5, 7, 10, 11, 14–16, 19 & 22 are the pressure regulation valves for nanofiltration process. P is the multistage centrifugal pump (high pressure).

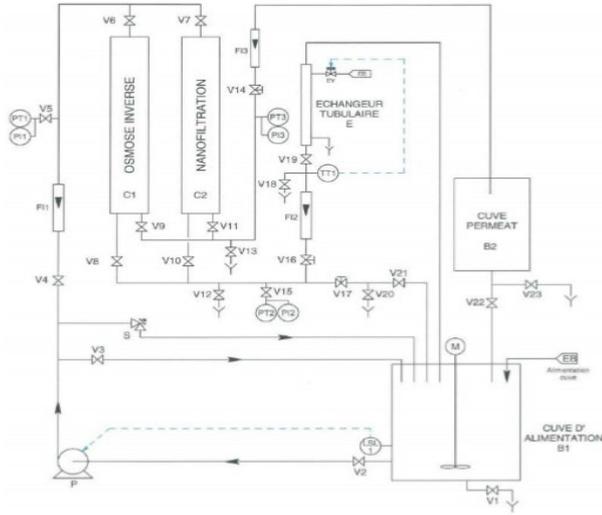


Figure 1. Schéma de principe.

Table 1. Characteristics of OI and NF membranes

Characteristics	OI membrane	NF membrane
Membrane model	XLE- 2540	NF 270-2540
Membrane material	Polyamidethin-film composite	Polyamide thin-film composite
Membrane configuration	Spiral wound	Spiral wound
Membrane surface area, m <sup>2</sup>	2.6	2.6
Allowable operating pH range	2-11	2-11
Maximum operating pressure, bar	41 (600 psi)	41 (600 psi)
Maximum operating temperature, °C	45 (113 °F)	45 (113 °F)
Free chlorine tolerance, ppm	< 0.1	< 0.1
Maximum feed turbidity, NTU	1	1

## 2.4. Data analysis

The retention was calculated by Eq (1):

$$Y(\%) = \left( \frac{C_0 - C_p}{C_0} \right) \times 100 \quad (1)$$

Where  $C_p$  and  $C_0$  represent permeate and feed solution concentration (ppm).

## 3. RESULTS AND DISCUSSION

### 3.1. Extraction of copper

#### 3.1.1. Permeate flux

Figure 2 shows the evolution of the permeate flow as a function of the pressure for Cu (II) solutions at different concentrations ranging from 50 ppm to 75 ppm. We note that for each solution the permeate flow increases with the increase of pressure.

The permeate flux of 75 ppm solutions is less than that of water. In this case, the transfer of solvent is favored over the solute [3-5], These results are in agreement with the

hypothesis which states that the presence of solutes makes it difficult for the membrane surface to be more compact due to the contraction of the pores, which leads to a decrease in permeation [6].

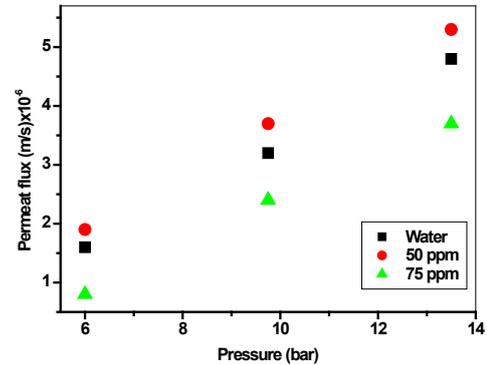


Figure 2. Variation of permeate flux according to the pressure.

#### 3.1.2. Effect of pressure

The results obtained in figure 3 shows that the retention of Cu (II) ions increases with increasing pressure.

This increase in retention is explained by the increase in water flow due to pressure, and the transfer of ions through the membrane does not increase in the same way.

Thus, the ion will be shared in a large volume of water, which means that the permeate solution will be less concentrated and therefore the retention increases. We work in total recycling where the two permeate solutions and the retentate have been returned to the feed tank in order to keep a constant concentration. This phenomenon has been observed by previous Works [7, 8].

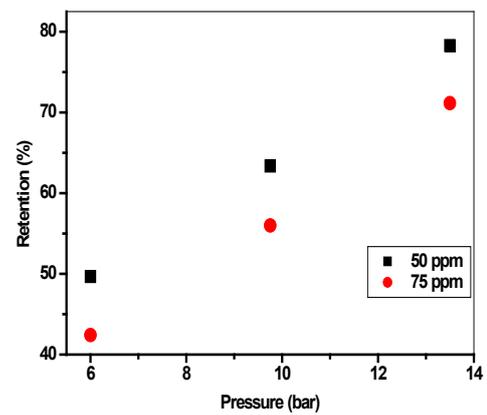


Figure 3. Variation of copper retention according to the pressure.

#### 3.1.3. Effect of pH

The rejection from nanofiltration membranes is due to both size exclusion and co-ionic electrostatic repulsion (or exclusion of charge) [9]. It has been acknowledged that the polyamide membrane are negatively charged at pH above the isoelectric point and positively charged at pH under the isoelectric point, and zero charge at the isoelectric point. For the NF270-2540 membrane the isoelectric point measured was in the pH < 3 [5].

Figure 3 presents the effect of Copper retention according to the pH for different pressures

At pH=5.0, where the membrane pore is more negatively charged, the copper ion experiences electrostatic repulsion from the membrane pore and will be rejected by the membrane. Because the electroneutrality of the permeate solution must be maintained. As the pH decreases the electrostatic repulsion and therefore the ion rejection decreases, at pH=4.0 the rejection reaches a local minimum, resulting in an increase pore size and salt passage [9].

At strong acidic pH (pH=3.0), the increase in protons in the solution induces a progressive neutralization of the negative sites on the surface of the membrane. Then, as the repulsion of co-ions decreases, their transfer increases. In this case, the retention of the ions depends only on their size and their mobility. Protons which are characterized by high mobility ( $34.90 \times 10^{-9} \text{ m}^2 / \text{s.V}$ ), small size and high diffusion coefficient ( $9.34 \times 10^{-9} \text{ m}^2 \cdot \text{s}^{-1}$ ) pass easily through the membrane carrying acetates with them to restore electroneutrality on both sides of the membrane [10].

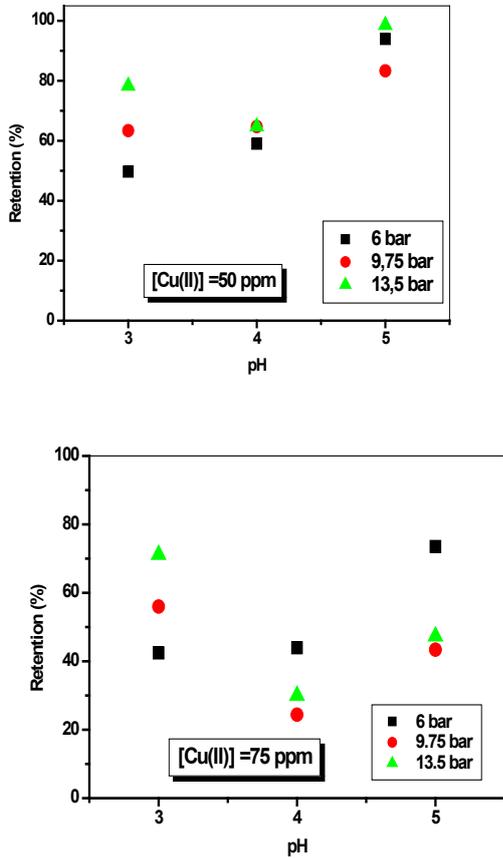


Figure 4. Variation of copper retention according to the pH for different pressures.

**3.15. Effect of concentration**

It is noted that the retention of solutions decreases with increasing concentration (Figure 5). These results are attributed to the phenomenon of concentration polarization, which tends to decrease the flow of the permeate and consequently the decrease in the retention of metal ions by membrane [11,12]. This is also explained by the

neutralization of the negative sites of the membrane due to the increase in positive charges, resulting from the metal ions, which reduces the power of the membrane in the rejection of the ions, and consequently the reduction of the flux of permeate [12]. This result is in agreement with that previously found [4,13].

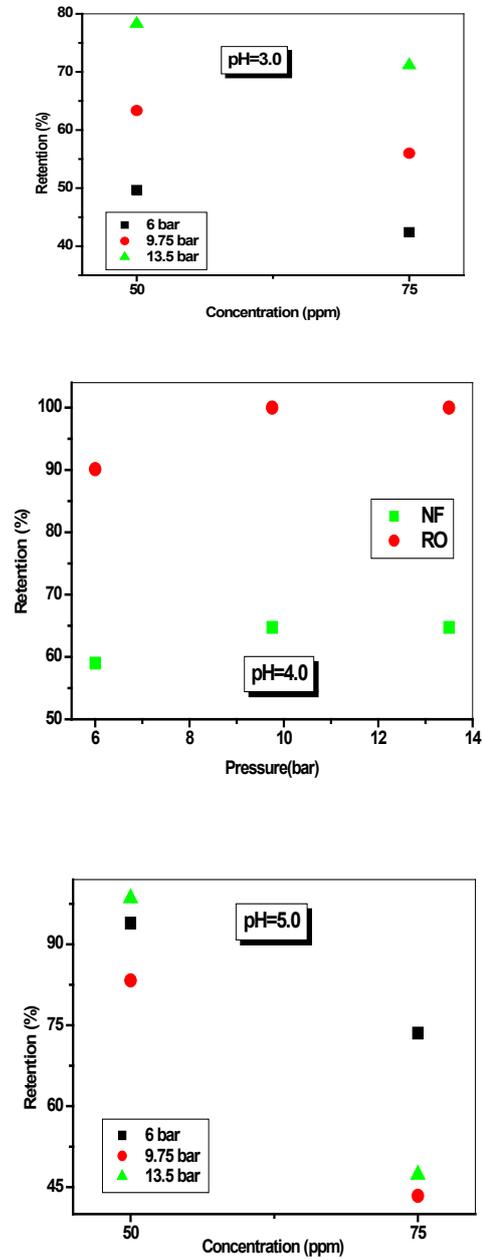


Figure 5. Variation of copper retention by RO and NF processes.

**Conclusions**

In this work, the performance of the Nanofiltration and Reverse Osmosis processes as a thin film composite membrane in removing copper from a synthetic solution was studied, the influence of changing the pressure, concentration and pH of copper acetate in the feed solution on the transport of water and salt. The results show that, the extraction efficiency of copper by reverse osmosis varied from 90% to 100 % for an initial feed concentration of 50 ppm, and by nanofiltration ranged from 49 % to 98% and

from 24% to 73 % for an initial feed concentration of 50 and 75 ppm, respectively.

The results obtained show that copper (II) was successfully removed by Reverse Osmosis than the Nanofiltration.

The best initial conditions were copper (II) concentration equal to 50 ppm, initial pH=3.0, and pressure equal to 6 bars with extraction yield of 100 % was obtained by reverse osmosis.

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