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11. An Overview of Nanotechnology (Materials and Applications)

Prof. Tanmay Ghosh

Department of Microbiology,
Dinabandhu Andrews College,
Kolkata, W.B., India.

Abstract:

Nanotechnology is gaining prominence rapidly as a highly potent technology. Its immense potential promises the possibility of significant changes in near term future, once the most essential machines - called the Universal Assembler and the Nano computer are built.

Today the products manufactured employing nanomaterials having general as well as unique applications like curing cancer, phosgene detection, energy harvesting for self-powered Nano systems, chip manufacturing, batteries, aerospace materials etc. The research in the area of carbon nanotubes, nano-polymers, nano-vectors, nanocomposites, nano-crystals, nanoparticles, nanofibers, nanoclays, nanotubes, nanofilters, nanohorn, nanowires, Nano springs, Nano rods etc. have been reported. Particles smaller than 100 nm are typically associated with nanotechnology, as are nanomaterials made from nanoparticles.

Nanotechnology is also being developed for use in drug delivery, biosensors, and other biomedical applications. Further, nanotechnologies are also being developed for use in environmental applications, e.g., clean-up of environmental pollutants.

Keywords:

Nanoscale, Quantum Size Effect, Nanotechnology, Nanometers, Molecule.

11.1 Introduction:

At atomic, molecular, or macromolecular levels in the range of approximately 1-100 nanometers to provide fundamental understanding of phenomena and materials at the nanoscale. [1] A nanometer is a millionth of a meter in length. The diameter of a human hair is around 10,000 nanometers. Because of their minuscule size, nanoscale structures, devices, and systems are a primary application of nanotechnology.

He coined the phrase "nanotechnology" in a paper he wrote in the 1970s. It's technically correct to say that the term "Nanotechnology" refers to an area of applied science and technology concerned with manipulating matter at the atomic and molecular level, which is typically at or below the size of 100 nanometers. [2]

Approaches used in nanotechnology

- **Bottom-Up Approach:**

The "bottom-up" approach uses molecular components to build materials and devices, which assemble chemically through molecular recognition principles. To put it another way, the goal of this type of assembly is to combine tiny parts into larger ones.

- **Top-Down Approach:**

When using the "top-down" technique, nano-objects are built from larger things without atomic-level control. Smaller devices are assembled by using larger ones as a guide for their construction. [3]

11.2 Applications of Nanotechnology:

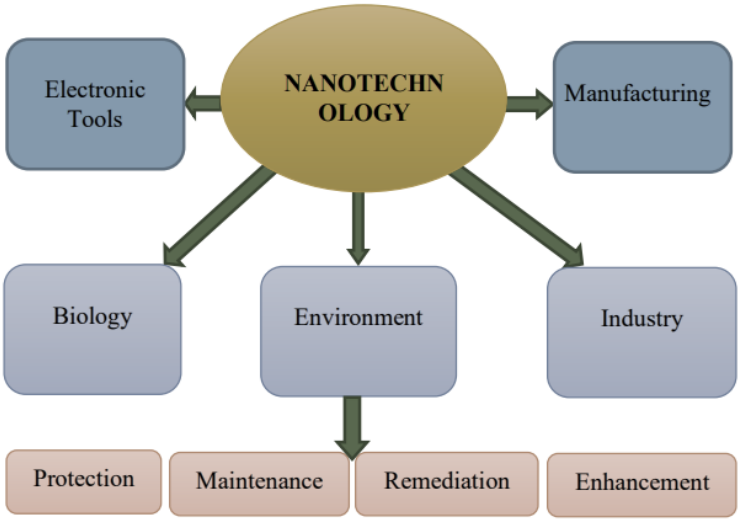

Figure 11.1: Applications of Nanotechnology

- **Medicine and Drug Delivery:**

  With medical nanotechnology, treatment would be more accurate and efficient. A minuscule Nano tool could save a patient from a gruesome and dangerous surgical procedure by preventing the need to open up their entire body. Precision in medical treatment is possible with nanotechnology, which eliminates the need for medicine prescription that is based on trial and error. A comprehensive picture of the body's systems and activities, including the underlying cause of disease and potential treatments, may be automatically gleaned from a single laboratory test using high-tech computers. [4] Medical malpractice would be eradicated and the adverse effects of taking drugs based on doctors' guesses would be avoided if nanotechnology was used in medicine. Detection and prevention of diseases can be easily accomplished with modern medical technology. As long as diseases can be averted, human longevity and quality of life will both improve?

- **Energy Sector:**

  This technology opens the door to the creation of smaller, more efficient, and more effective energy-producing, absorbing, and storing systems. Batteries, solar cells, and fuel cells, for example, can all be made more compact while maintaining their functionality.

- **Development of Quantum Computer:**

  Nanotechnology can actually revolutionized a lot of electronic products as nano transistors, nano diodes, quantum computers etc. and their procedures and applications. Quantum computers are groups of billions of customized atoms that are created and manipulated using nanotechnology.

  Quantum computers represent data differently than any classic computer. [5] While a classical computer represents data in bits that either "0" or "1", a quantum computer uses quantum bits to represent "0's," "1's,"and both "0's" and "1's" simultaneously. Because quantum bits can represent both 1's and 0's at the same time it is possible to do many calculations simultaneously.

- **Reactivity and Strength Of Materials:**

  As a result of their high surface area to volume ratio, nanoparticles are far more reactive than larger particles. It's been discovered that iron nanoparticles can remove pollutants from groundwater more effectively than other media. It's possible to make bulletproof vests out of carbon nanotubes because they're exceedingly robust. [6]

- **Food Nanotechnology:**

  In the food industry, nanotechnology has opened up a wide range of new possibilities. Food packaging and preservation are two areas that have recently acquired popularity in this field. Prognoses of substantial economic advantages in this area have helped to draw attention to it. According to data, sales of nanotechnology products for food and beverage packaging will top $20.4 billion in the United States by the year 2010. Carbon nanotubes are one of the most promising nanomaterials in this field.

  The same tube may have antimicrobial effects in addition to improving the mechanical properties of food packaging materials. Nanomaterials may also be useful in the preservation of food. When food spoilage microorganisms come into contact with Nano sensors that fluoresce in a variety of colors, they could provide a solution. Food poisoning cases could be reduced as a result, as the detection time would be shortened.

  Food packaging is already using Nano silica and Nano selenium, which is said to enhance selenium absorption in a beverage. [7] Although it can also be used to purify water, nano-iron is more commonly used as a health supplement. Nanosalt, which is still in the early stages of development, has to be mentioned for its ability to reduce salt intake in the diet.

11.2.1 Nanomaterials:

Materials with morphological characteristics smaller than one tenth of a micrometer in at least one dimension are known as nanomaterials. For example, nanomaterials have unique physical and electrochemical properties that allow for the creation of stronger, tougher, and more wear-resistant products. Carbon nanotubes, different fullerenes, various nanoparticles, and Nano rods are only a few of the materials that interface and colloid research has produced. In nanotechnology research, members of the fullerene family are a key focus. [8]

11.2.2 Review of Literature:

Nanotechnology is enhancing the efficiency of fuel generation from normal and low-grade raw petroleum materials through better catalysis, as well as fuel consumption efficiency in automobiles and power plants through higher-efficiency combustion and less friction (Low et al., 2015) [9]. Nano-bioengineering of enzymes is trying to enable conversion of cellulose into ethanol for fuel, using wood chips, maize stalks (not just the kernels, as today), and unfertilized perennial grasses (Chaturvedi and Dave, 2014) [10]

Nanotechnology is enhancing the efficiency of fuel generation from standard and low-grade raw petroleum materials through better catalysis, as well as the efficiency of fuel consumption in automobiles and power plants through higher-efficiency combustion and reduced friction (Low et al., 2015).

The nano-bioengineering of enzymes is aimed at making it possible to turn wood chips, corn stalks, and unfertilized perennial grass into ethanol for fuel. [9] (Chaturvedi and Dave, 2014) [11] Impurities in water can be detected quickly and inexpensively using nanotechnology, which can then be filtered and purified at a minimal cost (Rabbani et al., 2016[12]; Sobolev and Shah, 2015[13]; Mishra et al., 2012[14]).

The building industry will gain greatly from nanotechnology in the future. Self-cleaning windows and concrete capable of devouring pollution are just two examples of how this new technology may transform building materials into new levels of energy, light, strength, security and beauty (Halicioglu, 2009). [15]

Nanomaterials like carbon nanotubes and carbon Nano horns are also being used in energy applications because of their potential to provide outstanding conductivity for charge transportation (Yimin, 2011) [16]. PbTe-based quantum dot superlative system, for example, has shown an increase in energy conversion. In order to create more energy-efficient thermoelectric devices, it has been proposed that this feature be reproduced (Yimin, 2011). [16]

11.2.3 Objectives:

- To investigate the use of non-technological methods
- To learn more about the food delivery system and nanotech.
- Researching nanotechnology's meaning

- To learn more about nanotechnology's techniques.

11.3 Research Methodology:

It is the systematic, theoretical investigation of the methods used in a particular field of research. Theoretical analysis of a branch of knowledge's methodologies and principles is included.

Parameters like paradigm, theoretical model and phases are typically included in this type of research. In this study, many studies on learning and research linked to the issues are analysed and reviewed in detail.

Journals were gathered from internet databases that primarily focus on journals for their subject matter and content. This topic's identification centre on the study's materials, participants, and methods of instruction.

Classification accuracy and items, methods, and results were the primary criteria for identifying research publications. Using the findings of the analysis, a systematic overview of the learning and research in the themes was developed.

11.3.1 Result and Discussion:

E. coli and other pathogens can be rapidly, sensitively, reliably, and simply isolated and detected using nanotechnology.

Quantum dots, localized surface plasmon resonance of metallic nanoparticles, improved fluorescence, dye immobilized nanoparticles, and metallic nanoparticles immobilized with a Raman reporter molecule are a few of the nanotechnology-enabled detection approaches. [17]

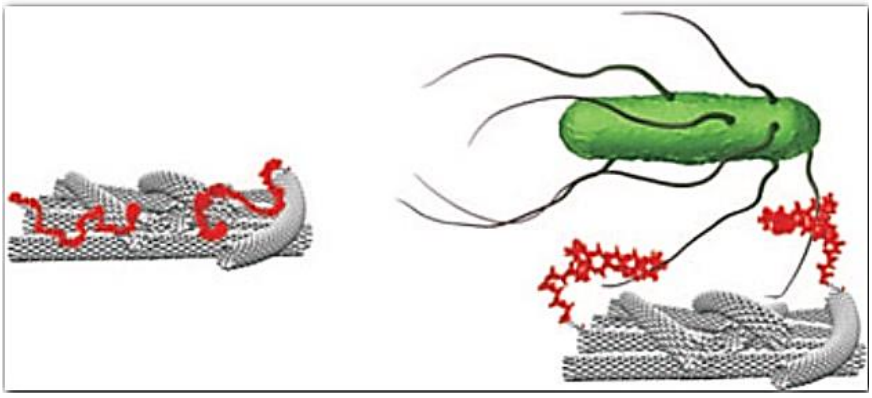

Figure 11.2: Detection of Foodborne Illnesses

The promise of "personalized medicine" can be realized if successful medication development is achieved through the use of such therapies and diagnostics in clinical

practice. [18] For diagnostics and therapies, Figure 11.3 shows how the two markets have grown and how they will grow in the future.

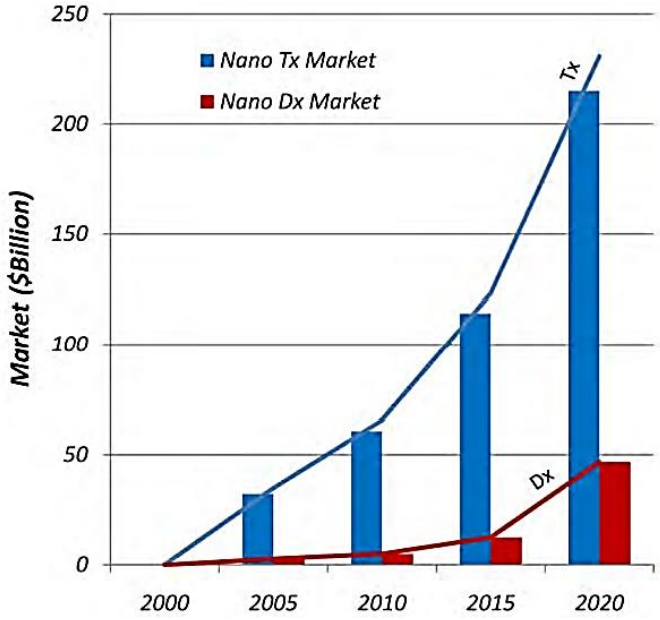

Figure 11.3: Historical and Projected Markets for Nano Therapeutics (Tx) and Nano Diagnostics (Dx).

Current food and agricultural nanotechnology research, includes processing, packaging, nano-additives, cleaning, and pollutants sensors, and future advancements in the burgeoning field of agri-food nanotechnology. [19]

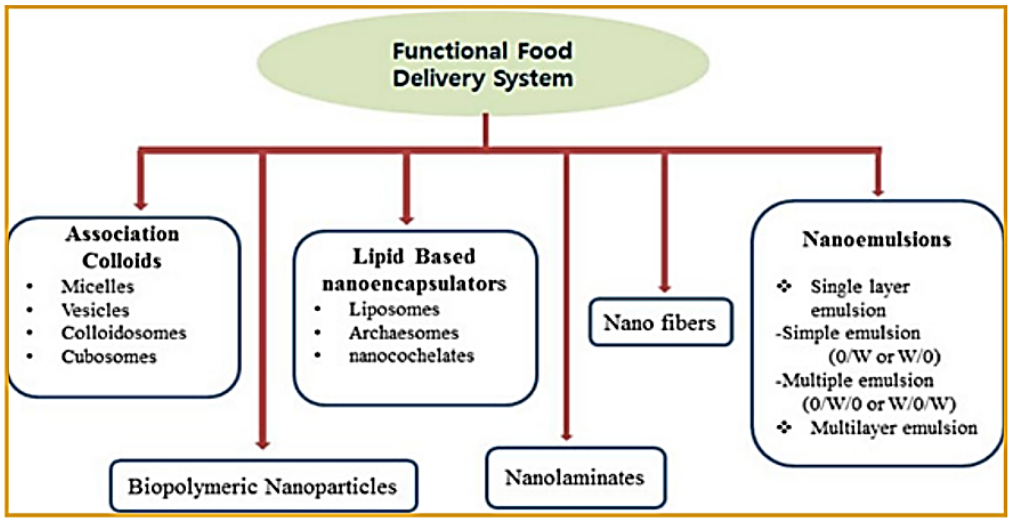

Figure 11.4: Food Delivery System

Nanotechnology may also have the ability to improve the quality and safety of food products. Nano sensors are being tested for their potential to detect pathogens in food systems in a number of research. Materials made with nanotechnology, or goods grown, processed, or packed with the help of nanotechnology, are referred to as nonfoods. [20]

11.4 Conclusion:

When it comes to food and agriculture, construction materials, mechanical, medical, and electrical engineering, nanotechnology has the potential to open the door to a new world. However, despite the fact that replicating natural systems holds great promise, scientists are still grappling with their astounding complexity.

Manufacturing, energy, environmental science, information and communication technology (ICT), and medical research could all be transformed by nanotechnology. When considering nanotechnology as one of numerous developing technologies, it is important to keep an eye out for the temptations of research hype.

Concerns about immediate dangers and assessments of the broader impact of such technologies on human nature and human futures, both in their individual and global dimensions, must also be given careful study. When evaluating these new technologies, it is necessary to look beyond the specific risks and benefits associated with each application and ask more general questions in order to identify and fill any conceptual gaps that may arise in such a quickly growing area of research and development.

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