Liquid-solid extraction of metallic cations by cationic amphiphiles

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In the field of selective metal ion separation, liquid-liquid extraction is usually conducted through an emulsion mixing of hydrophobic complexants dispersed in an organic phase and acidic water containing the ionic species. Recently, it has been shown that amphiphilic complexants could influence strongly extraction efficiency by enhancing the interfacial interaction between the metal ion in the aqueous and the complexant in the organic phase. Moreover, these amphiphiles can also substitute the organic phase if an appropriate aliphatic chain is chosen. The dispersion of such amphiphilic complexants in an aqueous solution of salt mixtures is not only attractive for studying specific interactions but also to better the understanding of complex formation in aqueous solution of multivalent metal ions, such as lanthanides and actinides. This understanding is of potential interest for a broad range of industries including purification of rare earth metals and pollute treatment e.g. of fission by-products.

This principle can also be applied to liquid-solid extraction, where the final state of the separation is a solid phase containing the selectively extracted ions. Indeed, a novel solid-liquid extraction method exploits the selective precipitation of metal ions from an aqueous salt mixture using a cationic surfactant, below its Krafft point (temperature below which the long aliphatic chains of surfactant crystallize – see figure) [1]. This technique has been proven to be highly efficient for the separation of actinides and heavy metal using long chain ammonium or pyridinium amphiphiles.

The most important point in this process is the recognition of cationic metal ions by cationic surfactants. By computing the free energy of the polar head group per micelle as a function of the different counter-anions, we have demonstrated for the first time that different interactions exist between the micellar surface and the ions. These interactions depend on the nature of the cation but also on hydrophobicity of the anions [2]. Using multivalent cations, we demonstrated that the hydrophobicity of the anionic complex (of the anionic counter-ions and the metal cations) is of importance to tune the selectivity of liquid/solid extraction.