		
1	Full Name (s)	**Natarajan Rajamani**
2	Date & Place of Birth	15-01-1953; Mayiladuthurai (Tamil Nadu)
3	Designation & Office Address	Retired in 2015 as Director, Reprocessing Group, & Project Director, Fast Reactor Fuel Reprocessing Facility, Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu 603102
4	Residential Address (camp):	P38, Sector13, Jeevan Bhima Nagar, Bangalore – 560 075
5	Telephone	9443067543/8072324839
	Email	Rajamani_natarajan@yahoo.com Rajamani.natarajan@gmail.com

6 **Academic & Professional Qualifications**

Sr. No	Degree / Diploma	University	Year	Achievements / Subjects
1.	B.E (Chem)	Annamalai University	1975	Chemical Engineering; First Class with Distinction; Gold Medal winner
2.	Post Graduate Training	BARC Training School	1976	Nuclear Engineering
3.	Diploma in Systems Analysis and Data Processing	Annamalai University	1991	Systems Analysis; Data Processing
4.	Ph.D	Satyabhama University	2013	Chemical Engineering; Solvent Extraction

7 **Employment Particulars**

Name & Address of Employer	Period	Designation

	Indira Gandhi Centre for Atomic Energy, Department of Atomic Energy, Kalpakkam, Tamil Nadu	2013- 2015	Director, Reprocessing Group & Project Director, FRFCF
	-do-	2012-2013	Director, Reprocessing Group and Director, Engineering Services Group
	-do-	2005-2012	Director, Reprocessing Group
	-do-	2001-2005	Associate Director, Reprocessing Group
	-do-	1996-2001	Head, Fuel Reprocessing Process Division
	-do-	1992-1996	Head, Process Engineering Section
	-do-	1976-1992	Scientific Officer

9 **Membership of Academic / Professional bodies, with details of positions held:**

- Life Member of Indian Institute of Chemical Engineers
- President, IIChE-Kalpakkam Chapter - 2005 onwards
- Life Member of Indian Nuclear Society

10 **Recognition / Awards / Honours**

Awards :

- **NOCIL Award** for Excellence in Design and Development of Process Plant and Equipment for the year 2005 from The Institution of Chemical Engineers, Kolkata, 2005
- **INS Award** from the Indian Nuclear Society for the year 2006
- **Vasvik Award** for Excellence in Industrial Reseach in the area of Chemical Sciences and Technology for the year 2014

Honours :

- Elected Fellow of Indian Academy of Engineers in 2009
- Elected Honarary Fellow of Indian Institute of Chemical Engineers in 2010

11 **Specific Achievement:**

Dr R.Natarajan was involved in the development of the process and equipment for spent fast reactor fuel reprocessing, since joining the Department of Atomic Energy in 1975. Though, spent thermal reactor fuel reprocessing was started in 1965 in India, fast reactor fuel reprocessing is a challenging task as it calls for one order higher radioactivity and handling at least 10 times more plutonium concentration. The reprocessing is carried out

	by a chemical engineering process called, PUREX, which involves various unit operations and processes such as fuel dissolution, feed conditioning, feed clarification, recovery of desired chemical elements such as Uranium and Plutonium to levels greater than 99.9%. Purification of Uranium and Plutonium from impurities of more than thirty different fission product elements down to a few hundred parts per million is really challenging. As the development work was started with the requirement of reprocessing the spent fuel of Fast Breeder Test Reactor (FBTR), there was an added challenge since the mixed (uranium and plutonium) carbide used as the reactor fuel is pyrophoric in nature. Due to the strategic nature of the material involved, very limited literature is available in the public domain to aid in the development. Dr R.Natarajan was instrumental in the development of critical process equipment like chopper, dissolver, centrifugal extractor etc., and in the formulation of the process flow sheet. It should be mentioned that hitherto no open document is available on the design and development of such specialised equipments. He has contributed in the development of chopping equipment for cutting the highly pyrophoric fuel, titanium dissolver for the chopped fuel and the advanced centrifugal extractors for purification and separation of uranium and plutonium. The dissolution of mixed carbide fuel with this very high concentration of Plutonium (70% in FBTR fuel) is known to be difficult because of the complex carbon compounds formed during the dissolution which interferes with subsequent solvent extraction process. The dissolution process was developed under his leadership through systematic R&D studies. His unique contribution is in the development of solvent extraction process modeling which resulted in the optimization of the plant design. He has contributed significantly in the critical equipment design for remote maintenance and improved availability. Some of these equipments were used for the reprocessing campaigns of irradiated thorium rods from CIRUS and DHURUVA reactors of BARC for recovering the uranium fuel (U^{233}) which was used in FBTR to simulate the Prototype Fast Breeder Reactor (PFBR) fuel composition and as fuel for KAMINI reactor, in IGCAR. These campaigns enabled validation of the designs of critical equipments. He has also carried out extensive studies on materials of construction for enabling trouble free operation of reprocessing plant. He has been responsible for finalising the specification of stainless steel grades for these plants based on extensive studies and these are now commercially produced by Indian manufacturers. He has also been responsible for the deployment of titanium material for fast reactor spent fuel dissolvers as stainless steel is not recommended for such conditions. These sustained developments culminated in the setting up of a pilot plant facility, called, CORAL (Compact Reprocessing facility for Advanced fuels in Lead cells) in 2003. This

	facility was designed, erected and commissioned under his leadership. This is a unique facility to reprocess the FBTR spent fuel so as to establish the process and equipment for high burnup Plutonium rich fuels. Dr R.Natarajan led a team of colleagues for the reprocessing of spent fuels of FBTR of different burnups such as 25, 50, 100 and 155 GWd/t in this facility to gain confidence in the operation and safety of this highly radioactive chemical facility. The performance of the campaigns, in terms of the recovery and product purity is comparable to the international bench marks. It continues to provide valuable inputs to improve the economics and safety for the commercial reprocessing plants that are being designed. Currently a demonstration plant, called DFRP is in advanced stage of construction. The design of reprocessing plant for the reprocessing of spent fuels from PFBR has also been successfully completed. He is responsible for both the design and construction of these two plants. His comprehensive understanding of the various facets of reprocessing domain has helped in evolving a suitable ageing management and decommissioning policy for the fast reactor reprocessing facilities. Several R&D problems have been formulated by him for evaluation in CORAL facility. He has also piloted several collaborations with premier academic and national institutes for the development of this technology. Under the leadership of Dr R.Natarajan, fast reactor spent fuel reprocessing technology has attained many significant milestones. He has also established a sound infrastructure for the successful closing of the fast reactor fuel cycle with his chemical engineering skills.

Annex-2

LIST OF PUBLICATIONS OF DR R.NATARAJAN

IN THE LAST TEN YEARS AS ON DEC 2014

DOCTORAL THESIS: 1; PATENTS: 2; JOURNAL PUBLICATIONS: 70;

INTERNATIONAL CONF: 26 ; NATIONAL CONFERENCES : 58

Doctoral Thesis

1. Studies to improve the separation and purification of uranium and plutonium in the solvent extraction of Fast Reactor Fuels, **R.Natarajan,** Doctoral Thesis, Sathyabama University, 2011

List of Patents:

1. Process for solvent washing in Nuclear fuel Reprocessing, P.Govindan, K.Dhamodharan, K.S.Vijayan, R.V.Subba Rao, M.Venkataraman and **R.Natarajan**, PCT/IN2008/000516
2. Process for In-line monitoring of uranium and plutonium in process streams of a nuclear fuel reprocessing/processing plant, International publication number WO2011/067775A1 dated 09 .06. 2011.

List of technical papers published in Journals/books

1. Reprocessing of spent nuclear fuel in India: present challenges and future programme, **R.Natarajan**, Progress in Nuclear Energy, 101(2017) 118-132
2. Mechanism of dissolution of nuclear fuel in nitric acid relevant to nuclear fuel reprocessing, N. Desigan, Nirav P Bhatt, N. K. Pandey, U. Kamachi Mudali, **R. Natarajan** and J. B. Joshi, Journal of Radio Analytical and Nuclear Chemistry (2017), 312:141.
3. Separation characteristics of Liquid-Liquid Dispersions: Gravity and Centrifugal Settlers: Balamurugan Manavalan, Tushar V. Tamhane, Jaysree Patra, Aniruddha J. Joshi, Jyeshtharaj B. Joshi, Niranjan K. Pandey, Shekhar Kumar, Kamachi U. Mudali, R.Natarajan, Vivek S. Vitanka and Raosaheb N. Patil, Ind. Eng. Chem. Res., 2017, 56 (27), pp 7814–7823
4. Dissolution of intact UO2 Pellet in batch and rotary dissolver conditions, Jayendra K, Gelatar, Bijendra Kumar, M. Sampath, Shekhar Kumar, U. Kamachi Mudali and **R. Natarajan**, Journal of Radioanalytical and Nuclear Chemistry, Online Published on 02 Nov 2014, DOI 10.1007/s10967-014-3683-z (2014).
5. Feasibility studies on the separation of ruthenium from high level liquid waste by constant potential electro-oxidation, Pravati Swain, C. Mallika, K. Sankaran, N.K.

Pandey, R. Srinivasan, U. Kamachi Mudali, **R. Natarajan,** Progress in Nuclear Energy, 75 (2014) 198-206.

6. Probing Uranium(IV) Hydrolyzed Colloids and Polymers by Light Scattering, N. Priyadarshini, M. Sampath, Shekhar Kumar, U. Kamachi Mudali, and **R. Natarajan,** Journal of Nuclear Chemistry Volume 2014, Article ID 232967, DOI: 10.1155/2014/232967 (2014)
7. A Combined Spectroscopic and Light Scattering Study of Hydrolysis of Uranium(VI) Leading to Colloid Formation in Aqueous Solutions, N. Priyadarshini, M. Sampath, Shekhar Kumar, U. Kamachi Mudali and **R. Natarajan,** Journal of Radioanalytical and Nuclear Chemistry, Proofs cleared for publication (2013)
8. Crystallization Based Bulk Uranium Separation from Simulated Dissolver Solutions, C.K. Shakya, Shekhar Kumar, M. Sampath, P.N. Tewari, M. Ramasomayajulu, U. Kamachi Mudali and **R. Natarajan,** In Press, International Journal of Nuclear Energy (2013)
9. Design of Liquid- Liquid Settlers: Capacity and Solvent Characterization Using Dimensionless Dispersion Number, J.B. Joshi, T. Tamhane, J. Patra, M. Balamurugan, N.K. Pandey, Shekhar Kumar, U. Kamachi Mudali, **R. Natarajan** and R. Patil, In Press, Industrial And Engineering Chemistry Research (2013)
10. Thermodynamics of solubility of tri-n-butyl phosphate in nitric acid solutions, Satyabrata Mishra, S. Ganesh, P. Velavendan, N.K. Pandey, C. Mallika, U.K. Mudali and **R. Natarajan,** Advanced Chem. Eng. Res. (In Press).
11. Separation of ruthenium from simulated nuclear waste in nitric acid medium using n-Paraffin hydrocarbon, Pravati Swain, S. Annapoorani, R. Srinivasan, C. Mallika, U. Kamachi Mudali and **R. Natarajan,** Separation Sci. Technol. (In Press).
12. A Combined Spectroscopic and Light Scattering Study of Hydrolysis of Uranium(VI) Leading to Colloid Formation in Aqueous Solutions, N. Priyadarshini, M. Sampath, Shekhar Kumar, U. Kamachi Mudali and **R. Natarajan,** Journal of Radioanalytical and Nuclear Chemistry,Vol. 298 (3), 1923-1931, DOI: 10.1007/s10967-013-2624-6 (2013)
13. Effect of Limited Overpressure on Low Range Differential Pressure Transmitters, Reuben Daniel JW, Raghunath Rajan, Satheesh Kumar RV, Geo Mathews, **R Natarajan.** 'Journal of the Instrument Society of India. P 263-266, Vol. 43, No. 4, December 2013.
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15. Development of solvent regeneration process, Journal of Desalination and Water Treatment, N.K. Pandey, R. Rajeev, C.V. Joyakin, P. Vishnu Anand, P. Velavendan, U. Kamachi Mudali and **R. Natarajan,** DOI: 10.1080/19443994.2013.830688
16. Direct spectrophotometric determination of ruthenium in aqueous streams of nuclear reprocessing, S. Ganesh, P. Velavendan, N.K. Pandey, U. Kamachi Mudali, and **R. Natarajan,** Journal of Radioanalytical and Nuclear Chemistry 295 (2013) 2091-2094
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20. Synthesis of N, N, N', N'-Tetraoctyl-3-Oxapentane-1, 5-Diamide (TODGA) and its Steam Thermolysis-Nitrolysis as a Nuclear Waste Solvent Minimization Method, Deepak D. Dicholkar, Pradipta Kumar, Parminder Heer Kaur, Vilas G. Gaikar, Shekhar Kumar and **Rajamani Natarajan,** Industrial Engineering and Chemical Research, Vol.52, 2457-2469, doi:10.1021/ie302603q (2013)
21. Kinetics and optimisation of process parameters for electrochemical generation of uranous ions in nitric acid – hydrazine media, K. Sini, Satyabrata Mishra, C. Mallika, N.K. Pandey, R. Srinivasan, U. Kamachi Mudali and **R. Natarajan,** Journal of Radioanalytical and Nuclear Chemistry, Published online (2013), DOI: 10.1007/s10967-013-2470-6.
22. Development and characterization of porous silicon nitride tubes, Satyabrata Mishra, C. Mallika, P.K. Das, U. Kamachi Mudali and **R. Natarajan,** Trans. Ind. Ceram. Soc., 72 (2013) 52-55.
23. Separation and recovery of ruthenium - a review, Pravati Swain, C. Mallika, R. Srinivasan, U. Kamachi Mudali and **R. Natarajan,** J. Radioanal. Nucl. Ch., DOI: 10.1007/s10967-013-2536-5 (2013).
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26. Recovery and Purification of plutonium in lean product stream obtained during reprocessing of Fast Reactor spent fuel, P.Govindan, K.S. Vijayan, G. Santhosh Kumar, V. Vijayakumar, M. Venkataraman and **R. Natarajan,** J. Radioanal. Nucl. Chem., (2013) 295: 307-313
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29. Solvent extraction studies of Gadolinium in tri-butyl phosphate, N. Desigan, P. Velavendan, N. K. Pandey, R. V. Subba Rao, V.Vijayakumar, U. Kamachi Mudali and **R. Natarajan,** Procedia Chemistry, Vol. 7, 2012, 295 – 301.
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Ganesh, N. K. Pandey, U. Kamachi Mudali and **R. Natarajan,** Journal of Analytical Sciences, Methods and Instrumentation, Vol. 2, 2012, 156 – 160.

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35. Light Scattering Studies to Determine Molecular Weight of Freshly Prepared Zr(IV) Hydrous Polymer, N.Priyadarshini, M.Sampath, Shekhar Kumar, U.Kamachi Mudali and **R.Natarajan,** Online Published on 25 July 2012, Journal of Radioanalytical and Nuclear Chemistry (2012), DOI: 10.1007/s10967-012-1951-3
36. Studies on solubility of TBP in aqueous solutions of fuel reprocessing; P. Velavendan S. Ganesh, N.K. Pandey, R. Geetha, M.K. Ahmed, U. Kamachi Mudali and **R. Natarajan,** Paper is accepted for publication in Journal of Radioanalytical and Nuclear Chemistry (DOI: 10.1007/s10967-012-1945-1)
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