CADMIUM REMOVAL FROM AQUEOUS SOLUTIONS BY FLOTATION WITH ANIONIC COLLECTOR

— research paper —

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Abstract: The paper presents cadmium removal by flotation from dilute aqueous solutions, at a laboratory scale, using an anionic collector (oleic acid). The optimum values of the main parameters influencing this process were determined: pH of Cd(II) solutions, molar ratio collector:Cd(II), air flow rate, flotation time, initial concentration of Cd(II) and temperature. Using these optimal conditions, a very high removal degree of cadmium (over 99%) was obtained.

Keywords: cadmium, removal, flotation, anionic collector, oleic acid

INTRODUCTION

Heavy metals can cause significant environmental and human health damage as a result of their toxicity. They are defined as metals that have specific gravity greater than about 4 or 5, but more often, the term heavy metals is simply used to denote metals that are toxic (Hg, Cd, As, Cr, Tl, Pb, Cu, Zn, Ni) (Abu Al-Rub et al., 2003). Many studies have shown that these metals are toxic, even at low concentrations. These toxic metals can cause accumulative poisoning, cancer, and brain damage when found above the tolerance levels.

Cadmium is mainly used as an anticorrosion coating in electroplating, as an alloying metal in solders, as a stabilizer in plastics, as a pigment and as a component of nickel-cadmium batteries (Jarup et al., 2000, Borjeson et al., 1997). Cadmium, like other heavy metals, is released into natural waters by industrial and domestic wastewater discharges (Mathialagan et al., 2003).

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In humans, cadmium is accumulated in the kidneys which will begin to malfunction at overdoses, spilling proteins in the urine and disrupting potassium metabolism (Prankel et al., 2005). The harmful effects of cadmium include a number of acute and chronic disorders, such as renal damage, emphysema, hypertension, and testicular atrophy (Huang et al., 1978). It is well known that chronic cadmium toxicity has been the cause of Japanese Itai–Itai disease (Kjellstrom, 1992).
This paper investigates the possibility to remove cadmium by flotation from dilute solutions by using oleic acid as anionic collector. The influence of pH, molar ratio of oleic acid, air flow rate, flotation tine, initial cadmium concentration and temperature on the cadmium removal are analysed.

MATERIALS AND METHODS

Chemicals:

- Cadmium chloride ($CdCl_2 \cdot 2,5H_2O$ p.a.) stock solution (2 g Cd(II)/dm^3) from which were prepared solution with 100 mg Cd(II)/dm^3;
- anionic collector (oleic acid) 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, 3,3 cm inner diameter glass flotation column (60 cm in height) with porous glass frit (porosity G_4).
From stock solution with 2 g Cd(II)/dm^3 there were prepared solution with 100 mg Cd(II)/dm^3, the pH was adjusted to the desired value by adding NaOH or HNO_3 and than it was added the collector, oleic acid. The resulted solution was submitted to flotation.
The main parameters influencing this process were studied: pH of Cd(II) solutions, molar ratio collector:Cd(II), air flow rate, time, temperature and initial concentration of Cd(II) in sample. An atomic absorption spectrophotometer PYE UNICAM model SP 1900 was used to determine the cadmium content of the solutions.
The cadmium removal efficiency, R%, was calculated with the relation:

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

where: C – concentration of Cd(II) after flotation;
C_0 – initial concentration of Cd(II) in solutions.

RESULTS AND DISCUSSIONS

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 cadmium removal efficiency, (R%) and on the cadmium concentration after flotation, (Cd(II)rez. (mg/dm^3)).

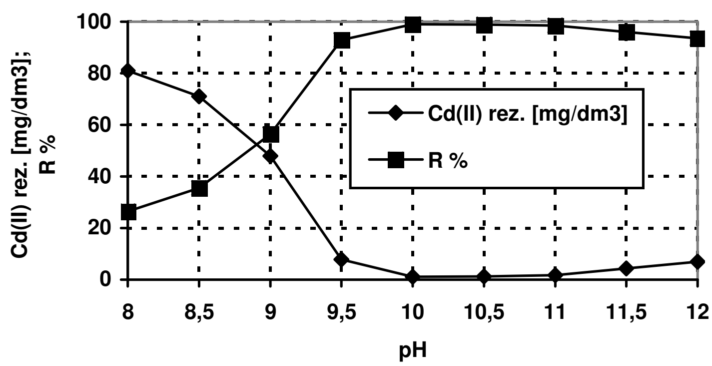

Figure 1. Influence of pH on the cadmium removal efficiency:
Molar ratio oleic acid:Cd(II)=1; air flow rate=15 dm^3/h, flotation time=15 min.

It can be seen that the flotation of cadmium ions, with oleic acid as collector, begins at pH = 8, but a good separation efficiency is obtained at pH values greater than 9,5. At this pH values Cd(II) precipitates as hydroxide and flotation is a precipitate flotation process.

The second studied factor was the effect of the molar ratio oleic acid:Cd(II). As surfactant was used oleic acid 0,25 M 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 oleic acid:Cd(II) determines a fast increase of removal efficiency

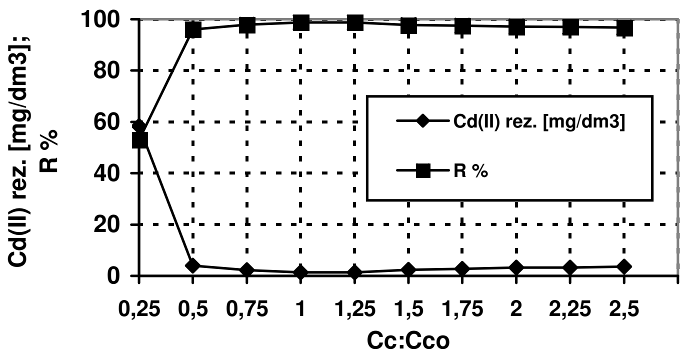

Figure 2. Effect of molar ratio oleic acid:Cd(II) on the cadmium removal efficiency: pH=10; air flow rate=15 dm^3/h, flotation time=15 min.

The influence of air flow rate on Cd(II) removal efficiency is shown in Figure 3. The maximum separation efficiency (over 98%) was obtained at low air flow rates. By increasing the air flow rate over 15 dm^3/h, it can be seen a decrease of removal efficiency, but however not under 95%.

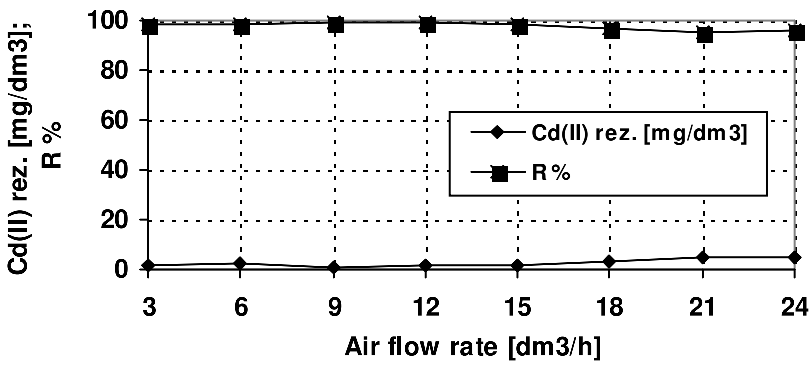

Figure 3. Effect of air flow rate on the cadmium removal efficiency: pH=10; molar ratio oleic acid:Cd(II)=1, flotation time=10 min.

The influence of flotation time on Cd(II) removal efficiency is shown in Figure 4. The separation process is very fast. In only 3 minutes is achieved a removal efficiency of 95%, and increasing the flotation time over 10 minutes the efficiency is more than 99%.

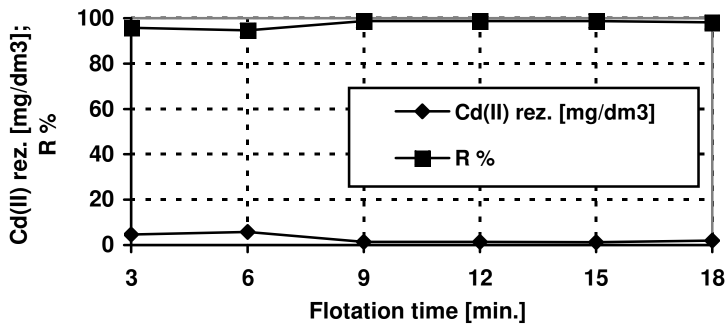

Figure 4**.** Effect of flotation time on the cadmium removal efficiency: pH=10; molar ratio oleic acid:Cd(II)=1, air flow rate=15 dm^3/h

Another factor influencing the flotation process is the initial concentration of Cd(II) in solution. The results are shown in Figure 5. By decreasing Cd(II) concentration it can be observed a slow decrease of removal efficiency, until 93%.

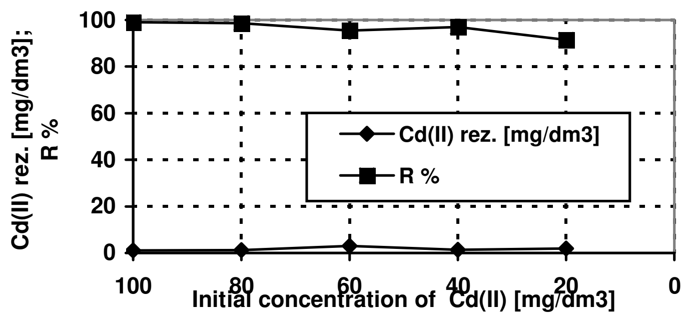

Figure 5. Cadmium initial concentration effect on the removal efficiency: pH=10; molar ratio octadecilamine:Cd(II)=1, air flow rate=15 dm^3/h, flotation time=10 min.

The temperature influence was also studied in interval 20 – 60°C and we found out that the removal efficiency was not significant modified for this interval of temperature (Figure 6).

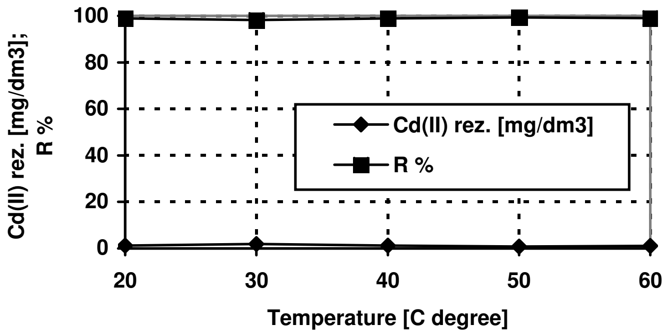

Figure 6. Effect of temperature on the cadmium removal efficiency: pH=10; molar ratio octadecilamine:Cd(II)=1, air flow rate=10 dm^3/h, flotation time=10 min.

CONCLUSIONS

High removal efficiency (>99%) of Cd(II) from dilute aqueous solutions has been obtained by applying the precipitate flotation process, at relatively shorter time than those used within other removal methods.

The optimal conditions for cadmium removal from synthetic solutions are: pH = 10 – 11; Molar ratio oleic acid:Cd(II) = 1; Air flow rate = 3 dm^3/h; Flotation time =9 -12 min.; Initial concentration of Cd(II) =40-100 mg Cd(II)/dm^3; Temperature =20 – 60^{o}C

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