

Chapter 70

Preparation of a Uranium Conversion Plant's Nuclear Waste for Final Disposal by Means of Magnetically Assisted Chemical Separation

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ABSTRACT

Uranium is separated from the raffinate of Isfahan's uranium conversion solvent extraction process by means of solvent coated magnetic nanoparticles. These particles were synthesized via chemical co-precipitation and were analyzed by XRD, TEM and TGA methods. The particles' surface were modified with D2EHPA and analyzed with FT-IR method. The results revealed that 0.5 M nitric acid and 25% w/w D2EHPA on nanoparticles gives the maximum uranium extraction yield. The raffinate of the solvent extraction plant can be disposed safely after its uranium content reduces to the allowable values.

INTRODUCTION

Isfahan's uranium conversion plant is one of the most important and pivotal facilities of atomic energy organization of Iran. In this plant, Yellow cake (U_3O_8) is converted to other uranium compounds such as UO_2 , UF_4 and UF_6 .

Uranium in the ore is extracted by leaching then is purified by means of resins or solvents. Finally by drying the precipitates in 600 to 800 degrees of centigrade, yellow cake is produced. Uranyl nitrate is formed by adding nitric acid to the yellow cake and further purification by a solvent. The main process for uranium di-oxide production is the reduction of ammonium di-uranate, ammonium tri-carbonate or uranium tri-oxide.

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UF₄ is then formed by hydro fluorination of UO₂ and finally UF₆ is produced by fluorination of UF₄ (Benedict et al., 1981). In all these steps a considerable amount of liquid waste is produced which is all transferred to the evaporation lagoons. There, as time goes by, the liquid is evaporated and heavy metals especially uranium move to the bottom layer and form precipitates. Due to the great amount of soluble salts in these precipitates, and the possibility of polluting the environment, uranium recovery from this waste and then its final disposal is quite inevitable.

Since uranium and its daughters especially plumb are extremely toxic and cause irrecoverable damage to the kidneys and in extreme lead to death, district rules have been legislated by environmental organizations and IAEI for the disposal of hazardous waste. Legislation of new rules on the scope of uranium content of disposable nuclear waste from one hand, and economical issues related to this precious metal on the other hand, lead to research about the most suitable and efficient method to recover and purify uranium. Diverse and accessible techniques for extraction and recovery of uranium from aqueous solutions include biological methods, liq-liq extraction, ion exchange, electrolysis, precipitation etc. Solvent extraction is an important economical, practical and clean hydrometallurgical process (Owusu, 1998). It is over half a century that uranium extraction and purification via solvent extraction is being used owing to the rapid development of atomic energy industries in recent 40 years (Law et al., 2000).

Solvent extraction is a chemical process by which uranium can be recovered from high concentration solutions. However, in order to reach the allowed concentrations for the final waste to be disposed, several stages of extraction is required. Also there are some limitations regarding solvent extraction such as: limitations regarding organic and aqueous phase dissolution, third phase formation during extraction, difficult stripping process and cumbersome processes for organic solvents

disposal. In order to overcome these problems, a new method of separation named MACS i.e., magnetically assisted chemical separation has been noticed in recent years. This method combines the selectivity of chemical separation with separation by means of magnetic field. In this method, fine magnetic particles are formed by coating iron or other Ferro magnetic materials with organic polymers or ion exchange resins (Nunez et al., 1995). These particles were first used by Nunez to separate radioactive elements from the waste of nuclear industries (Bauer et al., 1995). Tiny magnetic particles are used to remove the trace amount element from waste solutions under wide range of chemical conditions. Magnetic particles are prepared by coating ferromagnetic materials with an organic extractant that has affinity for the targeted elements (Yamaura et al., 2002; Buchholz et al., 1997). The coated particles are then directly added to the tank containing waste solution. The organic extractant selectively chelates with the elements contained within the solution. The loaded particles are then recovered by the use of an external field to the waste tank and finally are stripped with a small volume of stripping solution. The stripped particles can be recycled by applying a fresh coating of organic extractant (Fulmer et al., 2001).

Fe₃O₄ magnetic nanoparticles have found wide application in the scope of radioactive elements separation from the waste of nuclear industries. Nowadays, various methods of Fe₃O₄ magnetic nanoparticles synthesis have been developed such as: chemical co-precipitation, pyrolysis, sol-gel and hydrothermal (Bahadur et al., 2005). Among these methods, chemical co-precipitation is widely used because of its simplicity and reproducibility (Zeng et al., 2010). These particles characteristics such as: size, interfacial surface area factors, charge and magnetizability, depend on the production process and its parameters (Hongzhang et al., 2010). Particle size greatly influences the extraction efficiency. By reducing the size i.e., interfacial surface area increase, the ability of

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