

# NANOTECHNOLOGY

## *Present Status and Future Prospects in Developing Countries*

*- Editors -*

*Harish Padh*

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**CENTRE FOR SCIENCE & TECHNOLOGY OF THE  
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## *Foreword*

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In order to review state-of-the-art research and development in nano-scale phenomenon, devices, systems and manufacturing, the NAM S&T Center along with the Iranian Research Organization for Science and Technology (IROST), Iranian Nanotechnology Initiative Council (INIC) and IOR-ARC Regional Centre for Science and Technology Transfer (RCSTT) organised an international workshop on 'Nanotechnology–Present Status And Future Prospects In Developing Countries' from 18-20 May 2009 at Kashan, Iran. Scientists from developing and developed countries actively participated in its deliberations. The latest developments in the areas related to nanoscience and nanotechnology were reviewed by well known experts besides presentation of several country reports. This publication includes 21 articles and review papers on various aspects of nanotechnology and would be useful for the nanotechnology researchers, experts and practitioners in this fast emerging field.

India has always had an open attitude to scientific collaboration particularly with developing countries and I am very happy at this endeavour. Nanotechnology has tremendous applications to widespread industrial development and development of new products and cost reduction. It is a scale neutral global technology and is compatible with industrial organizations of different types including relatively small hi tech firms with mobility between 'worker' and 'employer' and encompasses both competition and cooperation. It can lead to Lean Production with emphasis on costs, competitiveness and profitability. Application to medical and infrastructure areas like drinking water shows it is possible to integrate the strengths with social

organisation issues? The papers show the need for balancing of objectives with a major focus on growth and profitability but with synergy with social concerns.

I am sure this effort will lead to others in a globally cooperative form.

I congratulate Dr. H.Padh and his colleagues.

**Yoginder K. Alagh**

*Chairman*

*MSME Foundation, Chancellor, Nagaland University; and*

*Former Minister of Science and Technology of India*

## *From the Editors' Desk*

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It has been said that nowadays any significant problem in science requires interdisciplinary or rather more accurately a multi-disciplinary approach. More than any other areas of science, this holds true for the science of 'NANOTECHNOLOGY'. Science has once again amazed us that the same chemical compound in nano-size particles and micron size particles can have surprisingly very different properties which can be very useful in as diverse areas as electronics, forensic sciences, drug delivery, agriculture and pesticide control.

Realising the significance of this emerging area of science and its implication to developing countries, NAM S&T Centre in New Delhi organised an international workshop on 'Nanotechnology: Present Status and Future Prospects in Developing Countries' at Kashan, Iran, from May 18-20, which was attended by 37 experts and professionals from 16 countries. This workshop had two major objectives: (1) To review the science of nanotechnology and its applications, and (2) To review the status of nanotechnology in member countries of NAM S&T. This workshop also had the objective of fostering collaboration among member state and to come out with some common directions for development of this aspect of science in the member countries.

The three-day workshop took place in serene atmosphere of Kashan, approximately 240 km south of Tehran in the foothills of Zagros Mountains. Whether by design or by chance, the location had a lot to do with the open and friendly atmosphere in which intense deliberations resulted. Several participants presented technical aspects of this new branch of science and its applications in varied fields. These presentations are summarized in total of 11 chapters presented in the first two sections of this book. Section I includes six chapters on the theme of "Characterization and Synthesis of Nanomaterials", while Section II having five chapters attempts to sample a few of the applications of nanomaterials. Needless to emphasise, nanoscience has wide spread applicability—these five chapters represent only a small sample. There were many more presentations reviewing the status of this area in several

developing countries. These have been effectively captured in Section III having ten chapters—giving us flavour of country status and various government initiatives to bring benefits to people. Wide gap exists among the developing countries in terms of progress and planning for this new aspect of technology. The deliberations resulted in KASHAN DECLARATION, appended here, and outlining common platform for the member countries to develop the science and applications of the NANOTECHNOLOGY for the benefits of developing nations and their people. It also outlines scope of collaboration among the member countries.

This book represents efforts of the NAM S&T Centre, its member countries and other developing countries. Particularly reference is made to the host country, Iran, also a member of the NAM S&T Centre, which took painstaking efforts in making this workshop a meaningful one. We acknowledge the NAM S&T Centre and the team from Iran for effective organisation of this workshop. Thanks are due to all the authors for timely submission and revision of their respective chapters. Our special thanks are to Mr. Bandopadhyay of the NAM S&T Centre for detailing the arrangements for the workshop and Dr. V.P.Kharbhanda of the NAM S&T Centre for seeing through the compilation and printing process.

*Editors*

# *Introduction*

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Nanotechnology is the engineering, and related science, of the structures on the scale of molecules. It involves nearly all the scientific fields and specialties aimed at developing new materials and devices by precise manipulation of the structure of matter at the atomic- and molecular scales. The field of nanotechnology has found a variety of incredible applications with passive nanostructures including aerosols, colloids, coatings, nano-particle reinforced composites, nano-structured metals, polymers etc., and the active nanostructures embracing items such as targeted drugs, bio-devices, actuators, robots, sensors, molecular computers, surveillance devices and for use in space technology. Nanotechnology is hailed by many as the next industrial revolution, promising to change everything from the cars we drive to the clothes we wear, from the medical treatments our doctors can offer to our energy sources and workplaces, from new cancer therapies to pollution-eating compounds, from more durable consumer products to detectors for biohazards like anthrax, from novel foods to more efficient solar cells. Internationally, more than 100 foods have been manufactured, processed or packaged using nano-particles. The global nanotechnology market is expected to top \$2.7 trillion by 2012.

Nature is already working at the nano-scale. But in so far as the manufactured nanostructures are concerned, these have special composition, reactivity and uniformity that may substantially increase the health and environmental vulnerability. Nano-particles are chemically more reactive than larger particles and can more easily get inside cells, even into the nucleus. Nano-tubes can behave like asbestos fibres and may possibly cause mesothelioma in living beings. One must recognise that free nano-particles do pose a hazard and this must be investigated from the beginning keeping in mind a balance between the benefits and risks from the use of nanotechnology materials and devices. The social and ethical issues concerning this fast emerging scientific field must be quickly addressed.

Although nanotechnology is in its infancy, this is the right time for the developing countries to invest in this new arena. Individual developing countries should take their own policy decision to identify the facet of advancements in nanotechnology which can address their specific economic, social and environmental needs.

In order to deliberate on the issues encompassing the growing significance of nanotechnology and its role in sustainable development, the Centre for Science and Technology of the Non-Aligned and Other Developing Countries (NAM S&T Centre) organised a 3-days international workshop on 'Nanotechnology: Present Status and Future Prospects in Developing Countries' at Kashan, Iran during 18-20 May 2009 jointly with the Iranian Research Organization for Science and Technology (IROST), Iranian Nanotechnology Initiative Council (INIC) and IOR-ARC Regional Centre for Science and Technology Transfer (RCSTT).

The Workshop was attended by 37 experts and senior professionals from 16 countries, including Armenia, Cuba, India, Indonesia, Iraq, Kenya, Libya, Malaysia, Mauritius, Myanmar, Nigeria, South Africa, Sri Lanka, Syria and Uganda, and the host country Iran. The overseas participants were from Armenia [Prof. Vladimir Aroutiounian, Head, Department of Physics of Semiconductors and Microelectronics, Yerevan State University, Yerevan]; Cuba [Dr. Ariel M. Felipe Gómez, Program Manager, Scientific Advisor Office, Council of State, Havana]; India [Dr. Harish Padh, Director, B. V. Patel Pharmaceutical Education and Research Development (PERD) Centre, and Project Director, National Institute of Pharmaceutical Education and Research (NIPER), Ahmedabad; Dr. Vinod Kumar Jain, Director, Amity Institute of Advance Research and Studies, Amity University, Noida; Dr. Uma Shanker Tandon, Scientist 'F', Council of Scientific and Industrial Research (CSIR), New Delhi]; Indonesia [Dr. Silvester Tursiloadi, Head, Division of Process and Catalysis Technology, Research Centre for Chemistry, Indonesian Institute of Sciences, Tangerang]; Iraq [Ms. Ndhall N. Hosain, Chief of Technical Observers, Central Organization for Standardization and Quality Control (COSQC), Baghdad]; Kenya [Prof. Bernard Odhiambo Aduda, Professor, Department of Physics, University of Nairobi, Nairobi; Dr. Erastus Gatika Gatebe, Lecturer, Department of Chemistry, Jomo Kenyatta University of Agriculture and Technology, Nairobi; Dr. Lutta W. Muhammad, Senior Research Officer, Kenya Agricultural Research Institute (KARI), Nairobi]; Libya [Dr. Nagib Ali Elmarzugi, Lecturer, Faculty of Pharmacy, Alfateh University, Researcher, Biotechnology Research Centre, Tripoli]; Malaysia [Mr. Radin Zulfazmi Bin Radin Abdul Halim, Principle Assistant Director, Industry Division, Ministry of Science, Technology and Innovation (MOSTI), Wilayah Persekutuan and Mr. Zailani Bin Safari, General Manager, Intelligence and Research Division, Malaysian Industry-Government Group for High Technology (MIGHT), Wilayah Persekutuan]; Mauritius [Mr. Hemraj Ramsurrun, Resource Officer, Rajiv Gandhi Science Centre, Port Louis]; Myanmar [Dr. Moe Zin Win, Researcher, Materials Science and Metallurgical Engineering Research Centre, Ministry of Science and Technology, Nay Pyi Taw]; Nigeria [Dr. (Mrs.) Zainab Hammanga, Deputy Director, Advance Materials Division, Raw Material Research and Development Council (RMRDC), Abuja]; South Africa [Ms. Nontombi Marule, Deputy Director, Emerging Research Areas, Department of Science and Technology, Pretoria]; Sri Lanka [Prof. Ajith P. de



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Alwis, Professor, Sri Lanka Institute of Nanotechnology, University of Moratuwa, Malwana]; Syria [Dr. Nofal Ibrahim, Assistant Professor and Dr. Mhd. Ali Alsayed Ali, Researcher, Higher Institute for Applied Science and Technology (HIAS), Damascus;]; and Uganda [Mr. Henry Mugisha Bazira, Executive Director, Water Governance Institute, Kampala].

Workshop was conducted in nine technical sessions broadly categorised under the themes 'Characterization and Synthesis of Nano-Materials', 'Applications of Nanotechnology', 'Nanotechnology: Policy, Strategy and Market Development' and 'Nanotechnology: Status and Prospects in Developing Countries'. These sessions were co-chaired by Dr. Saeed Sarkar, Dr. M. Molanejad, Dr. Mohsen Jahanshahi, Dr. Safai, Dr. F. Davar, Dr. Bahram Khoshnevisan and Dr. Abdolhamid Bamoniri from Iran, and Dr. Abbas Sadri (ISESCO), Prof. Vladimir Aroutiounian (Armenia), Dr. Ariel M. Felipe Gómez (Cuba), Dr. Harish Padh and Dr. Vinod Kumar Jain (India), Prof. Bernard Odhiambo Aduda and Dr. Lutta W. Muhammad (Kenya), Dr. Nagib Ali Elmarzugi (Libya), Mr. Hemraj Ramsurrun (Mauritius), Dr. (Mrs.) Zainab Hammanga (Nigeria), Prof. Ajith P. de Alwis (Sri Lanka) and Dr. Nofal Ibrahim (Syria) from among overseas participants.

The foreign participants, who presented their papers, were Prof. Vladimir Aroutiounian (Armenia) on 'Nanotechnology–Present Status and Future Prospects in Armenia'; Dr. Ariel M. Felipe Gómez (Cuba) on 'The Cuban Approach towards Nano Biotechnology: A New Step on Scientific Development of the Country'; Dr. Harish Padh (India) on 'Drug Delivery and Drug Targeting using Therapeutic Nanoparticles'; Dr. Vinod Kumar Jain (India) on 'Applications of Micro and Nanotechnology in Biomedical Engineering' and 'MEMS and Nanotechnology Based Explosive Detector'; Dr. Uma Shanker Tandon (India) on 'Nano-Structures, Nano-Materials and Systems'; Dr. Silvester Tursiloadi (Indonesia) on 'Syntheses of Nano Size Anatase Type of Titania Aerogels by Addition of Silica'; Prof. Bernard Odhiambo Aduda (Kenya) on 'Status of Nanoscience and Nanotechnology in Kenya'; Dr. Lutta W. Muhammad (Kenya) on 'Harnessing Emerging Technologies for Kenya's Vision 2030 Development Strategy: Prospects for Leveraging Advances in Nano-Technology'; Dr. Erastus Gatika Gatebe (Kenya) on 'Development of Nanostructured Smart Delivery Systems for Pesticides and Fertilizers'; Dr. Nagib Ali Elmarzugi (Libya) on 'The Surface Study of Different Architectures of DMAEMA Polymer at Nano Scale for Transfer DNA in Gene Therapy'; Mr. Zailani Bin Safari (Malaysia) on 'Driving Nanotechnology Development in Malaysia'; Mr. Radin Zulhazmi Bin Radin Abdul Halim (Malaysia) on 'Nanotechnology: Present Status and Future Prospect in Malaysia'; Mr. Hemraj Ramsurrun (Mauritius) on 'A Vision for Civic Engagement in Nanotechnology in Mauritius'; Dr. Moe Zin Win (Myanmar) on 'Present Status of Nanotechnology Research in Myanmar'; Dr. (Mrs.) Zainab Hammanga (Nigeria) on 'Nanotechnology–Present Status and Future Prospects in Nigeria'; Ms. Nontombi Marule (South Africa) on 'South African Nanotechnology Strategy'; Prof. Ajith P. de Alwis (Sri Lanka) on 'Sri Lanka Nanotechnology Initiative'; Dr. Nofal Ibrahim (Syria) on 'Growth and Characterization of PbS Nanocrystalline Thin Films Deposited on Glass Substrates by Chemical Bath Deposition', Dr. Mhd. Ali Alsayed Ali (Syria) on 'Characterization of Carbon Nanoparticles formed in Diluted Environments'; and Mr. Henry Mugisha

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Bazira (Uganda) on 'Application of Nano-Science and Nanotechnology in Uganda's Economy'. Prof. Arun Kulshreshtha (NAM S&T Centre) made a presentation on 'South-South Cooperation through NAM S&T Centre'.

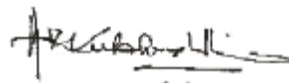
The participants from Iran, who made presentations during the workshop were Dr. Saeed Sarkar, Director, INIC on 'Iran 'Nano Initiative' Program, Targets and Achievement'; Dr. Mohsen Jahanshahi, Head, Nanobiotechnology Research Centre, Babol University of Technology on 'Nanofiltration Membranes: Preparation, Characterization and Industrial Application in Water / Waste Water Treatments'; and Dr. Bahram Khoshnevisan, Assistant Professor, Institute of Nanoscience and Nanotechnology, University of Kashan, Iran on 'Hydrogen Storage as a Fuel Resource in Future'

The Plenary Concluding Session was led by Dr. M. Molanejad (Director, International Cooperation, IROST), Dr. Mohsen Jahanshahi (Head, Nanobiotechnology Research Centre, Babol University of Technology) and Prof. Arun Kulshreshtha (Director, NAM S&T Centre) when a Kashan Declaration on 'Nanotechnology: Present Status and Future Prospects in Developing Countries' was adopted after considerable deliberations and debate.

The present publication is based on the deliberations of the Iran workshop and includes papers contributed by eminent specialists in the field. It comprises of twenty-one articles and review papers under four Chapters namely 'Characterisation and Synthesis on Nano-Materials', 'Application of Nanotechnology', 'Nanotechnology: Policy, Strategy and Market Development', and 'Nanotechnology: Status and Prospects in Developing Countries'.

I acknowledge with gratitude the deep involvement and determined efforts of Dr. Harish Padh, Director, B. V. Patel Pharmaceutical Education and Research Development (PERD) Centre, Ahmedabad, India; Prof. Bernard Odhiambo Aduda, Professor, Department of Physics, University of Nairobi, Kenya; and Prof. Ajith P. de Alwis, Sri Lanka Institute of Nanotechnology, Sri Lanka in editing this valuable publication. I am also indebted to the entire team of the NAMS&T Centre, particularly Mr. M. Bandyopadhyay, Dr. V.P. Kharbanda, Mrs. Manjari Manisha, Ms. Chitra Prasad and Mr. Pankaj Buttan in compiling the presented papers, liaising with the authors and editors and giving a shape to this volume.

I sincerely trust that this publication will serve as a valuable reference material not only for the developing countries but for other countries as well and will pave way for the promotion of South-South and North-South cooperation in the fast emerging area of nanotechnology.



**Prof. Arun P. Kulshreshtha**  
*Director, NAM S&T Centre*

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# Chapter 1

## *Nanostructures, Nanomaterials and Systems*

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### ABSTRACT

The precision needed in the shape and dimensions of an ultimate nanostructure or system entail exacting restrictions on its engraving mechanisms. The generation of nano-structures producing miniaturized components such as lab-on-a-chip, DNA-array and NEMS calls for processes, which offer more flexibility than that available with the conventional surface milling. The shapes of components structured by classical processes are often governed by the crystalline properties of the substrate and chemical as well as physical parameters of the unit process. Reactive gas cold plasma has led to engraving of structures such as lines, holes, channels, grooves or pyramids of stipulated dimensions. Bottoms up approach like arc discharge, CVD, biomimetics and reverse micellar routes have given a spurt in the variety of nanomaterials being investigated. It has expanded the interest of researchers from nanoscience and technology towards the design of new nanomaterials with specific characteristics. Nano-biomaterials with better mechanical, thermal, chemical properties than found in known materials are being made. Nano-fibres, -particles, -phosphors and -composites on varied templates are being synthesized.

**Keywords:** *Biomimetic, Functionalize, Granule, Mushrooms, Nanocomposite, Nanoreactor, Stimuli, Tissue Engineering.*

### Introduction

Spectacular developments in various unit processes of micro-nano-fabrication kept propelling the revolution in microelectronics for a period longer than two decades