CHAPTER

4

RECOVERY OF METAL USING SYNERGISTIC STRIPPING AGENT

Norul Fatiha Mohamed Noah, Sazmin Sufi Suliman, and
Muhammad Abbas Ahmad Zaini

4.1 INTRODUCTION

In the emulsion liquid membrane (ELM) process, stripping or recovery performance is taken into consideration, especially for precious and valuable metals such as silver, chromium, and zinc (El-Said et al., 2003; Suliman et al., 2023). The selection of a suitable stripping agent is considered to be one of the key factors in designing an effective ELM. During the process, the complex of metals-carrier will form at the external interface and diffuse through the membrane into the internal interface. Metals are released into the internal phase at the internal interface through a reaction known as stripping, and the "free carrier" diffuses back into the membrane phase. The stripping agent should have high selectivity towards metals. If the stripping agent fails to function, the solutes will accumulate and be trapped inside the pore of the membrane phase. The stripping agents are incorporated in the internal phase and can be either acid or base, depending on the species to be extracted.

In order to formulate a synergistic stripping agent, liquid-liquid extraction is utilised. The procedure for the selection of stripping and synergist stripping agents is illustrated in Figure 4.1.

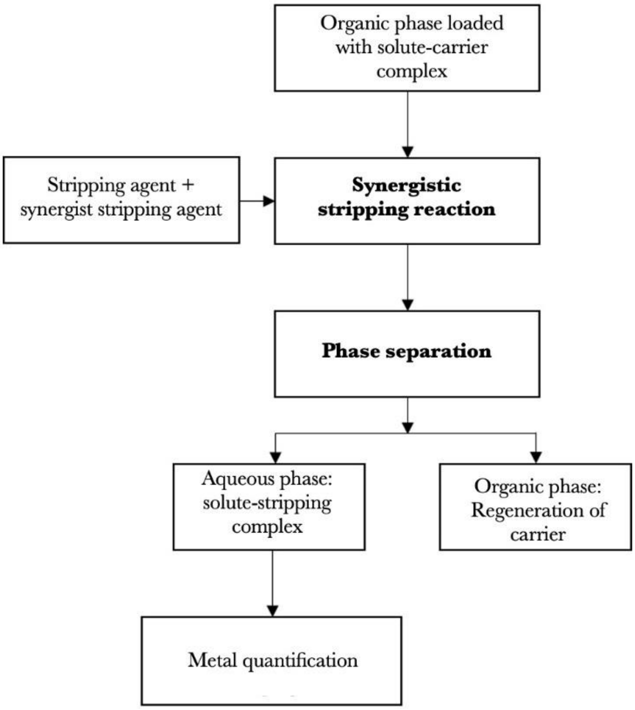

Figure 4.1 Synergistic stripping process

For years, researchers used single-stripping solutions such as thiourea or acid solution as a stripping agent. These single-stripping agents, while valuable, often exhibited limitations in terms of their efficiency and selectivity (Davoodi-Nasab et al., 2019; Khan et al., 2022). This leaves space for innovation and optimisation. Of late, synergistic stripping solutions have attracted considerable attention. It is acknowledged that the stripping efficiency of metals in the loaded membrane phase can be enhanced by applying synergistic stripping agents of thiourea mixed with an acidic solution. The recovery of silver using acidic thiourea was investigated by Jusoh et al. (2022) employing response surface methodology, and it was found that 82% of silver was successfully recovered under optimised conditions. Although Gupta et al. (2011) previously utilised acidic thiourea in their research, no studies on recovery have been reported. Nevertheless, this suggests that acidic thiourea enhances extraction and the stability of the ELM process.

Thiourea is an interesting class of ligands and can form a stable coordinated complex with noble metals in various pathways i.e. neutral, mono/dianionic ligands, monodentate or chelating ligands. Thiourea is a good nucleophilicity ligand owing to its two donor atoms in the molecule (S and N). Thiourea has a soft nature and has been shown to selectively trap noble metals in extraction and stripping processes. It has been acknowledged that thiourea is effectively coordinated through sulphur atoms with noble metals such as silver and zinc. Much research has been conducted on metals recovery using thiourea ligand (Fajar et al., 2019). Combining thiourea and acid solutions such as hydrochloric, sulphuric, and nitric acid in the internal phase of an extraction process can offer several potential benefits such as enhanced metal recovery, increased selectivity, and improved efficiency.

4.2 SYNERGISTIC STRIPPING IN ELM PROCESS

Based on previous studies, Suliman et al. (2022) conducted zinc ELM extraction using D2EHPA-Cyanex 302 as carriers, blended Tween 80 and Span 80 as surfactants, and palm oil as the diluent, achieving a 93.14% extraction efficiency. Additionally, Noah et al. (2016) reported a 97% palladium extraction using a formulation of Cyanex 302 as the carrier, Span 80 as the surfactant, and kerosene as the diluent. Similarly, Sulaiman et al. (2016) achieved a 99% nanosilver extraction using a formulation of Cyanex 302 as carriers, Span 80 as the surfactant, and kerosene as the diluent. Furthermore, Noah et al. (2020) performed chromium extraction using a formulation of Aliquat 336 as the carrier, Span 80 as the surfactant, and palm oil as the green diluent, achieving a 99% extraction performance. These studies were subsequently extended to investigate the stripping performance for the recovery of the extracted metals.

In order to perform the ELM process, a simulated feed phase such as zinc (50 ppm), palladium (10 ppm), nanosilver (5 ppm), silver (2490 ppm), and chromium (40 ppm) was prepared by dissolving desired amounts of targeted solute in 1 L of distilled water to investigate the recovery of the targeted solute in the internal phase. Atomic absorption spectroscopy