

N°220 / OC / PC

TOPIC(s) : Chemical engineering / Alternative solvents

Intensifying solvent extraction of Co/Ni with undiluted ionic liquids in milliflow systems

AUTHORS

Joren VAN STEE / KU LEUVEN, CELESTIJNENLAAN 200F, HEVERLEE

Koen BINNEMANS / KU LEUVEN, CELESTIJNENLAAN 200F, LEUVEN

Tom VAN GERVEN / KU LEUVEN, CELESTIJNENLAAN 200F, LEUVEN

PURPOSE OF THE ABSTRACT

Over 60 metallic elements, e.g., cobalt and neodymium, are involved in the electrification of our energy system, making them of great economic and environmental importance [1]. Recovery often involves several liquid-liquid contacting steps between an organic solvent and aqueous solution containing the metallic elements, i.e., solvent extraction (SX). The latter is a well-established technology, however, difficult separations and mass transfer limitations can result in large solvent volumes and industrial units. Extensive research has been dedicated to better phase contacting solutions and solvents to improve the energy requirements, economics and safety aspect of SX. Despite, integrating both aspects is yet to be investigated.

In the last years, the use of undiluted hydrophobic ionic liquids (ILs) has shown great potential in terms of selectivity, loading capacity and distribution ratio compared to conventional solvents [2], [3]. In theory, this could imply a reduction in solvent volume ranging between 50-80%. Regardless, industrial applications have yet to emerge because the viscosity of these ILs can be up to three orders of magnitude larger than conventional solvents. This makes it difficult to implement undiluted ILs in the currently available industrial liquid-liquid contacting technology (e.g., mixer-settlers).

Similarly, extensive research has been done to improve mass transfer in biphasic systems over the past decennia to reduce unit sizes. Milliflow systems, i.e., continuous flow systems with a characteristic length (e.g., inner tube diameter) of 1 mm or smaller, have shown great potential. A significant improvement is achieved due to the increase of specific surface area and internal circulations patterns. The latter occurs in the so called slug-flow regime, which is shown in Figure 1. Prior research with a toluene-water system achieved a mass transfer rate 2.5 times faster in a milliflow system compared to a mixer-settler [4]. Finally, it is noted that milliflow systems can deal with higher viscosity differences between fluids in biphasic systems [5].

Handling highly viscous fluids and improving mass transfer (with respect to mixer-settlers) is the rationale for implementing solvent extraction of the described ILs in milliflow systems. This study investigates the separation of cobalt-nickel from a hydrochloric acid solution in the latter. A feed solution containing Co and Ni, each between 1-30 g/L, is contacted with the IL-phase in a milliflow system. Subsequently, the extraction efficiency and mass transfer rates are determined in terms of feed concentration, flow rate and residence time. The results show that, for residence times shorter than 1 minute, Co can be selectively extracted (selectivity factor > 40 000) with an extraction efficiency exceeding 99%. This is a major improvement compared to prior research with mixer-settlers, that required a residence time of over 30 minutes [3]. Therefore, it is concluded that milliflow systems, together with ILs, show great potential to intensify solvent extraction in hydrometallurgical processes.

FIGURES

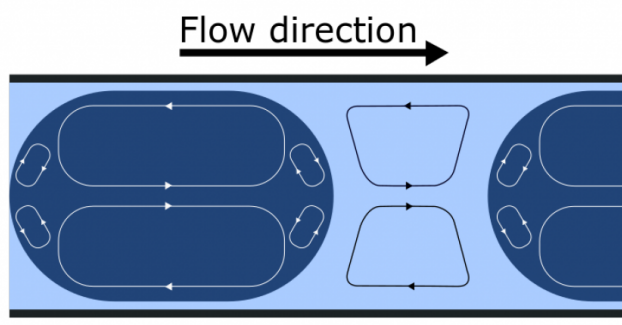


FIGURE 1

Slug flow in a milliflow system. Internal circulation patterns are present in both phases, enhancing mass transfer.

-

FIGURE 2

KEYWORDS

Milliflow systems | Solvent extraction | Ionic liquids | Process intensification

BIBLIOGRAPHY

- [1] S. J. Zepf V., Reller A., Rennie C., Ashfield M., *Materials critical to the energy industry. An introduction*. 2nd ed. BP, 2014.
- [2] S. Wellens, B. Thijs, and K. Binnemans, *Green Chem.*, vol. 14, no. 6, pp. 1657–1665, 2012.
- [3] S. Wellens, R. Goovaerts, C. Möller, J. Luyten, B. Thijs, and K. Binnemans, *Green Chem.*, vol. 15, no. 11, pp. 3160–3164, 2013.
- [4] J. J. John, S. Kuhn, L. Braeken, and T. Van Gerven, *Chem. Eng. Process. Process Intensif.*, vol. 102, pp. 37–46, 2016.
- [5] C. Yao, Y. Zhao, and G. Chen, *Chem. Eng. Sci.*, vol. 189, pp. 340–359, 2018.