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An overview of phosphorus based extractants for nuclear fuel reprocessing in Indian Scenario

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Phosphates are esters of phosphoric acid having general structure $P(=O)(OR)_3$. Tri-n-butyl phosphate (TBP) was first used as an extractant in 1944, during Manhattan project for the separation of actinides,[1] and further explored by Warf in 1949 for the extraction of Ce(IV) from aqueous nitric acid. TBP was further used as an extractant in the Plutonium Uranium Recovery by Extraction (PUREX) process.[2] To meet the stringent requirements of the nuclear industry, TBP has been extensively investigated.

In spite of its wide applicability, TBP suffers from various disadvantages such as high aqueous solubility, third phase formation, chemical and radiation degradation leading to the formation of undesired products. It also suffers from incomplete decontamination of the actinides from fission products.[3]

India initiated an Fuel Reprocessing programme around the late 1960s. The design and construction of the first experimental reactor FBTR (40 MW (th), 12 MW(e)) at Kalpakkam, Tamil Nadu, was initiated in the early 1970s with French collaboration.

Various attempts have been made to overcome the problems associated with TBP by way of using higher homologues of TBP. Considerable work has been carried out in IGCAR, Kalpakkam, on the development of alternate TAPs. Several higher homologues of TBP, such as TIAP, tri-n-amyl-phosphate, tri-2-methyl-1-butyl-phosphate and tri-nhexyl-phosphate, have been synthesized in-house, characterized and their suitability for the reprocessing applications assessed. These phosphates are devoid of the problems associated with TBP, such as high aqueous phase solubility and third phase formation, while extracting tetravalent actinides.

In pursuit of an alternative to TBP an attempt is made to synthesised unsymmetrical phosphates dibutyl secbutyl phosphate (DBsBP), dibutyl pentyl phosphate (DBPnP) and dibutyl heptyl phosphate (DBHpP) were explored in comparison with TBP and their preliminary studies for acid uptakes and extraction of U and Th from a surrogate system were carried out(4). It observed that there is no marked effect in the extraction of nitric acid , U and Th, after introducing a branching near the phosphoryl (P=O) group of phosphate or by increasing the carbon chain length of one of the alkyl groups

References

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