Report of 2 Days National workshop on Nanotechnology: Emerging Frontiers & Applications NEFA 2017

Department of Physics & Department of Chemistry , Shyam Lal College
University of Delhi
30th -31st January 2017
Venue: Seminar Room, Department of Chemistry, University of Delhi, Delhi-110007, India

Acknowledgments

We would like to express our appreciation to the institutions that help us to organize this workshop:

- Department of Physics & Department of Chemistry, Shyam Lal College, University of Delhi, Delhi, India
- Department of Chemistry, University of Delhi, Delhi, India
- Department of Physics & Astrophysics, University of Delhi, Delhi, India
- University Scientific Instrumentation Centre, University of Delhi, Delhi, India
- Luminescence Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India
- ECMS Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India
- Material Science Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India

We give special thanks to Prof. K. Shreeniwas, Prof. Vinay Gupta and Prof. P. D. Sahare for providing a facility well suited for the working sessions. We also want to acknowledge Prof. R. P. Tandon & Prof. Gurmeet Singh for helping us to organize this workshop. We especially thank the speakers at our workshop and the workshop participants for their enthusiastic participation and generous sharing of their time and ideas. Last but not the least we would wish to acknowledge the cooperation and support provided by our learned Principal Dr. Rabi Naryan Kar, patron of the workshop.

Executive Summary

This document presents the findings of a workshop held to discuss conceptual issues and needs related to integrating the science and technology of the nanoscale into science education. The workshop was jointly organized by the Department of chemistry & Department of physics, Shyam Lal College, Shahdara, Delhi, India and was held at Seminar Room, University of Delhi,

Delhi on January 30-31, 2017. The primary purpose of the workshop was to bring together a wide variety of participants, including educational researchers and science educators, nanoscientists, to discuss and better understand the impact of nanoscience on current scenario of the world.

Importance of Considering the Nanoscale

Research at the nanoscale both depends on and influences advances in physics, chemistry, biology, material science, engineering, medicine, and technology. Nanoscience and nanotechnology advances have had a significant qualitative impact on science, and have become one of the top R&D priorities. Consideration of nanoscience brings an interdisciplinary approach to core issues and concepts from physics, chemistry, biology, materials science, and engineering. The ability to manipulate matter at the scale of molecular, metallic and ionic aggregates, within living or manmade materials, focuses attention on a domain of nature where the predominant models of physics are not the same as they are at the microscopic or atomic scales. The pervasive accessibility of significant computational power introduces the ability to experiment with different representations of reality and to explore their limits and applications based on current scientific knowledge. As a consequence, the problems of interest to science have become more interdisciplinary and complex, as have the mathematical simulations used to explore and illustrate the unobservable behavior of the smallest particles of matter. The boundaries between traditional disciplines of science—physics, chemistry, and biology—disappear when characterizing or describing the behavior of matter at the nanoscale. Nature, whether within living or nonliving systems, operates by one set of laws. It is important, therefore, to recognize that the models that best describe the behavior of nanosized particles do not differ between disciplines.

Workshop Organization

The workshop took place over a two-day period (30-31, January 2017). Representatives from the organizing institutions gave their perspectives on nanotechnology innovations, nanoscience education, and collaborations to support the development of a new nanoscience technologies.

One hundred and forty (140) participants and 40 Volunteers participated in the workshop. The program included several keynote talks addressing the state-of-the-art in nanoscience and technology .This was followed by several individual oral presentations.

Patron	Dr. Ravi Narayan Kar, Principle, Shyam Lal College
Co-ordinator	Dr. Vijay Kumar Sharma, Department of Physics, Shyam Lal college
Convener	Dr. Sanjay Kumar, Department of Chemistry, Shyam Lal college, Dr. Seema Dabas, Department of Physics, Shyam Lal college

Secretary	Dr. Narendra Singh, Department of Physics, Shyam Lal college
Treasurer	Dr. Vinod Kumar, Department of Chemistry, Shyam Lal college

Introduction:

Nanotechnology is recogniziswed as one of the most emerging technology in the modern times. that shows applicability in several different sectors such as medicine, biotechnology, electronics, materials science and energy technologies. Nanotechnology makes use of phenomena and fine-tuning of materials at atomic, molecular and macromolecular scales, where properties differ from those at a larger scale. The innovation in this sector is pulled by manufacturers and producers because of the beneficial new properties of nanomaterials,attracting large-scale research investments.

The purpose of the "Workshop on Nanotechnology: emerging frontiers and applications (NEFA2017), held at seminar room ,department of chemistry, university of delhi on 30th and 31st January 2017, was to review the current state of knowledge in the field of nanoscience and technology along with their novel applications and challenges. This workshop brought together leading.The workshop brought together more than 80 participants from health, physical and social sciences, humanities and ethics, industry, citizen's groups and government. Collectively, they identified and prioritized key research gaps in nanotechnology, especially as they related to the ethical, legal, social, economic, environmental and health impacts and risks of nanotechnology, and the regulatory and governance mechanisms needed to address them.

Objectives:

Nano Science is one of the most emerging fields of inter-disciplinary research.In last two decades a remarkable development in discovery of novel materials especially in nanoscale have been attained. In fact, nanoscience and technology will be in commanding position to modify the human life in true sense. It is worth to take a note that these technological innovations will be new driving force in Global market for sustainable development. As characterization and manipulation tools are gaining accuracy, the ability to resolve and manipulate single atoms and clusters of atoms is increasing day by day leading to significant advancement in technology. The Increasing energy demands and environmental issues, has led to the use of nanotechnology to encourage the replacement of existing products with new nano-products that are more environment friendly throughout their life cycle. The workshop will highlight the multifaceted applications of nanotechnology, through current research and hand on experience on experimental techniques.This workshop aims to develop a holistic approach of nanoscience and nanotechnology by bringing together researchers and practitioners from the field to explore the

recent trends to understand the major challenges.The workshop also aims to identify synergies where nanotechnology can be applied. More than ten experts on the subjectwill provide their respective understandings, perspectives and experiences to audience to accomplish the objective of the workshop. The workshop will provide opportunities for participants to have new ideas about, how nanotechnology can be explored for the betterment of human beings. This workshop will be useful for students of UG, PG, academics, practitioners, policy makers, professionals in the field of science & technology, engineering technology and innovation. It also provides the premier interdisciplinary forum for participants to present and discuss the most recent innovative and practical challenges in this field.

Technical Details, Discussions & Lab Details:

Inauguration Session: This session starts with the welcome words by the Prof. Ashok K Prasad, Department of Chemistry, University of Delhi, Member, Governing Body, Shyam Lal College. Then, the Chief Guest Dr. R. K. Sharma, Director, SSPL, DRDO, enlightened the audience with his wisdom words on the importance of the event. Prof. Gurmeet Singh, Head, Department of Chemistry, gave overview of the workshop. Then it was the turn of a luminary Prof. R. P. Tandon, Department of Physics & Astrophysics, University of Delhi, who set the tone of the workshop with his key note lecture entitled "Overview of Nanofabrication & Future Challenges". In his talk the past present and future aspects on Nanotechnology was discussed in details.

Technical Session I: This session was chaired by **Prof. Pratik Kumar,** Head, Health Physics division from AIIMS. In this session there were three invited talks. The first lecture entitled " Energy Harvesting Using Functional Materials" was delivered by Prof. Vinay Gupta, Dean Examination & Professor, Department of Physics & Astrophysics, University of Delhi, introduced a very new concept to the participants. For decades, people have searched for ways to harvest energy from natural sources. Lately, a desire to address the issue of global warming and climate change has popularized solar or photovoltaic technology, while piezoelectric technology is being developed to power handheld devices without batteries, and thermoelectric technology is being explored to convert wasted heat, such as in automobile engine combustion, into electricity.

Energy Harvesting with Functional Materials explains the growing field of energy harvesting from a materials and device perspective, with resulting technologies capable of enabling low-power implantable sensors or a large-scale electrical grid. In addition to the design, implementation, and components of energy-efficient electronics, this lecture covers current advances in energy-harvesting materials and technology, including: High-efficiency solar technologies with lower cost than existing silicon-based photovoltaics, Novel piezoelectric technologies utilizing mechanical energy from vibrations and pressure, the ability to harness thermal energy and temperature profiles with thermoelectric materials.

The second invited talk was something very interesting on NonLinear optics. " Nonlinear Optics in Photonics Materials" by Prof. Devendra Mohan, G. J. S& T University, Hisar, Haryana, India. Second-order nonlinear optical processes are forbidden, in the electric-dipole approximation, in centrosymmetric materials. For organic materials, noncentrosymmetry and significant second-order response (first molecular hyperpolarizability) is relatively easy to achieve on the molecular level by connecting donor and acceptor groups by a conjugated π-electron system. However, the macroscopic noncentrosymmetry of such materials is usually achieved only by aligning the molecules in an electric field. In polymeric materials, the alignment can be frozen by cooling the material below its glass-transition temperature while the field is applied. Unfortunately, this poling process results in a thermodynamically unstable material whose nonlinearity tends to relax with time.

Dr. J. S. Rawat, Scientist G, SSPL delivered the third invited talk on CNT. Carbon nanotubes (CNTs) are allotropes of carbon, made of graphite and constructed in cylindrical tubes with nanometer in diameter and several millimeters in length. Their impressive structural, mechanical, and electronic properties are due to their small size and mass, their strong mechanical potency, and their high electrical and thermal conductivity. CNTs have been successfully applied in pharmacy and medicine due to their high surface area that is capable of adsorbing or conjugating with a wide variety of therapeutic and diagnostic agents (drugs, genes, vaccines, antibodies, biosensors, etc.). They have been first proven to be an excellent vehicle for drug delivery directly into cells without metabolism by the body. Then other applications of CNTs have been extensively performed not only for drug and gene therapies but also for tissue regeneration,

biosensor diagnosis, enantiomer separation of chiral drugs, extraction and analysis of drugs and pollutants. Moreover, CNTs have been recently revealed as a promising antioxidant. This mini review focuses the applications of CNTs in all fields of pharmacy and medicine from therapeutics to analysis and diagnosis as cited above. It also examines the pharmacokinetics, metabolism and toxicity of different forms of CNTs and discusses the perspectives, the advantages and the obstacles of this promising bionanotechnology in the future.

Technical Session II: This session was chaired by Prof. Devendra Mohan, G. J. S& T University, Hisar, Haryana, India. There were two invited talks in this session. Prof. P. D. Sahare, Professor, Department of Physics & Astrophysics, University of Delhi, delivered an invited talk on" Dosimetery using Nano Phosphors: Few Challenges and Solutions". A phosphor, most generally, is a substance that exhibits the phenomenon of luminescence. Somewhat confusingly, this includes both phosphorescent materials, which show a slow decay in brightness (> 1 ms), and fluorescent materials, where the emission decay takes place over tens of nanoseconds. Phosphorescent materials are known for their use in radar screens and glow-in-the-dark materials, whereas fluorescent materials are common in cathode ray tube (CRT) and plasma video display screens, sensors, and white LEDs. Phosphors are often transition metal compounds or rare earth compounds of various types. The most common uses of phosphors are in CRT displays and fluorescent lights. CRT phosphors were standardized beginning around World War II and designated by the letter "P" followed by a number.

Dr. A. K. Mohapatra, Department of Physics & Astrophysics, University of Delhi, Delhi-11007, India beautifully described the technological advancement in Nanoscale in his lecture "Progress of science and technology in nanometer scale." The field of Nanometer Scale Science and Technology (NSST) is very broad, ranging from nanoparticles, nanoclusters, mesoscopic systems and nano constrictions, to individual atoms and molecules and their self-assembly into defined structures such as nanowires or biomolecules. This is a field where the border between the traditional disciplines like physics, chemistry and biology is no longer detectable and interesting synergies arise, e.g., instruments developed in physics provide the precision and sensitivity to perform specific molecular recognition experiments in biology. The roots of NSST go back to Feynman. The originator of the famous sentence ``There is plenty of room at the bottom". His focus was on tools based mainly on electron microscopes. Taniguchi contributed to the roots by stressing the importance of the nanometer in precision mechanics. The breakthrough occurred with new types of microscopes (SPM), materials (carbon-based fullerenes, nanotubes and quantum dots), mesoscopic systems, new trends in iniaturization based on the view of chemists and the vision that nature is the best example of nanotechnology. In this discussion it is of interest to know the answers to the questionnaire:
-Significant SCIENTIFIC discoveries; Significant TECHNOLOGICAL advancements. Few quoted significant scientific discoveries were

- the development of SPM and atom manipulation;
- the discovery of fullerenes, nanotubes, nanocrystals and quantum dots;
- demonstration of single electron devices at room temperature;
- demonstration of molecular electronic devices;
- biological examples of functional nanostructures: rotary motors, self/non-self recognition.

The quoted significant technological advancements are

- expansion of types and uses of SPM;
- nano-lithography via molding and stamping as low-cost, high-throughput nanopatterning technologies with sub 10 nm feature size;
- Micro-Electro-Mechanical Systems (MEMS) or Nano-Electro-Mechanical Systems (NEMS);
- high-speed AFM-based lithography.

Lab Session I: To make this session effective, the participants were divided into five small groups. The students were supposed to visit at least two /three labs. Five Labs were selected to visit.

(a) University Scientific Instrumentation Centre (USIC), University of Delhi, Delhi, India, where Prof. K. Srinivasan had given hands on experience on various experimental techniques e. g. XRD, SEM, TEM, AFM and Raman spectroscopy etc.
(b) Luminescence Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India Prof. P. D. Sahare conducting this session on Synthesis, TL, PL and OSL on nanophosphors.
(c) Prof. Vinay Gupta conducted a practical session on fabrication and charactersation of IC and nano structures in ECMS Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India.
(d) Prof. R. P. Tandon and Dr. Naveen Mehra conducted hands on experience on fabrication of thin film in Material Science Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India.
(e) Corrosion Lab was visited by the participants where Dr. Ompal Singh took charge to give the experimental inputs on AFM.

Technical Session III:

This session was chaired by Prof. P. D. Sahare, Professor, Department of Physics & Astrophysics, University of Delhi, Delhi. In this session two different aspects of the Nanotechnology were covered by two eminent personalities. Prof. S. P. Singh, Scientist G, NPL explained " Prospects of material engineering in biomedical applications". Two-dimensional (2D) nanomaterials are ultrathin nanomaterials with a high degree of anisotropy and chemical

functionality. Research on 2D nanomaterials is still in its infancy, with the majority of research focusing on elucidating unique material characteristics and few reports focusing on biomedical applications of 2D nanomaterials. Nevertheless, recent rapid advances in 2D nanomaterials have raised important and exciting questions about their interactions with biological moieties. 2D nanoparticles such as carbon-based 2D materials, silicate clays, transition metal dichalcogenides (TMDs), and transition metal oxides (TMOs) provide enhanced physical, chemical, and biological functionality owing to their uniform shapes, high surface-to-volume ratios, and surface charge. Here, we focus on state-of-the-art biomedical applications of 2D nanomaterials as well as recent developments that are shaping this emerging field. Specifically, we describe the unique characteristics that make 2D nanoparticles so valuable, as well as the biocompatibility framework that has been investigated so far. Finally, to both capture the growing trend of 2D nanomaterials for biomedical applications and to identify promising new research directions, the speaker provide a critical evaluation of potential applications of recently developed 2D nanomaterials.

Prof. A.K. Dinda, AIIMS, gave an eye opening lecture on "Applications of Nanotechnology in Medicines: The Challenges Ahead:" The use of nanotechnology in medicine offers some exciting possibilities. Some techniques are only imagined, while others are at various stages of testing, or actually being used today. Nanotechnology in medicine involves applications of nanoparticles currently under development, as well as longer range research that involves the use of manufactured nano-robots to make repairs at the cellular level (sometimes referred to as *nanomedicine*). Whatever you call it, the use of nanotechnology in the field of medicine could revolutionize the way we detect and treat damage to the human body and disease in the future, and many techniques only imagined a few years ago are making remarkable progress towards becoming realities. One application of nanotechnology in medicine currently being developed involves employing nanoparticles to deliver drugs, heat, light or other substances to specific types of cells (such as cancer cells). Particles are engineered so that they are attracted to diseased cells, which allows direct treatment of those cells. This technique reduces damage to healthy cells in the body and allows for earlier detection of disease. For example, nanoparticles that deliver chemotherapy drugs directly to cancer cells are under development. Tests are in progress for targeted delivery of chemotherapy drugs and their final approval for their use with cancer patients is pending.

Technical Session IV:

This session was chaired by Prof. Gurmeet Singh, Professor & Head, Department of Chemistry, University of Delhi, Delhi, India. Dr. Sanjay Dhakte Scientist G, NPL was the resource person who gave a thought provoking lecture entitled as " Recent trends in Carbon nanotubes and its applications" Carbon based nanostructure materials exhibit unique mechanical, electrical, and optical characteristics, which may result in many unique device designs. These materials are biocompatible, chemically inert but capable of altering their electronic properties in the presence

of some chemical species, and dimensionally compatible with biomolecules. They have interesting electronic characteristics, thus rendering them as potential chemical and biosensors. The recent progress in nanostructured materials and their possible applications in chemical and biological sensors could have a significant impact on data collection, processing, and recognition. This investigation is aimed towards evaluating the applications of nano-structures of carbon and giving a consolidated view of the structure, properties and applications of carbon nanotubes, with the aim of drawing attention to useful available information and to enhancing the interest in this new highly advanced technological field for the researcher and the manufacturing engineer.

Last invited talk " Roles of Synthesis in Nanotechnology" was given by Prof. R. Nagrajan, Department of Chemistry, University of Delhi, Delhi. The synthesis of metallic nanoparticles is an active area of academic and, more significantly, applied research in nanotechnology. Several methods have been introduced for the synthesis of these materials. The techniques for synthesizing nanoparticles can be divided into solid-phase, liquid-phase and gas-phase processes. The solid-phase techniques include mechanical ball milling and mechanochemical, the liquid-phase techniques include laser ablation, exploding wire, solution reduction, and decomposition process, whereas the gas-phase processes include gas evaporation, exploding wire, and laser ablation process. This lecture was an attempt to present an overview of nanoparticles preparation by various methods.

Lab Session II: To make this session effective, the participants were divided into five small groups. Five Labs were selected to visit.

1. University Scientific Instrumentation Centre (USIC), University of Delhi, Delhi, India, where Prof. K. Srinivasan had given hands on experience on various experimental techniques e. g. X-Rd, SEM, TEM, AFM and Raman spectroscopy etc.

2. Luminescence Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India Prof. P. D. Sahare conducting this session on Synthesis, TL, PL and OSL on nanophosphors.

3. Prof. Vinay Gupta conducted a practical session on fabrication and charactersation of IC and nano structures in ECMS Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India.

4. Prof. R. P. Tandon and Dr. Naveen Mehra conducted hands on experience on fabrication of thin film in Material Science Lab, Department of Physics & Astrophysics, University of Delhi, Delhi, India.

5. Corrosion Lab was visited by the participants where Dr. Ompal Singh took charge to give the experimental inputs on AFM.

Oral Presentation Session: In this session there were 24 presentations from various presenters. These 27 abstracts were peer reviewed by an external independent reviewer. To conduct it smoothly three parallel session were conducted chaired by Dr. Vinod Kumar, Department of Chemistry, Shyam Lal College, Dr. Pankaj Kumar, Department of Physics, Deshbandhu College and Dr. Narendra Singh Department of Physics, Shyam Lal College, respectively. These presentations were divided into three groups. Out of these 24 presentations only 20 were presented as listed in annexure I.

Valedictory Session: This session started as an Overview of the workshop by the coordinator Dr. Vijay Kumar Sharma. On the same lines Prof. Gurmeet Singh congratulated the organizers and participants for a wonderful event. Prof. R. P. Tandon advised the organizers to organize the events frequently for betterment of students of Shyam Lal College. Dr. Pravin Kumar Principal Shyam Lal College(Evening) also graced the occasion. Our respected Principal Dr. Rabi Naryan also thanked all reviewers, speakers and participants. Feedback was also taken by the Principal Sir which was very much satisfactory. Dr. Seema Dabas and Dr. Sanjay Kumar Convener of the workshop gave vote of thanks.

Conclusion

The main goal of this workshop was to develop a list of key nanotechnology research areas that will need to be addressed for nanoscience and nanotechnology to have their desired impacts. Many of these key research areas will require multidisciplinary approaches. This workshop was also intended to build greater linkages among participants and researchers from different disciplines and fields and help create greater mutual awareness of the potential positive outcomes of nanotechnology as well as the potential risks and needs. The future health of nanotechnology can only be secured if the science is advanced within the bounds of a multidisciplinary framework, supported by adequate tools and resources. Only through the concerted efforts of individuals in all disciplines that exert an influence over the present and future course of research will nanotechnology safely achieve its potential benefits for all of society.