Editorial

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Biographical notes: Ajayan Vinu is a Senior Researcher at the International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science. He was born and raised in the city of Kanyakumari, which is located at the southernmost tip of the Indian peninsula. He got his PhD in November 2003 in India, at Anna University, though he carried out most of his research work at the University of Kaiserslautern, Kaiserslautern, Germany, and worked there as a Research Scientist before coming to Japan in 2004 to work at the International Center for Young Scientists (ICYS), NIMS, Japan, as an ICYS Fellow. He has published ca. 175 papers in high quality journals. His research is mainly concerned with the design and synthesis of novel multifunctional nanoporous solids, including oxides, carbons, nitrides, and organic inorganic hybrid materials that find applications as selective catalysts for many organic transformations and biocatalysis, adsorbents, sensors, and fuel cell supports.

Avesh K. Tyagi is presently Head, Solid State Chemistry Section, Chemistry Division, Bhabha Atomic Research Centre (BARC) and also a Professor of Chemistry at Homi Bhabha National Institute (HBNI). He had joined BARC Mumbai in 1986. Since then he has been working in the field of Chemistry of Nanomaterials, Functional materials and Nuclear materials. He was awarded PhD Degree (Chemistry) in 1991 by Mumbai University. He was a Max-Planck Fellow at MPI, Stuttgart, Germany during 1995–1996. In recognition of his work, he has been conferred with several awards such as Homi Bhabha Science & Technology Award, Gold Medal of Indian Nuclear Society, MRSI Medal, CRSI Medal, Dr. Laxmi Award by ISCAS, Rheometric Scientific-ITAS Award, and IANCAS-Dr.Tarun Datta Memorial Award, Rajib Goyal Prize in Chemical Sciences. He is a Fellow of National Academy of Sciences, India and Maharashtra Academy of Sciences. He is a PhD guide of Mumbai University and Homi Bhabha National Institute. So far he has supervised 12 students for their PhD and another 10 students are at different stages of their PhD.

Although the very concept of nanotechnology owes its origin possibly to the landmark lecture of Richard Feynman dated back in 1959, the primary development in the field of nano-research took place between 1980s and early 1990s and the field continues to fascinate researchers all over the world even today. Considering the amount of contribution made in terms of publications, USA continues to top the list with nearly 28.5%. In this respect, Asian giants like China (with ~14.66%) and Japan (with ~10.95%) are also not lagging behind. India somehow stepped in late but is coming up very fast with about 1890 articles published in a single year (in 2008).

Indian research institutes started the research on nanomaterials in the late 1970s. The Tata Institute of Fundamental Research (TIFR) of the Department of Atomic Energy (DAE) reported the first microwave synthesis of fine grained nanocrystalline materials and their application in piezoelectric devices. Then, Indian Institute of Technology (IIT) at Kharagpur first reported the synthesis of ceramic oxide nanoparticles in 1980s. However, the research on the nanomaterials in India received a huge momentum when the Department of Science and Technology (DST), Ministry of Science and Technology, Government of India together with Professor C.N.R. Rao, the Father of Nanotechnology Research in India, launched the Nano Science and Technology Initiative (NSTI) programme in the year 2002. The programme initially launched for a period of five years had seen rapid development in the infrastructure facilities in academic and R&D institutions. With the success of the Nanoscience and Technology Initiative programme, the Department of Science and Technology has launched the Mission on Nano Science and Technology (Nano Mission) – an umbrella programme in May 2007 to promote R&D in this emerging and highly competitive area of research in a comprehensive fashion. The main objectives of the Nano Mission are basic research promotion, infrastructure development for carrying out front-ranking research, development of nano technologies and their applications, human resource development and international collaborations. In 2009–2010, Nano Mission recorded significant expansion in its activities and also continued to break new grounds in promotion of R&D in this field of research.

Around 150 projects have been supported to individual scientists mainly working on fundamental scientific aspects of nanoscale systems. Investigations are aimed at looking into new and improved understanding of the relationship between structure of various nanoscale systems and their properties using sophisticated characterisation facilities. Significant results have been reported from these projects. Extensive studies on semiconductor nanocrystals have been undertaken in several projects. As semiconductor particles exhibit size-dependent properties like scaling of the energy gap and corresponding change in the optical properties, they are considered as technologically important materials. Several projects have looked into synthesis of important nanomaterials like CdSe, ZnO etc. Size-tunable, organic-soluble industrially important CdS, AlN, GaN and InN nanocrystals have been prepared by employing novel solvothermal techniques and some soft chemical routes. In another project, it has been reported that flow of various liquids and gases over a mat of single-walled carbon nanotube (SWNT) bundles generate electrical signals. This discovery has several important technological implications. Negative differential resistance in a one-dimensional molecular wire with odd number of atoms attached between two macroscopic electrodes at some critical bias has generated considerable interest for possible device applications. Towards development of micro fluidic devices, interesting results have been obtained in another project. It may have several applications in the

fields of biotechnology, pharmaceutical industry, drug delivery, intelligent pneumatic systems, information technology etc.

The premier Indian research institutes engaged in nanoscience and nanotechnology research activities are Jawaharlal Nehru Center for Advanced Scientific Research (JNCASR), Bangaluru, Bhabha Atomic Research Centre (BARC), Mumbai, Indian Association for Cultivation of Science, Kolkata (IACS), Indian Institute of Science (IISc), Bangaluru, Indian Institute of Technology (IIT), Kharagpur, and National Chemical laboratory (NCL), Pune. Growth of nano-research in India took place in two distinct phases. First few years of inception i.e., 1982–1987 witnessed rise in activities in IIT-Madras, Chennai followed by BARC, and IISC. During latter half of the decade, institutes like IACS, Tata Institute of Fundamental Research (TIFR), Mumbai, IICT Hyderabad, University of Poona, and Pune, IIT-Kanpur joined the nanotechnology program. During 2000–2009 more Universities and institutes (*seven hundred and eighteen in all*) started researching on this topic that has provided greater impetus to Indian nano-research than before.

Nano-science, in turn has given birth to the mesmerising world of nanotechnology where novel optical and electronic materials and composites in the dimension range of 1–100 nm are opening up altogether new applications never dreamt off before. Nano-research in BARC focused mainly on micro-designing and simulation of micro electro-mechanical systems (MEMs) on one hand and synthesis of exotic materials on the other. Fascinating chemistry has been developed; both state of the art solid-state as well as soft-chemical methods have been employed for synthesising unusual functional materials in the nano-regime. Dilute magnetic semiconductor nano-materials doped with different transition metals have been synthesised that exhibit ferromagnetism even at room temperature. White light-emitting phosphors based on both oxides and fluorides for highly energy efficient solid state lighting have been developed. Novel zirconia based nano sorbents have been developed for Positron Emission tomography (PET) applications and have been tested under actual conditions. Templated synthesis has produced 1D nanostructures with excellent material properties. Nano-particle gas sensors have been produced that can detect different toxic gases at ppm level. Presently, research on potential multi-ferroic nano-materials is being carried in BARC in a big way. Mimicking mother-nature, bio-chemical routes have been developed for the synthesis of metal nano particles. Following similar routes, researchers in NCL, Pune have also synthesised different nanoparticles using extracts from natural herbs and bio-materials. Research on nano-carbon chemistry is largely being pursued in IISc, Bangaluru. JNCASR, Bangaluru has an ongoing active research on graphene based nanostructures. Synthesis of aligned carbon nanotubes with *Y* and *T* junctions has been demonstrated. Solubilisation of graphenes and their spectroscopic characterisation constitutes some of the recent highlights of the institute. NPL, Delhi is primarily developing devices based on nano-particles. Light emitting diodes and phosphors based on nanoparticles are being developed.

During the last few years, significant contribution has been made by Indian researchers in the field of nano-science and nano-technology as is evident from the steep rise in the number of publications. Their efforts have been well acknowledged all over the world and have resulted in the many international collaborations with countries like USA, Germany, Japan, South Korea, France and England. Indian researchers who are working in the field of nanotechnology have been enjoying the continuous

and encouraging support from the Department of Science and Technology, India which really helped them to publish high quality papers in the journals like *Science* and *Nature*. After realising the importance of research on the nanomaterials, recently, the Government of India has also decided to set up three big nanoresearch institutes at Bangaluru, Kolkata and Mohali. These initiatives will definitely take India one step forward in the research on nanomaterials and attract more and more talented young researchers to conduct research in the field of nanotechnology.