Selective Metal Separation Using Functionalised Ionic Liquids

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Rare earth metals are currently gaining importance in many every-day devices such as computer memory devices, screens, DVDs, catalytic converters and supermagnets. Due to the climate goals world-wide and the increasing use of electric and hybrid-electric vehicles, the need of rare-earth containing rechargable batteries will increase further in the near future. However, the concentration of these metals in ores are very low and the mining processes have negative impacts on the environment, leaving acids, heavy metals, uranium and fluorides back in the ground. Although recycling will not supply the whole demand for rare earth metals, it will at least reduce the need for mining and the so called "balance problem" of rare earth elements.[1] However, recycling from the current waste treatment processes is very complicated due to very low metal concentrations, complex matrix and various waste collection issues. A better way might be the collection of end-of-life, high concentrated rare earth materials directly from industry. Most promising materials are supermagnets, which make up 37% of the total value of the rare-earth elements market. The most commen ones are alloys of boron, iron and neodymium and the more temperature- and corrosion stable alloys of cobalt and samarium.

Common liquid-liquid extraction procedures usually involve an extraction agent and organic solvents, which are volatile and potentially environmentally hazardous. A potential alternative might be ionic liquids. Compared to organic solvents their vapour pressure is extremely low and their physical properties can be modified easily. Vander Hoogerstraete *et. al.* published promising results using *Tri*-hexyl-tetradecylphosphonium chloride as extractant.[2] However, the best separation was observed at strongly acidic conditions with relatively high amounts of the ionic liquid (1:1 volumetric ratio). Task-specific ionic liquids used as extraction media might improve this ratio.[3] Therefore, such ionic liquids should ideally have the following properties:

- High selectivity for a specific metal over other metals
- Good hydrophobicity for efficient and fast phase separation
- No transfer of cations/anions into the aqueous phase

We investigated a new task-specific ionic liquid, wherein the cation is functionalised with a hydroxamate group as metal-complexing species. Such complex contains both, the metal ion and the ionic liquid cation, which prefers to stay in the ionic liquid phase, even at less acidic conditions. The extraction efficiency for iron, cobalt, neodymium and samarium as well as the selectivity in Fe/Nd and Co/Sm systems was studied at different concentrations, mol fractions and pH. A very high selectivity for iron could be found, but Co and Sm separation seems to be possible as well.

[1] K. Binnemans, P. T. Jones, B. Blanpain, T. Van Gerven, Y. Yang, A. Walton, M. Buchert, *Journal of Cleaner Production*, **2013**, 51, 1.

[2] T. Vander Hoogerstraete, S. Wellens, K. Verachtert, K. Binnemans, *Green Chemistry*, **2013**, 15, 919.

[3] A. E. Visser, R. P. Swatloski, W. M. Reichert, R. Mayton, S. Sheff, A. Wierzbicki, J. H. Davis, Jr., R. D. Rogers, *Chemical Communication*, **2001**, 135.