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Purification of Uranium from acidic liquid wastes and ore solutions by selective hybrid materials

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IAEA reports forecast an important growth of energetic demand in the next decades. Indeed expansion of industrial countries rapidly emerging such as China or Brazil gets through a reinforcement of power capacity production. Nowadays, they use thermal power stations which are known for their high carbon impact. Therefore, to overcome this problem, development of nuclear power stations is fundamental. Thus, availability of Uranium as raw material appears as one of overriding issue in the next decades. However, to preserve its reserves and limit environmental footprinting, it is necessary to improve the front end purification and recycling processes.

In this case, solid phase extraction could be a smart alternative way to avoid the use of organic solvent. Moreover this technic is well adapted for low grade uranium solution. Actually, organic resins are widespread but they suffer from a weak chemical resistance and irreversible adsorption. To get around these drawbacks we investigate hybrid mesoporous silicas as efficient materials to recover selectively the uranium from acidic solutions to be used as nuclear fuel. Indeed, hybrid materials based on mesoporous silica coupling inorganic and organic properties with a very large specific surface areas, tuneable pore sizes and specific reactivity. Typical surface areas are spread from 500 to 700 m²/g and pore sizes range from 5 to 15 nm. The synthesis of mesoporous silicas is performed according to a sol-gel process: hydrolyse and condensation of an inorganic precursor occur around surfactant that acts as a structuration template. Then calcination leads to a silica mesoporous material with a narrow pore size distribution. By post-grafting method, the surface could be functionalized by complexing compounds leading to precise applications.

The purpose of these silicas being to fix selectively uranium, organic ligands showing a higher affinity to uranyl ions than acidic counterions are studied. The combinations of amido and phosphonate groups are well known for their affinity with actinides. We adapt this result to design a tridentate ligand. Materials are characterized by CP-MAS NMR (²⁹Si, ¹³C, ³¹P), small-angle X-ray scattering (SAXS), adsorption of nitrogen (BET, BJH methods), TGA and elementary analyses.

Recent results, obtained during tests of extraction on synthetic solutions, demonstrate an efficient extraction capacity of hybrid materials as well as an important stability of the silica structure in concentrated acidic solutions (5M). Therefore, an important selectivity for uranium face to iron has also been shown. Finally, stripping experiments of uranium by sulfuric acid solution (3M) allows to recover more than 90% of the uranium initially uptakes by the grafting silica.

Keywords: Extraction, Uranium, Hybrid mesoporous materials

