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An instrumented microfluidic tool for complex fluid phase diagram determination: Inline and real-time exploration of solvent extraction.

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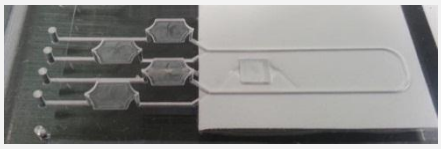
Liquid-liquid extraction, i.e. control of the reversible transfer of cations between phases, is a core chemical process for metal purification and recycling. The objective of the "REE-CYCLE" project (Rare Earth Element reCYCling with Low harmful Emissions)[1] is to develop the fundamental understanding of complex fluid processing in order to innovate environmentally friendly, economically competitive processes.

The presented work on micro-solvent-extraction takes this approach beyond the state-of-the-art[2]: An instrumented and computer-controlled microfluidic device is described, enabling the first steps towards fast measurement of the free energy of ion transfer between complex fluids[3]. Continuous screening of a manifold parameter set, including e.g. multi-component phase composition, pH, temperature, will be enabled by integrating inline, real-time measurements into a robotized lab-on-a-chip. Miniaturized spectroscopic and sensing methods will allow automated characterization of kinetics/thermodynamics, partition coefficients, chemical potential differences and constituent's activity coefficients.

First results of the microfluidic device, compared to batch mode assays, are presented concerning temperature and pH variation. Examples are shown on N,N,N′,N′-tetraoctyl-3-oxapentane-1,5-diamide (TODGA) reverse micelles diluted in dodecane for lanthanide extraction in the presence of iron. Partition coefficients and kinetics data for different parameters are addressed and resulting pathways explored to enhance separation and selectivity. First data on solvent activity coefficient measurements will also be presented, giving insight on molecule aggregation[4], constituents' chemical potentials and solvent vapour pressure.



Microfluidic device with on-line measurement sites.

[1] www.icsm.fr and http://reecycle-erc.blogspot.fr
[2] D. Ciceri et al., J Chem Technol Biotechnol. 89(2014)771–786.
[3] T. Zemb et al., Colloid Polym Sci. Thomas Graham medal lecture. 293(2015)1–22.
[4] R.G. French et al., Rev Mod Phys. 82(2010)1887.