

SEPARATION OF METAL IONS BY LIQUID-LIQUID EXTRACTION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation-in-Part of International Application No. PCT/US2017/048934, filed Aug. 28, 2017, designating the U.S. and published as WO 2018/097871 A2 on May 31, 2018, which claims the benefit of U.S. Provisional Application No. 62/505,458, filed on May 12, 2017 and 62/401,687, filed on Sep. 29, 2016, which is hereby incorporated by reference in its entirety. Any and all applications for which a foreign or a domestic priority is claimed is/are identified in the Application Data Sheet filed herewith and is/are hereby incorporated by reference in their entireties under 37 C.F.R. § 1.57.

STATEMENT REGARDING FEDERALLY SPONSORED R&D

[0002] The invention was made with government support under Contract No. DE-AC02-05CH 11231 between the U.S. Department of Energy and the University of California. The government has certain rights in the invention. This work was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, Chemical Sciences, Geosciences, and Biosciences Division at LBNL under Contract DE-AC02-05CH11231.

BACKGROUND

Field

[0003] The present disclosure is related to separation processes for metal ions.

Description of the Related Art

[0004] Owing to concerns related to global warming due to CO₂ emission by traditional energy sources, nuclear energy has emerged as an alternative energy source. However, disposing of nuclear waste is a major challenge.

[0005] A few processes, using liquid-liquid extraction, are under development with limited success in term of selectivity and efficacy: TALSPEAK process (USA), GANEX process (France), and DIAMEX-SANEX process (France). The purification of the element actinium (Ac³⁺) is also catching growing attention. In fact, actinium isotopes are emerging radioactive sources for cancer treatments such as the “targeted alpha therapies.” The methods of production of Ac³⁺ isotopes generate Ln³⁺ fission products in addition to the initial material that is usually made of thorium (Th⁴⁺). Current purification protocols for actinium involve numerous chromatographic steps that require different chemical media in order to obtain a purified fraction of Ac³⁺.

SUMMARY

[0006] In some embodiments, a method of processing spent nuclear fuel is provided. This comprises obtaining spent nuclear fuel dissolved in an acidic medium, contacting the dissolved spent nuclear fuel with an octadentate ligand and an organic phase to generate a mixture, and separating an aqueous phase enriched for Pu⁴⁺ from the mixture.

[0007] In some embodiments, a method for enriching a metal ion is provided. The method comprises contacting a

first aqueous phase with an organic phase to generate a mixture, wherein the first aqueous phase comprises: a plurality of metal ions; and an octadentate ligand, and wherein the aqueous phase has an acidic pH of less than 1. The method further includes separating from the mixture a second aqueous phase enriched for a metal ion of the plurality of metal ions.

[0008] In some embodiments, a method of preparing a medical isotope is provided. The method comprises obtaining a metallic precursor dissolved under an acidic condition, wherein the metallic precursor comprises a medical isotope; contacting the dissolved metallic precursor with an octadentate ligand and an organic phase to generate a mixture; and separating the medical isotope from one or more metal ions in the dissolved metallic precursor based on an interaction between the octadentate ligand and the medical isotope.

[0009] In some embodiments, a method of separating metal ions for nuclear forensics is provided. The method comprises obtaining a sample derived from a nuclear material, wherein the sample comprises UO₂²⁺, Ac³⁺, Pu⁴⁺, and Np⁴⁺; contacting the sample with an octadentate ligand to generate a first mixture, wherein the first mixture has an acidic pH of 1 or lower; separating UO₂²⁺ and Ac³⁺ from Pu⁴⁺ and Np⁴⁺ in the mixture based on an interaction or lack of interaction between the octadentate ligand and each of UO₂²⁺, Ac³⁺, Pu⁴⁺, and Np⁴⁺, to generate a second mixture comprising the Pu⁴⁺ and Np⁴⁺; and further separating each metal within both mixtures by classical techniques.

[0010] In some embodiments, a method of separating metal ions is provided. The method comprises contacting a liquid composition comprising a plurality of metal ions with an octadentate ligand to generate a mixture, under conditions sufficient to form a metal ion-ligand complex comprising a metal ion of the plurality of metal ions, and separating a first fraction of the mixture enriched for the metal ion-ligand complex from a second fraction depleted for the metal ion-ligand complex, wherein the first fraction of the mixture has an acidic pH of less than 1. The plurality of metal ions are selected from the group consisting of: a p-, d- or f-block element of period 5 or greater, a group 3 element, or a group 4 element

[0011] In some embodiments, a method of separating trivalent metal ions from tetravalent metal ions is provided. The method comprises providing an aqueous solution comprising tetravalent metal ions and trivalent metal ions, wherein the solution has an acidic pH; adding a HOPO chelator to the aqueous solution; and performing an extraction against the aqueous solution, wherein the HOPO chelator functions as a holdback agent to keep the tetravalent metal ions in the aqueous solution, while allowing the trivalent metal ions to be removed via decanting at the end of the extraction.

[0012] In some embodiments, a method for separating metal ions is provided. The method comprises providing an aqueous solution comprising a first metal ion and a second metal ion, wherein the solution has an acidic pH; adding a HOPO chelator to the aqueous solution; and performing an extraction against the aqueous solution. The HOPO chelator functions as a holdback agent to selectively keep the first metal ion in the aqueous solution, while allowing the second metal ion to go into an organic phase during the extraction.