# Solvent Extraction for Metal Recovery: Composition and Distribution of Organic and Ionic Species at the Water/Oil Interface

*Xiaochuan Ma [a], Coralie Pasquier [a], Maria Boltoeva [a], Pierre Bauduin [a], Jean-Francois Dufrêche [a], Jean Daillant [b], Olivier Diat [a] and Luc Girard [a]*

*[a] ICSM, CEA, CNRS, ENSCM, Montpellier University, Bagnols sur Cèze, France, [b] ESRF, Grenoble, France*

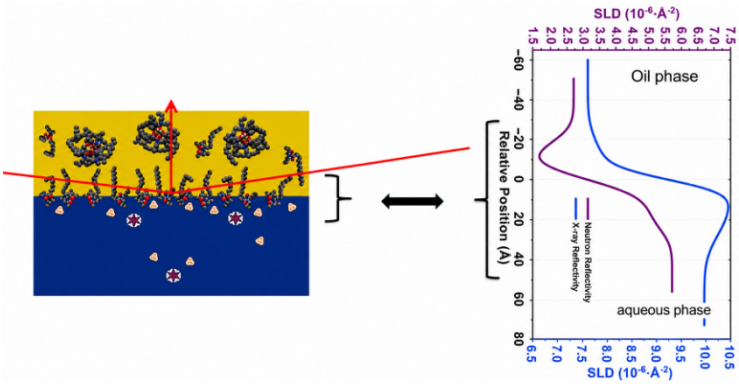
*luc.girard@enscm.fr*

Liquid–liquid extraction of metal ions relies on the difference in affinity of a solute between two immiscible phases and is widely used for the selective recovery of critical and valuable metals from industrial wastes. In this process, an amphiphilic phase-transfer agent (ligand or extractant) is typically added to the organic phase to promote the selective transfer of metal ions.[1]

When the complexation energy between the ligand and the metal ion is weak and the solubilization of the complex in the organic phase depends on ligand aggregation,[2] the structural organization of ligands at the water/oil interface becomes a key factor controlling ion-transfer kinetics.[3] A detailed understanding of the supramolecular structure of these interfaces is therefore essential for rationalizing and predicting extraction mechanisms.[4] However, experimental information at the nanoscale remains scarce due to the difficulty of probing fluctuating buried liquid–liquid interfaces. [3b, 3c, 5] Over the past decade, we have combined neutron and X-ray reflectivity (with nonlinear optical techniques and molecular dynamics simulations) to investigate the structure of ligand-containing liquid–liquid interfaces without imposing prior assumptions on ligand organization. We will present results showing that the extractant system—particularly diamide and monoamide ligands—controls the formation of either a sharp interface or an extended interphase, with direct implications for ion-transfer kinetics.

These findings provide new insights into the interfacial organization governing ion transfer in liquid–liquid extraction systems and perspectives using scattering techniques, non-linear optical technique and molecular dynamics [6] will be also proposed and detailed.

**Keywords:**
liquid-liquid interfaces, ion transfer, reflectivity




*Left: Schematic of a liquid–liquid interface in solvent extraction probed by X-ray or neutron reflectivity. Right: SLD profile normal to the interface for a system with an amide ligand in oil and uranyl nitrate in water. Neutrons probe organics, X-rays probe ions.*

**References:**

[1] J. Rydberg et al, Solvent extraction principles and practice. (Marcel Dekker, New York, 2004)
[2] D. Bourgeois et al, Current Opinion in Colloid & Interface Science, 46 (2020), pp. 36–5;
[3] a) Z. W. Zhu and C. Y. Cheng, Hydrometallurgy 107 (1-2), 1 (2011); b) E. Scoppola et al, Angewandte Chemie. 2016, Vol. 128; E. Scoppola et al, Phys. Chem. Chem. Phys. 2015, Vol. 17; c) X. Ma J. Phys Chem B (2026) to be submitted
[4] O. Diat et al, Current Opinion in Colloid & Interface Science, (2026) submitted
[5] W. Bu et al, J. Phys Chem B 118 (2014) 12486-12500
[6] J. Wang et al, J. Phys Chem C 124 (2020) 10916-10923