INVITED

Chemistry in the front end and back end of thorium fuel cycle

K.L. Ramakumar

The long term sustainability and future expansion of nuclear power programme in India would depend to a great extent on large-scale utilization of vast thorium resources for breeding ^{233}U and recycling the same in self-sustaining ^{232}Th-^{233}U closed fuel cycle in appropriate reactors. In this context, India is embarking upon development of Advanced Heavy Water Reactor (AHWR) and Molten Salt Reactor (MSR). Chemistry related R&D initiatives have been undertaken in Radiochemistry and Isotope Group of Bhabha Atomic research Centre in the fuel development programme for AHWR and MSR. These programmes include (i) Chemical characterization of ThO_2 and $(Th,U)O_2$ fuels, (ii) development of process flow sheet for AHWR fuel fabrication, (iii) determination of phase diagram and thermo-physical properties of thoria fuels, (iv) evaluating thermodynamic and transport properties of the oxide fuels for AHWR, (v) development of extractants for reprocessing of thorium based spent nuclear fuel, and (vi) development of inert matrix for waste immobilization. On the other hand, the MSR fuel development programme includes: (i) facility for preparation and purification of fluoride based salts, (ii) determination of solubility of actinides in molten fluoride salts, (iii) determination of thermophyscial properties of molten salts, and (iv) determination solidus-liquidus and phase multi component phase diagrams of molten slat systems.

Microsphere impregnation technique has been developed for fabrication of Thoria based fuels in Fuel Chemistry Division. The process optimization was carried out to get homogeneous distribution of uranium in thoria. A simple and fast method for the dissolution of sintered ThO_2 and $(U_xTh_{1-x})O_2$ (sintered at 1600–1700°C and with approx. 94% of the theoretical density) and separation of thorium and uranium from the solution was developed by reacting the oxides with ammonium nitrate at 360°C. Analytical method was developed for determination of relative amounts of U and Th in MOX by using TXRF method. Extensive studies on phase diagram and thermophysical properties of thoria based fuels were carried out in a wide composition and temperature range. For reprocessing studies, a large number of amides (12 nos.) was evaluated for their extraction behavior with respect to U/Th separation and it was concluded that branched alkyl chain amide, di-2-ethylhexyl isobutyramide (D2EHIBA), is a promising candidate for the selective separation of ^{233}U from irradiated Th. Thermal and thermodynamic stability of Phosphate based inert matrix was also studied for its application for waste immobilization of thoria based fuels.

With respect to molten salt reactor system, thermal behavior, thermodynamic properties and phase diagrams of Th-F, U-F, Th-U-F, Th-O-F systems were investigated. A high temperature and hydroflourination facility has been set up for preparation and purification of thorium based fluoride salts.

This lecture will address some of the developments in the above field of research carried out in Radiochemistry & Isotope Group of BARC.

Prof. K.L. Ramakumar

Prof. K.L. Ramakumar is an alumnus of Sri Venkateswra University, Tirupati, Andhra Pradesh, India where he did his Masters in Physical Chemistry in 1973.

He joined the Department of Atomic Energy in 1974 and after successful completion of one year orientation course was absorbed in Bhabha Atomic Research Centre (BARC), Mumbai as Scientific Officer. He did his Ph.D. from Mumbai University in 1985. Currently he is Distinguished Scientist and is Director, Radiochemistry & Isotope Group (RC&IG) coordinating research and development activities of six Divisions catering to both front end and back end nuclear fuel cycles, radiation processing, isotope hydrology, radiopharmaceuticals, radioanalytical chemistry and radiochemistry

His expertise encompasses divergent fields in Chemical Sciences viz. Analytical Chemistry and Nuclear and Radiochemsitry. He specializes in trace and ultra trace elemental analysis employing mass spectrometry, spectroscopy, and chromatographic techniques. He is also expert in nuclear safeguards, nuclear material accounting and control (NUMAC) and nuclear law.

Concurrently Prof. Ramakumar is also holding the post of Head, Nuclear Controls and Planning Wing of the Department of Atomic Energy. His responsibilities as Head, NCPW includes coordinating (i) implementation of IAEA safeguards in the designated Civil nuclear facilities in the Country, (ii) international collaborations with other Countries in research and development fields involving mega science projects, , and also within the Country with DST and UGC, (iii) negotiating civil nuclear cooperation with other Countries, (iv) different regional and national training programmes of Global Centre for Nuclear Energy partnership (GCNEP), (v) compliance of export regulations of prescribed substances of SCOMET List.

Prof. Ramakumar has been peer reviewer with International Science Foundation, USA to review the research proposals of Russian Scientists for financial grants. He was on expert mission to International Atomic Energy Agency to establish calibration procedures for mass spectrometric determinations. He is a member of Standing Advisory Group for Safeguards Implementation appointed by Director General IAEA. He is chairman of Advisory council, GCNEP, Co-chairman of Indo-USA civil nuclear energy working group, Chairman, Indo-Canada civil nuclear energy working group. He also co-chaired the contract group established to resolve the outstanding issues in the implementation of civil nuclear cooperation with the USA.

Prof. Ramakumar is a Senior Professor in Chemical Sciences and Strategic Studies of Homi Bhabha National Institute (HBNI). He is a recognized Guide of Mumbai University and HBNI in Chemistry. He has published more than 400 scientific publications, 100 of which hare in international peer-reviewed Journals.