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The Study of Nanomaterial and Their Application with Special Reference to Biomedical and Pharma Industry in India

Vijay Laxmi Kalyani, **Saumya Paliwal**

***Vijay Laxmi Kalyani**, Assistant Professor, GWECA*
vijaylaxmikalyani@yahoo.com
***Sumya Paliwal**, B.Tech., [ECE], GWECA*
kotasaumya@gmail.com

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ABSTRACT: Nanomaterials are increasingly becoming popular in almost every other field. Due to their extremely small size and ability to do manipulation at atomic scale it has opened doors to a huge market. They are widely being used in the field of health and medicine, electronics, textiles, environment pharmaceuticals. Nanomaterials are being widely used throughout the world for their immense applications. In India, the biomedical industries and pharmaceutical industries also working on nanomaterials which are being used in a variety of fields. In this paper we are going to present the application of nanomaterials which are being used in the pharmaceutical and biomedical field. In this paper we will also discuss about various biomedical and pharmaceutical industries in India those who are working on different types of nanomaterials .We will also discuss about various names of government funding agencies in India those who are supporting to do the research in these fields.

keywords: Nanomaterials and applications, list of various Indian biomedical and pharmaceutical industries, various government funding agencies

I. INTRODUCTION

Nanomaterials means a new class of materials with a smaller size of <100 nm impart altered or enhanced properties. Nanomaterials are used in various applications such as solar cells, fuel cells, optical computing, biological science, catalysis, biomass conversion, and smart materials. Most of the nanomaterials are used in nanotechnology with a size less than 1 µm. Nanomaterials can be produced with various classification of modulation dimensionalities such as 0D used for spheres and clusters, 1D for nanofibers, wires, and rods,2D for films, plates, and networks, 3D for nanomaterial. It can be distinct nanostructure such as quantum dots, nanoparticles, nanocrystals, atomic clusters, nanotubes and nanowires, gold nanoshells ,nanofiber while gathering of nanostructures includes arrays, assemblies, and super lattices of distinct nanostructure.

The U.S forms the largest market for the nanomaterials owing to large application use of nanotubes in various industries. Electrical and electronics, pharmaceutical, and chemical products are the major application segments in North America market. Europe also held a significant market share in the nanomaterials market. Decrease in price of nanomaterials due to increase in mass production has lead to robust growth of nanomaterials in these regions. Asia Pacific is expected to witness remarkable growth in the projected period. Increasing government funding and support, rising environmental consciousness, and rising demand for specialty materials is expected to boost the growth of nanomaterials market in the foreseeable period. Nanomaterials are regulated under REACH and CLP regulation in the European market while U.S FDA regulates nanomaterials for the American market [1]. Nanoscale materials engineering will have an increasingly important impact on a number of sectors, including biotechnology, electronics, energy, and industrial products. Because of the rapid demand of nanomaterial in various sectors many companies are entering in field of nanomaterials market and they are working to achieve faster commercialization of the new products for their business. In the field of nanotechnology and nanomaterials many of the research and development funding agencies gives support to do the better research in this field. The global market for the nanomaterial's in the year 2006 was around US $14,000, and the global investments are to be increased 50% more by the ending of 2019.

Advancement and research on nanomaterials in the field of biomedical and pharmaceutical has revolutionized the twentieth century. In India there is a great need of this nanorevolution . As it has already started creating an impact in the field of medicine , but there is still a need of a rapid growth in India compared to other nations. Although there are some industries already employing nanomaterials for various applications. In previous research various studies done on nanomaterials for biomedical applictions. In [2] the review was focuses on the major nanoparticle based diagnostic and therapeutic modalities. In [3] applications of nano technology in tuberculosis treatment, the clinical application of nanotechnology in various field was discussed and Nano pharmaceuticals can be used to detect diseases at

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much earlier stages. In [4] methodology was being implemented at the Ecole Polytechnique de Lausanne in over 100 research labs dealing with nanomaterials.

In this paper we are going to discuss about various types of nanomaterial that are being used in biomedical and pharmaceutical field and their application. We will also discuss about various companies of India those who are working in the field of bio- medical and pharmaceutical sector.

II. IMPORTANCE OF NANOMATERIAL

Various chronic diseases like diabetes, and other cardiac problems are rapidly growing due to the present day lifestyle. According to World Health Organization, India has the largest number of diabetes and cardiac patients of the world's population. There is an urgent need to control this situation. Also the Indian pharmaceutical industries growing rapidly and it is the need of the hour.

In India, many industries are working on manufacturing of various nanomaterial for many purposes . In this paper our prime concern is about the pharmaceutical and medical companies which are using these nanomaterials. The main advantage of using the nanomaterials for making medicines is that it can reduce the dosage as they work on specific target and are not sent to every part of the body like the conventional medicines. Also, Instead of taking a large no. of medicines we can incorporate all of them in a single medicine using nanomaterials. Also it has made the diseases detection and prevention much easier, improved diagnosis and imaging and its treatment much easier. Nanomaterials being used for this purpose are zinc, titanium, carbon nanotubes, gold. It has given a solution for a severe diseases such as cancer, Parkinson's disease ,Alzheimer's disease, Tuberculosis etc. In the next 10-20 years, market will be flooded with nano-based medicines and drug delivery systems as well as nano-enabled ultrasensitive and rapid detection devices for diagnosis and therapy.

III. BASIC OF NANOMATERIALS

All materials in nano scale size have quite a large surface area to volume ratio. This single characteristic paves way for new quantum mechanical effects. Due to these effects the size of the particle reduces, which causes a change in the electronic properties of the solid. When the size of the material becomes micro, there will not be any interference of the quantum effect. But the effect will start its play as soon as the material becomes nano-sized. There will also be changes in the physical as well as catalytic activities of the material.

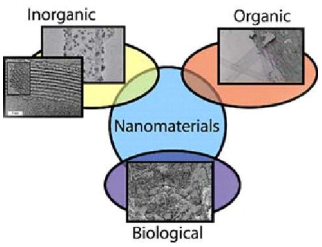

Fig 1: Nanoamterial applications in various fields

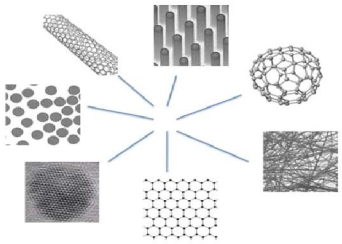

Fig 2: Types of Nanomaterials

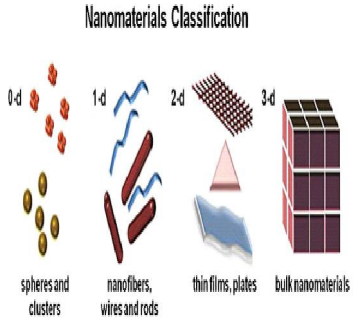

Fig 3 : Classification of Nanomaterials
Source:http://events.nace.org/TCCNews/2ndquarter_2014/teg474x.asp]

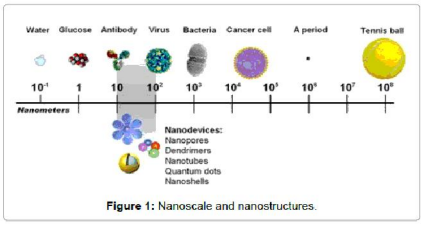

Fig 4 : Nanoscale and Nanostructures
Source: [Nikalje AP (2015) Nanotechnology and its Applications in Medicine.]

Nanomaterials are of two types: Fullerenes and Nanoparticles.

- Fullerenes are actually grapheme sheets rolled in the form of spheres and are actually a class of allotropes of carbon. A main example of fullerene is carbon nanotubes. They have good mechanical strength and good electrical conductivity. Fullerenes are mainly used in the medical field as they are known for binding certain types of antibiotics to the structure of resistant bacteria. They are also found to be resistant against melanoma, at type of cancer cell. They are also having high resistance and superconductivity properties. Thus, they also find great applications as light-activated antimicrobial agents. Fullerenes are obtained by inserting a large amount of current

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in between two very close graphite electrodes in an atmosphere that is inert in nature. From the reaction a carbon plasma arc is obtained in between the electrodes, which then forms as a residue. This residue is then converted to obtain fullerenes.

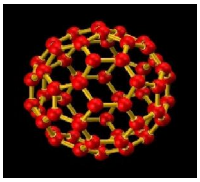

Fig 5: Fullerene Structure

- Nanoparticles are made from metals, semiconductors, and other particles that have great chemical, physical, electrical and magnetic properties. Nanoparticles find its main application as chemical catalysts. Nanoparticles have a size so small, that they actually lie between the bulk materials and the molecular structures. As a result they possess some of the properties of the bulk materials as well as molecular structures. Nanoparticles have emerged as promising nano platforms for efficient diagnostics and therapeutics by merging the characteristic properties they possess at the nanometric scale with the feasible immobilization of specific ligands on the surface. Therefore, they have become ideal candidates for molecularly sensitive detection, highly efficient contrast agents for molecular imaging, as well as carriers for targeted drug and gene delivery, and therapeutically reagents for targeted photo thermal therapy. Nanoparticle usually forms the core of nano-biomaterial. It can be used as a convenient surface for molecular assembly, and may be composed of inorganic or polymeric materials. It can also be in the form of nano-vesicle surrounded by a membrane or a layer. The shape is more often spherical but cylindrical, plate-like and other shapes are possible. Nanoparticles for some diagnostics purpose are in development process such as for molecular diagnostics Multifunctional nanoparticles, which incorporate diagnostic (quantum dots, magnetic, metallic, polymeric and silica nanoparticles) and/or therapeutic (magnetic and metallic nanoparticles) properties. They have been used in vivo to protect the drug entity in the systemic circulation, restrict access of the drug to the chosen sites and to deliver the drug at a controlled and sustained rate to the site of action.

  Nanoparticles are commonly used for diagnostics purpose such as Gold nanoparticles, Magnetic nanoparticles Quantum dot (QD) technology, DNA-protein and nanoparticle conjugates.

IV. DIFFERENT TYPE OF NANOMATERIALS USED IN BIOMEDICAL AND PHARMACEUTICAL FIELD AND THEIR APPLICATIONS

Many types of nanomaterials are used in Biomedical and pharmaceutical field such as Carbon Nanotubes, Quantum Dot, Gold Nanoshell, Nanofibre etc.

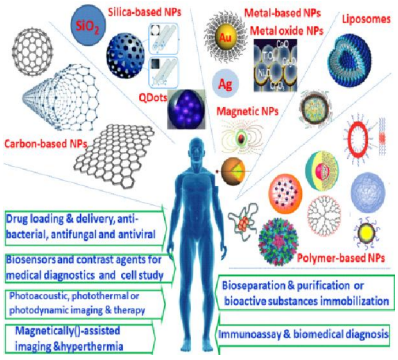

Fig 6: Various Biomedical applications of Nanomaterials

1. Carbon Nanotubes: A carbon nanotube is a tube-shaped material, made of carbon, having a diameter measuring on the nanometer scale. They come in a variety of diameters, lengths, and functional group content. CNTs today are available for industrial applications in bulk quantities of metric ton quantities. Several CNT manufacturers have >100 ton per year production capacity for multi walled nanotubes [5].

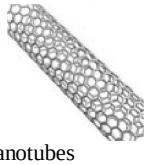

Fig 7: Carbon Nanotubes

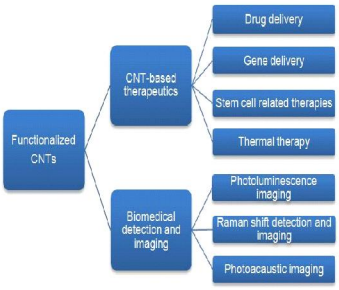

Fig 8:Applications of Carbon nanotubes

Applications
(i) To develop sensor for cancer diaganostics- Advanced biosensor
(ii) For delivery of genes or drugs into stem cells
(iii) They are used for detection of DNA mutation and for detection of disease protein biomarker.

2. Quantum Dot-

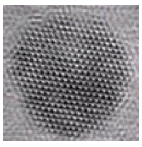

Fig 9: Quantum Dot

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Quantum Dots has caught attention in the biopharma industry. They have excellent therapeutic and imaging applications. Due to their small size they have properties very different from their bulk counterparts.

Nanoparticles such as quantum dots can be used to produce high contrast images of tumors at lower cost as compared to organic dyes. But quantum dots have some toxic effects. They can also be used in vivo live cell imaging. In vivo animal targeting as biosensors and various other applications. Nano particles have a special property of high surface area to volume ratio, which allows various functional groups to get attached to a nano particle and thus bind to certain tumor cells [6].

Applications-
(i) Used for molecular imaging and tracking of stem cells
(ii) It can help in optical detection of genes and proteins in animal models and cell assays, tumor and lymph node visualization.
(iii) Applications in composites, solar cells and fluorescent biological labels such as to trace a biological molecule which use both the small particle size and tunable energy levels.

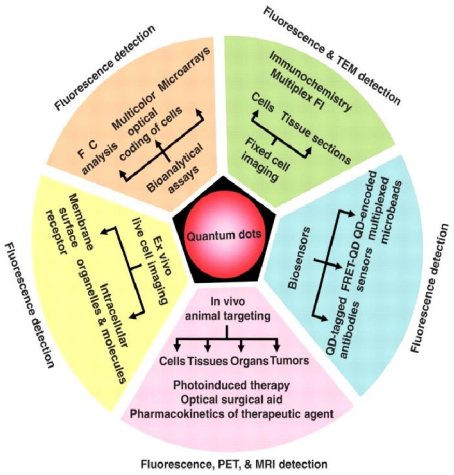

Fig 10 : Applications of quantum dots as multimodal contrast agents in bioimaging.

3. Gold Nanoshell: Nano shells of 120 nm diameter, coated with gold were used to kill cancer tumors in mice by Prof. Jennifer at Rice University. These nano shells are targeted to bond to cancerous cells by conjugating antibodies or peptides to the nano shell surface. Area of the tumor is irradiated with an infrared laser, which heats the gold sufficiently and kills the cancer cells [Anna Pratima Nikalje- Nanotechnology and it's applications in Nanomedicine et al 2015]

Application-
- For diagnosing and curing cancer
- In biomedical imaging
- Tissue Welding
- Drug delivery systems

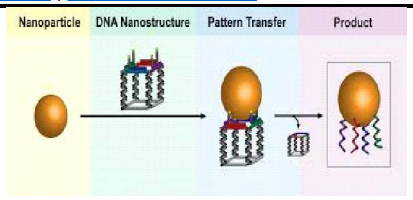

Fig 11:Gold Nanoparticle for medicine Source: [https://briandcolwell.com/2016/07/4ir-a-case-for-gold/.html]

4. Nanofibers: Nanofibers are an important and versatile class of one-dimensional nanomaterials that has attracted increasing attention in the recent years. Nanofibers especially made of biocompatible or biodegradable materials show great potential in biomedical and healthcare sector due to their unique combination of properties and intrinsic functionalities. High surface area and porosity associated with nanofibers that enhance adhesion of cells as well as various proteins and drug molecules are the key attributes, which make them superior to their micro and macro counterparts composed of same materials.


Fig 12: Nanofibers

Applications-
- In Drug Delivery
- In Wound Healing
- In Tissue Engineering
- As Barrier textiles for surgical gowns, drapes and in disposable face mask production.

5. Protein and peptides are macromolecules and are called biopharmaceuticals. These have been identified for treatment of various diseases and disorders as they exert multiple biological actions in human body. Nano materials like nano particles and dendrimers are called as nano biopharmaceuticals. The pharmacological and therapeutic properties of drugs can be improved by proper designing of drug delivery systems, by use of lipid and polymer based nano particles. Nano technology based drug delivery is based upon three facts: i) efficient encapsulation of the drugs, ii) successful delivery of said drugs to the targeted region of the body, and iii) successful release of that drug there [7].

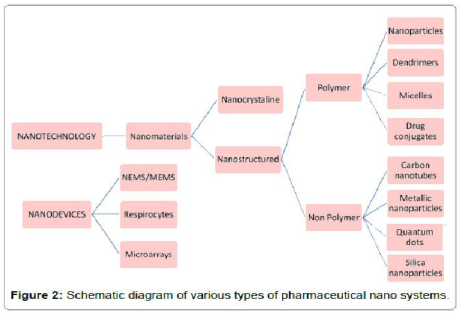

Fig 13: Schematic diagram of various types of pharmaceutical nano systems.

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Source:[https://www.omicsonline.org/open-access/nanotechnology-and-its-applications-in-medicine-2161-0444-1000247.php?aid=41535]

Some other applications of Nanomaterials:

1.Cancer Treatment: Nano particles, such as quantum dots, with quantum confinement properties, such as size-tunable light emission, can be used in conjunction with magnetic resonance imaging, to produce exceptional images of tumor sites. As compared to organic dyes, nano particles are much brighter and need one light source for excitation. Thus the use of fluorescent quantum dots could produce a higher contrast image and at a lower cost than organic dyes used as contrast media. But quantum dots are usually made of quite toxic elements. Also, iron and gold nanoparticles are used in Cancer treatment.

2. Drug Delivery : Nano particles are also used to deliver the drug with enhanced effectiveness for treatment for head and neck cancer. In this technique the required drug dose is used and side-effects are lowered significantly as the active agent is deposited in the morbid region only. This highly selective approach can reduce costs and pain to the patients. Thus variety of nano particles such as dendrimers, and nano porous materials find applications.

3. Drug Encapsulation - In Drug Encapsulation drugs are embedded inside the nanoshell. Nanomateriasl acts as external coating for drug delivery. Nanocarriers (NCs) protect their payload from premature degradation in the biological environment, enhance bioavailability, and prolong presence in blood and cellular uptake [8].

Development of biodegradable nanoparticles for delivery of quercetin [8].

- Nanomaterial will be able to offer Reaction Engineering, Advanced Gene Technology (High throughput screening) , Molecular Electronics , Molecular Modelling , Reactions on surfaces, Mass Spectroscopy , Self Organising (Drug Delivery Systems) , NMR Spectroscopy. could include Repairing Radiation damage , Artificial White Blood Cells , Extended Lifespan

V. RECENT ADVANCEMENTS

- Research inspired by the unique ayurvedic metallic preparations known as 'bhasmas' has led Indian researchers to propose a novel nano-particle-based drug for diabetes. Oral administration of zinc oxide nano-particles (ZON) resulted in significant reduction of blood glucose levels and increased insulin levels [9].

- The use of technology for developing smart drugs and drug delivery systems is growing across the world. An innovation by Indian scientists currently undergoing animal trials in the country is the nano-capsule, which, when ingested, helps in clear imaging of body organs to assist doctors in diagnosing diseases [10].
- Carbon capsules have bio-distribution in many organs including liver, heart, spleen, lungs, blood pool, and muscles, which mean these organs can easily be imaged by the MRI machine. Currently dyes are injected inside a patient's body for MRI imaging. The dyes may get absorbed in some or the other parts of the body and may cause toxicity and side effects.The nano capsules have been developed by scientists at the Indian Institute of Technology, Kanpur, Uttar [10].

VI. INDIAN NANOMATERIAL INDUSTRIES

In India , the industries which are employing nanomaterials for the production of various pharmaceutical and biomedical products are mentioned below:

Name of industries	**Supplier/manufacturer of various types of nanomaterials**
ADNANO INDUSTRIES	It is a supplier of various forms of graphene and multiwalled carbon nanotubes.
AVANSA Tech and Services.	This consultancy makes nanomaterials for serving to nanotech based industies for the manufacture of Carbon Nanotubes and various nanoparticles.
Bottom Up Tech Corporation	This company manufactures graphene and carbon Nanotubes
Botanica [Panchkula ,Haryana]	St.Botanicais a nanotechnology company it has launched nano technology breast cream and Botanica Cupidrex Serum for Men/ nitrides by a process of magnetically enhanced Nanotechnology-based cathodic sputtering under vacuum conditions.
Nanomics Technologies-	It manufactures wide range of nanomaterials such as C- nanotubes, grapphene ,nanoalloys , nanowires and nanoparticle powder and suspensions
Nanoresearch Elements-	It is a provider of nanomaterials
Nanoshell	It makes more than 50 types of nanomaterials of which main products are

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	SWCNTS, MWCNTS, nanoparticles
Nanospan	It is related to the manufacture , supply and application of graphene related materials . They offers a range of graphene types, functionalized graphene , graphene intermediates , C-Nanotubes , nanomaterials. It provides nanomaterials characterization and testing and services like HR-TEM, FESEM, FTR, XRD, BET, Raman Spectroscopy, AFM
Nano Xpert Tech	KCIL(Kairav Chemofibre industries Ltd.)- It has a hightech nanoparticle buisness
Quantum Corportion	It creates world class nanomaterials and nanocomposites with strong intellectual property that are changing properties of products around globe. It develops Smart Polymers . Nanomaterials and nanocomposites are core materials for manufacture in drug delivery and other Telecommunication and other industries
Sisco Research Lab (SRL)	It is a manufacturer of Molecular Biology Reagents, Biochemical Enzymes, Nanopowders, Carbon Nanotubes, Organic and Inorganic Intermediates , high purity solvents, Culture Media and BioLit DNA and protein tools for PCR and regular moleculear Biology
Dabur Pharma	Its most clinical advancement is a novel drug delivery system for Paclitaxel.It uses the polymeric nanoparticle drug delivery system
Reinste Nano Ventures [Noida]	A manufacturer of Nano-materials
Quantum Materials Corporation [Bangalore]	The company manufactures carbon Nano- tubes and grapheme
Candila health care limited [Ahmedabad]	Candila Health Care ltd. has launched nano gel for pain relief for bones
Velbionanotech	VBN Nanomedicine prepared for Heart disease, Galbladder, Liver, Kidney stones will have no side effect and it is safe to use since it is herbal.
Monad Nanotech	Monad Nanotech produces carbonaceous nanomaterials (CNM) using low cost production techniques developed at IIT Mumbai
Bilcare Technologies	Bilcare has used nanotechnology to counter drug counterfeits and has also developed nanofinferprints to check fake drugs

VII. NANOTECHNOLOGY STAKEHOLDERS IN INDIA GOVERNMENT AGENICIES

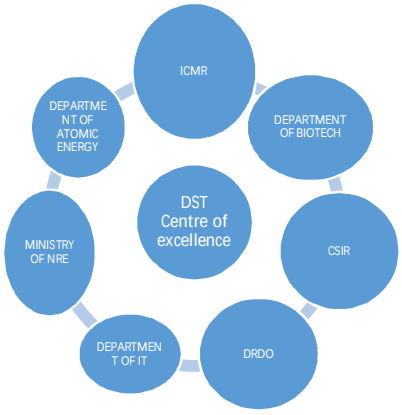

Fig 14 : Departments of Science and Technology

Nanotechnology which is the combination of Nanoscience and nanomaterial where nanoparticles show completely different properties from their bulk counterpart. Nanomaterials have been developed for diagnostic and therapeutic applications from last two decades.

The Department of Science and Technology is the organization primarily responsible for organizing, coordinating and promoting science and technology related activities in India. The Government has set up 10 Units of Nanoscience and 7 Centres of Excellence for the research and development in the field of nanoscience and nanotechnology. These includes various IIT'S and NIT'S,Public Sector R&D

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Institutions. Research is being carried out in private, and academic and scientific institutions.Units of Nnaoscience include IIT Madras, IACS Kolkata, University of Pune, S.N. Bose National Centre for Basic Sciences Kolkata, NCL Pune, JNCASR Bangalore, BHU Varanasi, IIT Kanpur, IISC Bangalore, IIT Delhi, SINP Kolkata.

There are 7 Centres of Excellence . They include Amrita Institute of Medical Sciences, Kochi, Kerala (Implants, Tissue Engineering, Stem Cell Research), S.N. Bose National Centre for Basic Sciences, Kolkata (NEMS & MEMS / Nano products), Tata Institute of Fundamental Research (Nanoscale phenomena in biological systems & materials), IIT-Bombay,Mumbai (Nanoelectronics, polymer nanosensors, nanobiotechnology), Indian Institute of Science, Bangalore (Nanodevices, Nanocomposites, Nanobiosensors), IIT, Kanpur (Printable Electronics, Nanopatterning), Indian Association for the Cultivation of Science (Photovoltaics & Sensor Devices)

There is one Centre ofComputational Materials Science at Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore

The main aim of Nano Mission is to promote research in the field of nano, to develop infrastructure for Nanoscience and Technology [11].

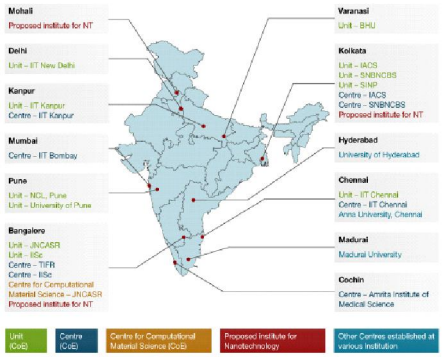

Fig :Various Organizations in India working of nanotechnology
Source:
[http://www.nishithdesai.com/information/areas-of-service/industry/nanotechnology.html]

VIII. FUTURE SCOPE

No doubt, nanotechnology has the promise of creating God out of man with the immense number of applications it has to offer. As a large research has been carried out for nanomaterials in the field of medicine. Now the time has come for its practical implementation and experiments. As only then we would come to know the real advantages and disadvantages of these nanomaterials. The possibilities are endless. But all this would only be possible with sufficient research and implementation. The Indian government has made a significant amount of investment for the research and development of applications of Nanomaterials. But still it require

CONCLUSION

In this paper we have studied about the various biomedical and pharma indutries which are using nanomaterials and manufacturing them. Although a significant amount of research has been carried out but now focus has to be made towards the actual implementation of these nanomaterials in medical industry . Then only we can analyze it's merits and demerits and make improvements for its future applications . All this would require tremendous support from the Indian Government . Although Government has provided funds for it's research and implementation of it's applications under the DST. But now the main work has to be carried out by the researchers and industries employing nanomaterials . Then only we can utilize the potential of nanomaterials.

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Author’s Details

Vijay Laxmi Kalyani, Former H.O.D and Assistant Professor from ECE Department.

SUAMYA PALIWAL, presently pursuing B.TECH (VIIth-Semester ECE branch) from Govt. Women Engineering College, Ajmer