

Nickel Removal from Aqueous Solutions by Flotation with Cationic Collector. Determination of the Optimum Separation Conditions

A. Turtureanu, C. Georgescu, L. Oprean

„Lucian Blaga” University of Sibiu, Faculty of Agricultural Sciences, Food Industries and Environmental Protection, 550012, Sibiu, Romania, Phone: (40) 269-211338, Fax: (40) 269-212558, E-Mail: aturtureanu@yahoo.com

Abstract: Nickel removal from dilute aqueous solutions is studied for environmental protection and nickel recovery. The paper presents the removal of nickel from dilute aqueous solutions by flotation (dispersed-air-flotation) at a laboratory scale, using a cationic collector (octadecylamine). The optimum values of the main parameters influencing this process were determined. (pH of Ni(II) solutions, molar ratio octadecylamine:Ni(II), air flow rate, flotation time, temperature and initial concentration of metal ions in sample). An atomic absorption spectrophotometer PYE UNICAM model SP 1900 was used to determine the nickel content of the solutions. The nickel removal efficiency was calculated with the relation: $R\% = (1 - C/C_0) \cdot 100$, where C_0 and C are initial and after flotation concentrations of nickel ions in solutions. Using the optimal conditions, high removal degree of nickel (> 98%) was obtained.

Keywords: nickel, removal, flotation, octadecylamine

1. Introduction

Industrial water is one of the major sources of aquatic pollution. Aquatic pollutants include organic compounds, pathogens, and heavy metals. Among these pollutants, heavy metals have gained relatively more significance in view of their persistence and toxicity. Many studies have shown that these metals are toxic, even at low concentrations [1]. These toxic metals can cause accumulative poisoning, cancer, and brain damage when they are found above the tolerance levels [2].

Exposure to nickel can cause dermatitis and allergic sensitization. About 10% of women and 2% of men in the global population are highly sensitive to nickel. A part of these sensitive people can develop a skin rash called nickel dermatitis if they are exposed to nickel through direct contact. This is the most common type of reaction to nickel exposure.

With nickel toxicity the type of nickel (speciation) is very important. Its form and the ease with which it dissolves in water affects the toxicity and the consequences for human health. The most serious health effects occur when nickel is inhaled: increased risk of respiratory cancer due to chronic inhalation of fumes or fine particles when exposure is to known carcinogenic forms like nickel oxide; asthma, nasal and sinus problems.

In animal studies, which are much more extensive, nickel exposure caused: decreased body weight, increase in still births, decrease in birth weight of offspring, and even death, when nickel exposure is very high.

Nickel is necessary for a healthy plant growth. It is an important component of an essential enzyme. At a level of 100 ppm or higher, nickel is considered to be phytotoxic, harmful or toxic to plants [3].

Heavy metal contamination exists in the effluent wastewater from different industries, such as metal

processing, photography, ceramic industry, metal plating, mining operation, radiator manufacturing, alloy industries and storage batteries manufacture, catalyst, electrical apparatus, extractive metallurgy, antibacterial, insecticides, fungicides, pyrotechnics, fertilizers, pigments, stabilizers, plumbing, roofing and building construction, piping, water purification, gasoline additives, and cable covering[4].

The concentration of heavy metals in the industrial wastewater from these industries should be decreased to the permissible limits; therefore the ground water will not be affected. Chemical precipitation, coagulation, solvent extraction, membrane separation, ion exchange, adsorption and foam flotation are commonly applied in the treatment of industrial effluents. Foam flotation presents high selectivity and efficiency low space requirements, rapid operation, flexibility, production of small volume of sludge and moderate costs [5]

The aim of the present study is to establish the optimum flotation conditions in term of: pH of Ni(II) solutions, molar ratio collector:Ni(II), air flow rate, flotation time, temperature and initial concentration of Ni(II).

2. Material and methods

Chemicals:

- Nickel sulphate ($\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ p.a.) stock solution (2 g Ni(II)/ dm^3) from which were prepared solution with 100 mg Ni(II)/ dm^3 ;
- cationic collector (octadecylamine) 0,25 M solution in ethanol;
- 15% and 1M NaOH solutions;
- 1M HNO_3 solution.

Apparatus:

- bench-scale equipment for dispersed-air flotation technique;

- pH-meter WTW 96;
- atomic absorption spectrophotometer PYE UNICAM model SP 1900.

Working procedure:

The flotation bench-scale equipment consist of compressor, cock for air flow rate adjustment, rotameter for air flow rate determination, 3,3 cm inner diameter glass flotation column (60 cm in height) with porous glass frit (porosity G₄).

From stock solution with 2 g Ni(II)/dm³ there were prepared solution with 100 mg Ni(II)/dm³, the pH was adjusted to the desired value by adding NaOH or HNO₃ solutions and than it was added the collector, octadecylamine. The resulted solution was submitted to flotation.

The main parameters influencing this process were studied: pH of Ni(II) solutions, molar ratio collector:Ni(II), air flow rate, flotation time, temperature and initial concentration of Ni(II) in sample. An atomic absorption spectrophotometer PYE UNICAM model SP 1900 was used to determine the nickel content of the solutions.

The nickel removal efficiency, R%, was calculated with the relation:

$$R\% = \left(1 - \frac{C}{C_0}\right) \cdot 100$$

where: C – concentration of Ni(II) after flotation;
C₀ – initial concentration of Ni(II) in solutions.

3. Results and discussion

The pH of the solution is one of the most important factors which influences the ion separation by flotation, as it determines the magnitude and sign of the charge on the ions and also the dissociation degree of the ionic groups of the surfactant molecules. Preliminary experiments, shown in Figure 1, were conducted in order to determine the pH effect on the nickel removal efficiency, (R%) and on the nickel concentration after flotation, (Ni(II) rez. [mg/dm³]).

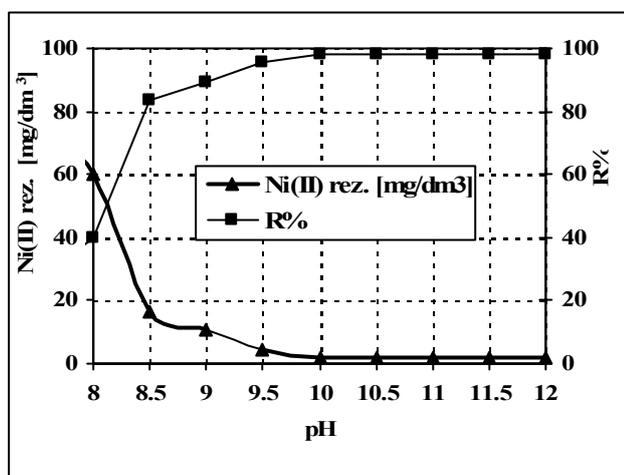


Figure 1. Influence of pH on the nickel removal efficiency. Molar ratio octadecylamine:Ni(II)=1; air flow rate=15 dm³/h, flotation time=15 min., initial concentration of Ni(II)=100 mg/dm³.

It can be seen that the flotation of nickel ions, with octadecylamine as collector, has significantly values of removal efficiency at pH > 8, but a good separation efficiency (≥ 98%) is obtained at pH values ≥ 10. The pH interval in which nickel ions precipitates as hydroxide, at the working concentrations, is 8,03 – 9,65 and so the separation process is a precipitate flotation process.

The second studied factor was the effect of the molar ratio octadecylamine:Ni(II) (Cc:Cco). As surfactant was used 0,25 M octadecylamine solution in ethanol. Addition of ethanol as frother had the further advantage that the sizes of bubbles are smaller, because of the lower surface tension of the solution. The results are shown in Figure 2. The increase of the molar ratio octadecylamine:Ni(II) determines a fast increase of removal efficiency until Cc:Cco = 1 and a slowly decrease at Cc:Cco values greater than 1,5

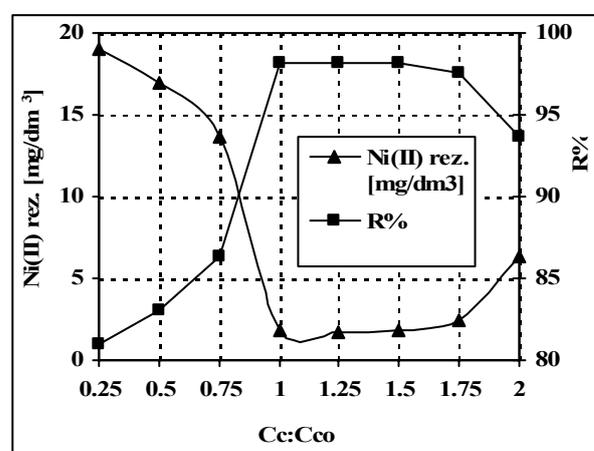


Figure 2. Effect of molar ratio octadecylamine:Ni(II) (Cc:Cco) on the nickel removal efficiency. pH=10, air flow rate=15 dm³/h, flotation time=15 min., initial concentration of Ni(II)=100 mg/dm³.

The influence of air flow rate on Ni(II) removal efficiency is shown in Figure 3.

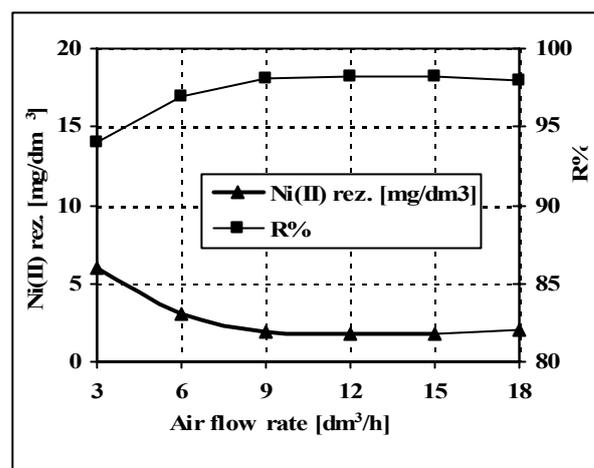


Figure 3. Influence of air flow rate on the Ni(II) removal efficiency. pH=10, Cc:Cco=1, flotation time=15 min., initial concentration of Ni(II)=100 mg/dm³.

The increase of air flow rate until 9 dm³/h, determines a fast increase of removal efficiency. The

increase of air flow rate in the range 9 -18 dm³/h did not have a major effect on removal efficiency.

The influence of flotation time on Ni(II) removal efficiency is shown in Figure 4. It can be seen that the separation process is very fast. In only 3 minutes is achieved a removal efficiency $\geq 95\%$, and increasing the flotation time over 6 minutes the efficiency is greater than 98%.

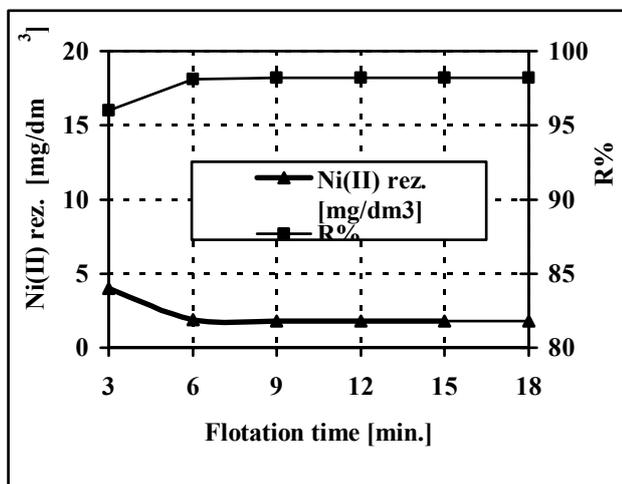


Figure 4. Influence of flotation time on the Ni(II) removal efficiency. pH=10, Cc:Cco=1, air flow rate=10 dm³/h, initial concentration of Ni(II)=100 mg/dm³.

The influence of temperature on Ni(II) removal efficiency is shown in Figure 5.

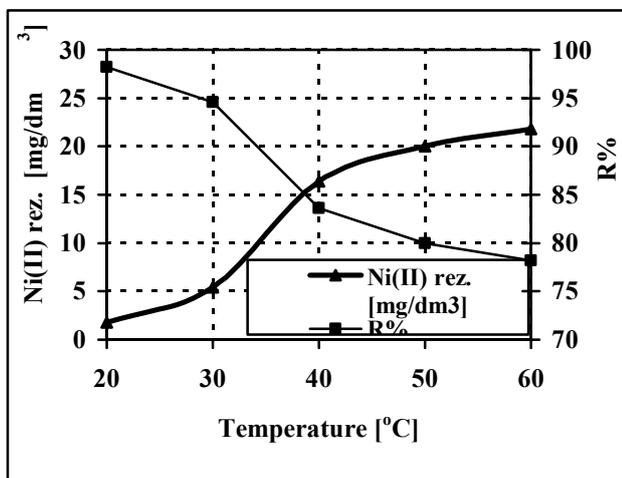


Figure 5. Influence of temperature on the Ni(II) removal efficiency. pH=10, Cc:Cco=1, air flow rate=10 dm³/h, flotation time=8 min. initial concentration of Ni(II)=100 mg/dm³.

By increasing the temperature between 20 and 60 °C, we observed an important decrease of removal efficiency until 78%

Another factor which influences the flotation process is the initial concentration of Ni(II) in solution. The results are shown in Figure 6. By decreasing the Ni(II) concentration it can be observed a decrease of removal efficiency, until 76%.

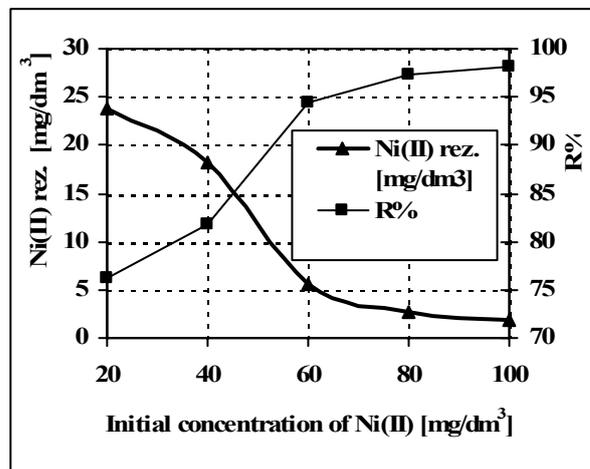


Figure 6. Influence of initial concentration of Ni(II) on the removal efficiency. pH=10, Cc:Cco=1, air flow rate=10 dm³/h, flotation time=8 min.

4. Conclusions

Using a precipitate flotation process (at pH > 10) and using octadecylamine as cationic collector, we obtained a high removal efficiency (> 98%) of nickel from aqueous solutions, in a very short time.

REFERENCES

1. Stoica, L. and Oproiu, G.C., Cu(II) recovery from aqueous systems by flotation, *Sep. Sci. Technol.*, 39(4), 2004, pp.893-909.
2. Zouboulis, A.I., Matis, K.A. and Lanara, B.G., Removal of cadmium from dilute solutions by hydroxyapatite. II. Flotation studies, *Sep. Sci. Technol.*, 32(10), 1997, pp.1755-1767.
3. <http://www.incowatch.ca/content/4-2%20Toxicology.htm>
4. Zouboulis, A.I. and Matis, K.A., Removal of cadmium from dilute solutions by flotation, *Wat. Sci. Technol.*, 31(3-4), 1995, pp.315-326.
5. Matis, K.A. and Zouboulis, A.I., Flotation techniques in water technology for metals recovery, *Sep. Sci. Technol.* 36(16), 2001, pp.3777-3800.