The extraction of nickel with the use of supported liquid membrane capsules

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Abstract

In the past few years there has been an increase in environmental awareness. This has forced industries to be more careful with the waste they generate. The cleaning and upgrading of metal-containing wastes have become a very demanding assignment. The reclamation of nickel from waste streams has the additional advantage that it is a very valuable metal and the process can be profitable. A new approach to supported liquid membrane extraction, whereby the strip solution is encapsulated within a microporous membrane capsule, was used for the experiments. The capsule constitutes an unconfined reactor and does not have the disadvantage of anexcessively high-cost to configure the required packing density (mVm^3). The capsule has the additional advantage that very high acid concentrations ban be used in the strip solution without the risk of high corrosion.

The research shows that there is a correlation between the extraction of nickel with capsule membrane- and supported liquid membrane extraction, except at high acid strip concentrations, where osmosis occurs. Extraction of 95 g/m^2 was obtained at an initial rate of 10 g/m^2-h.

Nomenclature

AA	Atomic absorption spectrophotometer
A_{mem}	Area of membrane capsule
Cir_{mem}	Circumference of membrane capsule
D2EHPA	Di-2(ethylhexyl) phosphoric acid
Ex	Extractant
Extr	Extraction of nickel
Rate	Rate of nickel extraction
SLM	Supported liquid membranes
CME	Capsuled membrane extraction

Introduction

In the past few years there has been an increase in environmental awareness. This forced industries to be more careful with the waste they generate. The removal and upgrading of metal-containing waste have become not only a very demanding assignment but a lucrative business. The reclamation of nickel from waste streams is no exception. Nickel has the additional advantage that it is a very valuable metal (R32.38/kg (Anon., 1995)).

Supported liquid membranes represent an attractive alternative to liquid-liquid extraction for the selective removal and concentration of metal ions from solution. The permeation of metal species through SLMs can be described as the simultaneous extraction and stripping operation combined in a single stage. A thin layer of an organic extraction reagent (extractant) is immobilised in a microporous inert support. This support is interposed between the feed solution (aqueous phase), in which the valuable metal is dissolved and the second (stripping) phase, in which enrichment of the metal occurs by transmembrane diffusion (Erlank, 1994).

The biggest obstacle for the use of SLMs to extract ionic species is that the sophistication of the various SLM reactors implies high costs to manufacture, maintain and operate. The advantage of CME is that the concept of an unconfined reactor is introduced, which implies that no fixed geometry (reactor containment) is required. An unconfined reactor is thus not restricted to a certain location or geometry. The capsules can be transferred to a different location while extracting the nickel. The capsule has the additional advantage that very high acid or alkaline concentrations can be used in the strip solution without the risk of high corrosion to the reactor.

A big disadvantage of SLM is the loss of the extractant from the membrane structure. This is a minor problem with the extraction of nickel, because both the extractant (di-2(ethylhexyl) phosphoric acid) and the membrane (Celgard® 4510) are highly hydrophobic.

The purpose of this research was therefore to determine the influence of conditions like the pH and nickel concentration of the feed solution and the hydronium and nickel concentration of the strip solution on capsulated membrane extraction. Another objective was to determine the optimum extractant concentration and the influence of the above-mentioned conditions on this optimum. These results could be used to determine the similarity (if any) between CME and SLM.

Experimental

The membrane capsule

The capsule configuration was used for the experiments (Erlank, 1984). The membrane was folded double and a hot wire sealer was used to seal all the edges, except for one. The capsule was then impregnated by leaving the capsule in the extractant and allowing the extractant to load into the membrane pores. The excess extractant (on the outside) was removed by blotting. The capsule was filled with strip solution at the open edge and then completely sealed. The capsules varied in size, but had an average dia. of approximately 40 mm (refer to Fig. 1). The average contact area of a membrane capsule is approximately 26 cm^2. A string was used to keep the capsule suspended in the bulk aqueous feed solution

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