TRANSPORTATION OF ZINC(II) IN BULK LIQUID MEMBRANES CONTAINING PHOSPHONIUM IONIC LIQUID

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Abstract

Investigations on trihexyl(tetradecyl)phosphonium chloride as selective carrier to remove zinc(II) from HCl solution in bulk liquid membrane system were carried out. The use of trihexyl(tetradecyl)phosphonium chloride as a selective carrier of zinc(II) in the membrane process is disadvantageous. Zinc(II) and the carrier form strong bounded ionic pair that makes zinc stripping very difficult. And the obtained zinc(II) concentration in the stripping phase is small, what disqualifies the use of the system on a larger scale.

1. INTRODUCTION

The undertaken investigation of ionic liquids as selective zinc ion carriers in the extraction process proved to be very promising and even a small addition of these compounds causes very effective recovery of that metal [1].

The extraction process in liquid-liquid system is connected with necessity of in- between operations, e.g: scrubbing of the organic phase before the stripping. It causes energetic outlay expansion and the possibility of environment pollution.

The use of systems with liquid membranes (LMs) is more effective method than the classic extraction. LMs offer a possibility of applying new and more effective extractants. Moreover, using supported or emulsion membranes the ratio between active substance and feed is very low.

The process course investigation at a supported (SLM) or emulsion (ELM) membrane is difficult, e.g: problem with analysis of stripping phase in case of ELM [2]. It is the aim of the work to investigate the application of trihexyl(tetradecyl)phosphonium chloride (classified as ionic liquid) for removal of zinc(II) from HCl solution in bulk liquid membrane system.

2. EXPERIMENTAL

An initial zinc(II) solution with the following composition: 5 g/dm^3 (0.077 M) Zn(II), 1.8% (0.58 M) HCl, 5 M Cl^- (adjusted with NaCl), was submitted to a membrane process. 0.2 M trihexyl(tetradecyl)phosphonium chloride solution in toluene was used as a membrane solution [3]. Fig.1 represents the structure of this compound. Solutions of 1 M Na_2SO_4 and H_2SO_4 were used as a stripping solution.

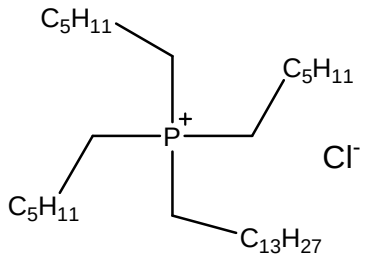

Fig. 1. The structure of trihexyl(tetradecyl)phosphonium chloride.

Investigations were made in double Lewis cell presented in Fig. 2. The device is built of two cylinders connected with bridge. All three phases of the system were stirred with minimal speed to avoid disturbances.

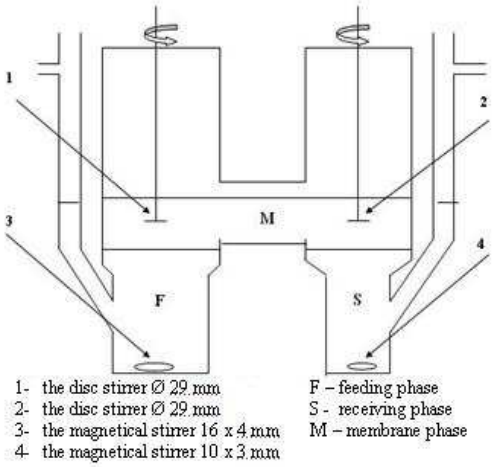

Fig. 2. The scheme of double Lewis cell.

The process was carried out for 24 hours. During the process samples of feed and stripping phase (2 cm^3) were collected every 30 minutes and after that both phases were replenished with equivalent amount of initial solutions. Zinc ions were indicated complexometrically with EDTA in the presence of eriochrom black T as an indicator.

3. RESULTS

The achieved results are used to create a profile graph of the change of zinc(II) concentration in individual phases of the system during the membrane process (Figs. 3 and 4).

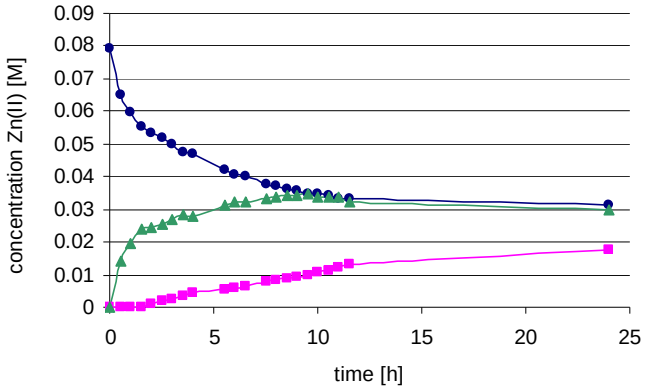

Fig. 1. Concentration of zinc(II) in bulk liquid membrane process when 1 M H_2SO_4 was used as a strip phase (● - feed, ▲ – membrane, ■ – strip).

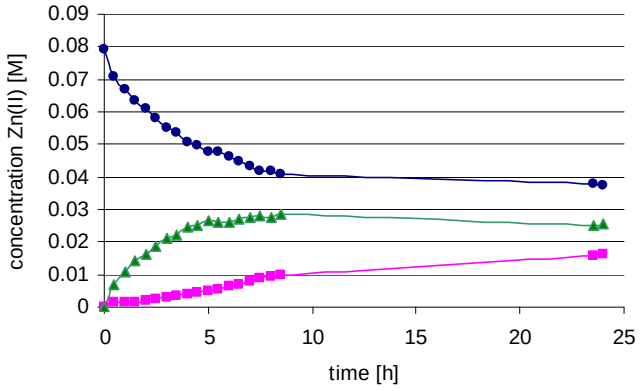

Fig. 2. Concentration of zinc(II) in bulk liquid membrane process when 1M Na_2SO_4 was used as a strip phase (● - feed, ▲ – membrane, ■ – strip).

During first hours of the process there is a sharp decrease in zinc(II) ion concentration in the feed due to fast loading of the organic phase. The transport of zinc(II) ions to the stripping solution takes place after the loading of the organic phase. After 10 hours no significant change in zinc concentration is observed. The most visible changes take place during first 5-7 hours, when the biggest decrease in zinc(II) ion concentration in feed

and the highest increase in the stripping phase appear. During the next 24 hours the system is slowly approaching to equilibrium state. The stripping does not depend on the stripping solution used (Na_2SO_4 or H_2SO_4).

The extraction process in bulk liquid membrane system with trihexyl(tetradecyl)phosphonium chloride as a carrier takes place quickly and soon after a few hours equilibrium state is achieved. The mechanism of zinc ion transport with the studied carrier is probably similar to base extractants and can be described with ion-exchange equation as fallows:

$$ZnCl_4^{2-}{}_{(w)} + 2H^+{}_{(w)} + 2[R_3R'P^+][Cl^-]_{(o)} \leftrightarrow$$
$$[(R_3R'P^+)_2][ZnCl_4^{2-}]_{(o)} + 2H^+{}_{(w)} + 2Cl^-{}_{(w)}$$

The stripping from the membrane to the stripping phase is slow and limits the rate of the whole process. The concentration of the zinc(II) ions in the stripping phase is constant and it does not depend on the concentration in the feed.

4. CONCLUSIONS

Resuming all achieved results we can state that the use of trihexyl(tetradecyl)phosphonium chloride as a selective carrier of zinc(II) in membrane process is disadvantageous. Zinc(II) and the carrier form strong bounded ionic pair that makes zinc stripping very difficult. And the obtained zinc(II) concentration in the stripping phase is small, what disqualifies the use of the system on a larger scale.

Acknowledgement

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