The synergistic effects of organophosphorus ligands on the extraction of thorium and uranium with Cyanex272

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ABSTRACT

In this study, the extraction of thorium (IV) and uranium (VI) from nitric acid solutions have been studied using the mixtures of Cyanex272 (HA) and neutral organophsphorus extractants (S) such as trioctylphosphine oxide (TOPO) and tributylphosphate (TBP). The results showed a strong synergistic effect and better extraction efficiency if the two ligands were used together. The synergistic effect of TOPO was higher than TBP and the synergistic enhancement factor for uranium was higher than that of thorium. Also from the results, it is clear that these metals are extracted into kerosene as $Th(OH)_2(NO_3)A.HA$ and $UO_2(NO_3)A.HA$ with Cyanex272 alone and as $Th(OH)_2(NO_3)A.HA.S$ and $UO_2(NO_3)A.HA.S$ in the presence of neutral organophsphorus ligands. The equilibrium constants of the synergistically extracted complexes have been concluded by non-linear regression method. The logarithm overall equilibrium constant values for extraction of thorium and uranium with TOPO were about twofold higher than that of TBP and this conforms with the difference between the log equilibrium constant values for adduct formation in the organic phase. Thus the binding to the neutral ligands by $Th(OH)_2(NO_3)A.HA$ and $UO_2(NO_3)A.HA$ follows neutral ligand basicity sequence.

Keywords: Synergistic effect, Thorium, Uranium, TOPO, TBP.

INTRODUCTION

Thorium and uranium have been considered as the most important nuclear fuels. With increasing demands for these elements, the separation and purification of them has gained considerable importance in recent years.

Solvent extraction has played an important role in the development of processes to recover metals from various sources. Various kinds of organophosphorus extractants, both acidic and neutral ligands were reported for extraction of these elements (Gupta et al., 2001; Koladkar and Dhadke, 2002; Karve and Gaur, 2006; El-Hefny and Daoud, 2004; Pathak et al., 1992; Maiorov et al., 2005; Stas et al., 2005; Habashi, 1997). These processes have been used for the extraction of these elements individually or separation of them. For example, Stas et al. (2005) studied the extraction of uranium from nitric acid solutions by tributyl phosphate and their results showed that the extraction was very fast. Karve and Gaur (2006) reported that Cyanex302 had the appreciable ability for thorium extraction from nitrate solutions. In the conventional process for thorium purification with TBP, the distribution ratio for thorium and uranium was 1 and 20 respectively and these elements were separated in the several stages (Habashi, 1997). However, even with the above extractants, a large number of separation steps are necessary to obtain highly purified of these elements.

Uranium and thorium, the two nuclear elements, usually present in the leach solutions together. Therefore, there is a growing interest in the development of new extraction systems for the separation of these two elements as an individual concentrate and then separation of them in a simple process such as TBP process (Habashi, 1997). Gupta et al. (2001) showed that, Cyanex923 could extract thorium and uranium from nitric acid solution, simultaneously.

Taking into account the synergistic effect, extractant mixtures have been used extensively in order to improve metal ion extraction. In the solvent extraction, the metal ion is not coordinately saturated by the ligand and hence it retains residual water. With respect to these mechanism and other