The role of nanomaterials in modern technologies is becoming increasingly significant because of the feasibility and ease of adding new functions to the existing commercial products, apart form products made completely from nanomaterials through the bulk, which is relatively difficult. Nanomaterials are usually characterized by a feature size of less than 100 nm at least in one dimension. Recently in April 2010, US EPA has announced a new working definition of nanomaterials as "an ingredient that contains particles that have been intentionally produced to have at least one dimension that measures between approximately 1 and 100 nanometers" in order to facilitate the implementation of regulations on use of nanomaterials in commercial products. The expectations on nanomaterials are enormous as their unique mechanical, optical, electrical, magnetic, thermal and catalytical properties make them special ingredients for number of applications. The market for nanotechnology over the years has not matched the initial hype that was based on the expectation that the nanotechnology based products will permeate through every industrial sector. Nevertheless, the market for nanotechnology products has grown significantly especially in the consumer products area.

The successful commercialization of nanomaterials is possible only when the material production and application development proceeds in parallel with each other. Often, material production is a challenging process although it looks simple from the synthesis point of view. This is because the surface functionalities of nanoparticles have to be tailored keeping in mind the application. For example, through surface modification, a number of properties of nanoparticles like dispersability in a suspension, compactability during subsequent consolidation, colour in case of metal and semiconductor quantum dots and compatibility with the matrix material in the case of nanocomposites can be altered and often dramatically. Thus, in real practice, multiple synthesis techniques have to be evaluated for each application, leave alone for different applications. Additional challenges in large scale synthesis include consistency in product quality, cost of raw material and equipment, yield of the product, safety of the process, waste disposal and environmental issues.

When it comes to application development, many of the proven technologies based on nanomaterials are related to health products, including water filters, medical textiles, cosmetics and drug delivery. Unlike USA, Europe and Japan, the Indian industries have started looking at nanotechnology only recently as a solution for their problems. Big companies like Reliance Industries, Tata Chemicals, Mahindra, Ashok Leyland, Asian Paints, Crompton Greaves have initiated programmes on nanomaterials on their own or in collaboration with academic/R&D institutions. Many of companies work on application of nanomaterials for value addition to their products but they purchase nanomaterials from abroad at high cost as the availability of nanomaterials in India is limited. Only very few institutes and industries are making efforts to develop scalable synthesis processes for mass scale production of nanomaterials. For example, International Advanced Research Centre for powder metallurgy and new materials (ARCI), an autonomous institute of DST, has taken up the responsibility of developing the synthesis processes for nanomaterials which are not only scalable for mass production but also are application specific. ARCI established the Centre for Nanomaterials in 2003 with a mandate of acquiring the capability of producing nanomaterials of all kinds including, metals, alloys, oxides, carbides, phosphates and nitrides. ARCI has started its nanomaterials activity by setting up processes that range from lab scale to small scale of material up to 100 gm/h or 100 ml/batch scale. The close interaction of Indian companies encouraged ARCI to set up facilities at pilot level production for metals, alloys, oxides, carbides and phosphates.

ARCI has selected only those application areas for nanomaterials wherein either the Indian market is very large in the world context or which are unique/specific to India. Examples of the former include textile markets and auto related products, while the health, drinking water are examples of the

latter. The technologies are either home grown or industry demand driven. ARCI has already transferred two health related nanosilver based technologies successfully to Indian companies in the areas of drinking water disinfection and antibacterial textiles. In addition, two technologies related to energy sector namely lightining arrestors (varistors) and Oxide dispersed strengthended (ODS) steel have been made ready for application. Photocatalytic self-cleaning TiO2 coating technology is under development for environ mental applications.

While nanomaterial based technology development is becoming very compitative, serious attention has to be paid in the safety and toxicology issues of nanomaterial both during synthesis and application development. ARCI takes much care in the design and selection of the equipment as well as in handling of the nanomaterials with great emphasis on avoiding inhalation, ingestion and skin contact of nanomaterials. Learning lessons from Samsung washing machine, which releases ionic silver into environment along with the rinsed water, the applications at ARCI are chosen in such a way that the nano particles are strongly immobilized on the substrates, embedded in the matrix or incorporated seamlessly in the form of bulk component or coatings.

Biography of Dr. Tata N. Rao:

Dr. Tata Narasinga Rao was born in India in 1963. He received his Ph. D degree in Chemistry from Banaras Hindu University, India in 1994. After working at IIT Madras as Research Associate, he moved to The University of Tokyo in 1996 as a JSPS post doctoral fellow and subsequently became an Assistant Professor in the same University in 2001. He joined International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) in Hyderabad, India, in 2003 as senior scientist and presently he is Scientist F and Head of Centre for Nanomaterials at ARCI. He is also guest faculty at IIT Hyderabad and University of Hyderabad. He is recipient of Material Research Society of India (MRSI) medal in 2009. He has published 80 research papers in International Journals, filed 15 Indian as well as international patents, written few book chapters and edited a book on Diamond Electrochemistry. His research interests include, photoelectrochemistry, conductive diamond electrodes for sensor applications, large scale synthesis of nanomaterials for energy, health and environmental applications.