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Extraction and Recovery of Valuable Metals from Wastewater Using Ionic Liquids

Enas Othman

enas.othman@wetsus.nl

Motivation

Water purification companies, chemical and mining industries produce numerous aqueous streams polluted with valuable (heavy) metal salts [1]. There is an environmental and economy-based incentive to recover these impurities from the water before reuse or discharge. Furthermore, it is challenging to selectively separate the different metal salts from each other.

One of the most widely used separation techniques is liquid-liquid extraction (LLE) as both capital and operational costs are relatively low [3]. The main disadvantage of LLE is however the use of toxic, flammable water-immiscible volatile organic solvents [2]. In order to improve the sustainability of the LLE process, an attractive alternative is the use of a new class of nature-based, water-immiscible extractants. These so-called hydrophobic ionic liquids (HILs) have much lower volatility, water-solubility and toxicity but a higher biodegradability compared to conventional volatile organic solvents.

In this research the initial focus is on the hydrophobic quaternary phosphonium-based ionic liquid tetraoctylphosphonium oleate [P8888][oleate], which will be synthesized and utilized for the extraction of cobalt chloride. This IL has been selected because:

1. it has the ability to selectively extract transition (Zn, Cu, Co, Mn, Ni etc) and rare-earth (La, Nd, Sm, Dy, Er, Yb etc) metal ions depending on pH,
2. it consists of hydrophobic anion and cation which minimize the loses to the aqueous phase,
3. it acts as both solvent (due to its relatively low viscosity of 200 mPa.s at room temperature) and extractant for the removal of metal ions.

Technological challenge

To develop an efficient continuous (multi-stage, countercurrent, regenerative) HIL-based LLE process for the selective recovery of metals from waste water. Even though the proof-of-principle already has been demonstrated [2,3], specific challenges of the present project are, first, in terms of economic viability 1) to extent the process duration from a single cycle (extraction - regeneration) to >1000 cycles, 2) to regenerate the loaded HIL effectively and 3) obtain the cobalt in the form of an economically attractive salt. Challenges in terms of sustainability are 1) to minimize the loss of HIL to the aquatic phase and 2) to either recover or break-down the minute amount of HIL that does escape to the water phase, the latter by UV and/or peroxide treatment.

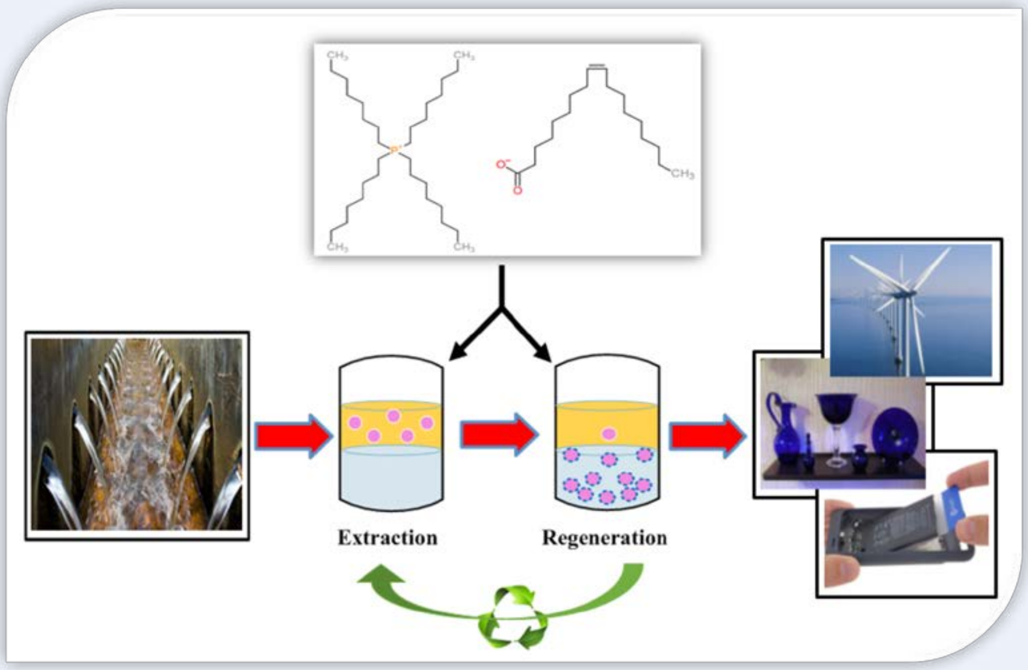

Fig.1 Research graphical abstract for metal extraction and recovery using ionic liquid

Research goals

The following process aspects will be tested and evaluated:

1. Developing, testing and optimizing the extraction and regeneration cycle using HIL for the extraction of cobalt chloride.
2. Definition of technical process parameters that allows up-scaling from lab to industrial scale.
3. Performing a technical and economical evaluation that allows a comparison with currently existing technologies.

References

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[3] Parmentier, D.; Vander Hoogerstraete, T.; Metz, S. J.; Binnemans, K.; Kroon, M. C., Selective Extraction of Metals from Chloride Solutions with the Tetraoctylphosphonium Oleate Ionic Liquid. *Industrial & Engineering Chemistry Research* **2015**, 54 (18), 5149-5158.

ir. E.A. Othman MSc, dr. H. Miedema,
dr.ir. L. van der Ham, prof.dr.ir. S. Kersten

UNIVERSITY OF TWENTE.