CHAPTER EIGHT
Diagnostic Imaging

Nanotechnology in Diagnostic

Medical diagnosis is the process of determining which disease or condition explains a person's symptoms and signs. It is most often referred to as diagnosis with the medical context being implicit. The information required for diagnosis is typically collected from a history and physical examination of the person seeking medical care. Often, one or more diagnostic procedures, such as medical tests, are also done during the process. Sometimes posthumous diagnosis is considered a kind of medical diagnosis. The fast pace of today's world has presented several challenges in the area of healthcare. Depression, hypertension, diabetes, cancers and several infectious diseases are just some of the common outcomes associated with the high speed stress-filled lifestyle. Early diagnosis has been the goal for prompt arrest and management of these health conditions. This has been a challenge in recent times. However, great scientific advancement with improved potential in medical diagnosis has equally been a giant stride in times like these. Early disease detection even before symptoms' presentation, improved imaging of internal body structure, as well as ease of diagnostic procedures, have been developed with the help of a new branch of laboratory medicine termed nanodiagnostics. Use of microchips, biosensors, nanorobots, nano identification of single celled structures, and microelectromechanical systems are current techniques being developed for use in nanodiagnostics.

Diagnosis is often challenging, because many signs and symptoms are nonspecific, and can only be undertaken by registered and licensed health professionals. For example, redness of the skin (erythema), by itself, is a sign of many disorders and thus does not tell the healthcare professional what is wrong. Thus differential diagnosis, in which several possible

explanations are compared and contrasted, must be performed. This involves the correlation of various pieces of information followed by the recognition and differentiation of patterns. Occasionally the process is made easy by a sign or symptom (or a group of several) that is pathognomonic.

Although the production and use of the tiniest particles invisible to the naked eye are not really a new invention, the concept of nanotechnology has been in the front burner of scientific research in recent times. Colloidal nanoparticles of silver and gold contained in the antique Roman glass cup have been found to be responsible for the phenomenon that makes it reflect different colours, when illuminated. The elasticity and resistance noticed in the legendary Damascene Sword have been described to be due to nanometer sized particles of carbon discovered to be present in them. From the physical, to environmental and even the life sciences, the use of particles at the nanoscale to achieve results, monitor processes and take part in reactions has not only been explorative but also interesting. In the life sciences, nanotechnology becomes ever relevant specifically as components of functional biological unit such as Deoxyribonucleic acid (DNA), Ribosomes, ribonucleic acids in living cells, for example, are mainly of nanoscale sizes. This presents a potential for the application of nanotechnology in affecting these cell components; to screen, detect any defect, improve, incorporate or knock them off.

Nanotechnology, according to the United State Environmental Protection Agency involves creating and using structures, devices, and systems that havenovel properties a d functions as a result of their small and/ or intermediate size; it is the branch of science that employs the use of nanoscale particles, studying its peculiar characteristics and employing these to obtain desired outcomes in the fields of Engineering, Medicine, Agriculture, or Pharmaceuticals . Nanotechnology deals with nanoparticles. Any material with dimensions of less than 1 μm is described as a Nanoparticle. Nanotechnology has provided many useful tools that can be applied for the detection of biomolecules and analytes relevant for diagnosis purposes nanodiagnostics. A good understanding of nanoparticles and their unique properties gives insight to the peculiar reasons for their application in different fields, specifically in medical diagnosis.

Medical diagnostics has been described using different catchy expressions by various textbooks on medicine. But capturing the main concept, the homepage of the website of journal of medical diagnostic methods, with slight modification, defines it as the discipline or practise of diagnosis which involves determining and describing of a disease state and its causative factors responsible, using signs, symptoms obtained from patient history or from physical examination of patients or their specimen with the help of several diagnostic techniques. The essence is to ascertain what medical condition is being treated, managed or endured. This is especially true considering that any attempt in treating, or managing a medical condition begins with identifying the disease condition. Thus, from the crude method of organoleptic assessment of body samples through the era of use of microscopy and now employing of biosensors and body imaging, medical diagnosis has a long history. So inclusion of nanotechnology to improve diagnosis is not only a positive step but also a welcome one

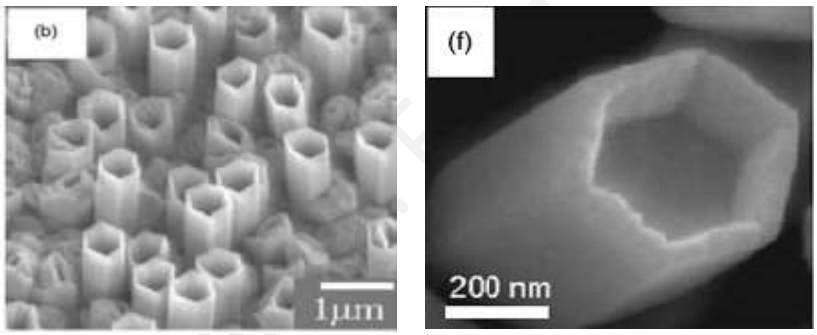
Nano-diagnostics

Nanodiagnostics is the new term that describes use of methods and techniques of nanotechnology and its principles for diagnostics purposes. It includes, although not limited to, the manipulation and assessment of single molecule, size reduction of systems and platforms to make use of nanoscale properties obtainable from interactions between surfaces and biomolecules. Nanodiagnostics is an evolving application of nanoscale technology to meet the demand of clinical diagnostics, determining disease state, any predisposition to such, the pathology of the condition and the identification of causative organisms. With nanotechnology, diagnosis is being carried out on a nano-scale leading to a trend of the use of hand held devices that are easy to use and marketable. Nanodiagnosticsas surging new fi ld of molecular diagnostics, have been positively changing laboratory procedures, providing new ways for patient's sample assessment and early detection of disease biomarkers with increased sensitivity and specificity. Nanoparticle platforms have been developed and optimized for the detection of pathogens and cancer biomarkers such that diagnostic proceedures now become less cumbersome but more sensitive because most of the complex proceedures are now integrated onto a simple device having the capacity to be used for on the spot diagnosis. The economic implications of these notable developments.

Application of Types of Nanoparticles in Medical Diagnostic

Nano Tube

These are cylindrical carbon molecule with novel properties which make them potentially useful in many applications in nanotechnology, electronics, and the material sciences. They exhibit extraordinary strength and unique electrical properties and are good conductors of thermal energy; this is because the chemical bonding is in line with sp2 orbital hybridization. Examples include fullerene, an allotrope of carbon. A research team at the University of Connecticut has reportedly used a sensor made from densely packed carbon nanotubes coated with gold nanoparticles, to develop a device capable of detecting oral cancer from samples Carbon nanotubes and Silicon nanowires have been utilized for detection of various volatile organic compounds present in breath samples of lung and gastric cancer patients respectively



Nano Tube

Carbon nano-tubes

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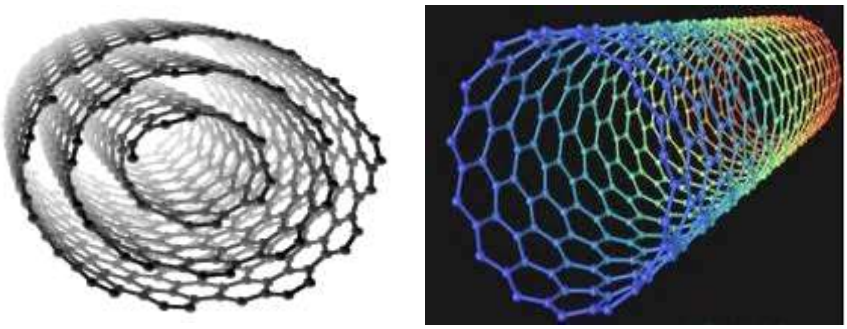
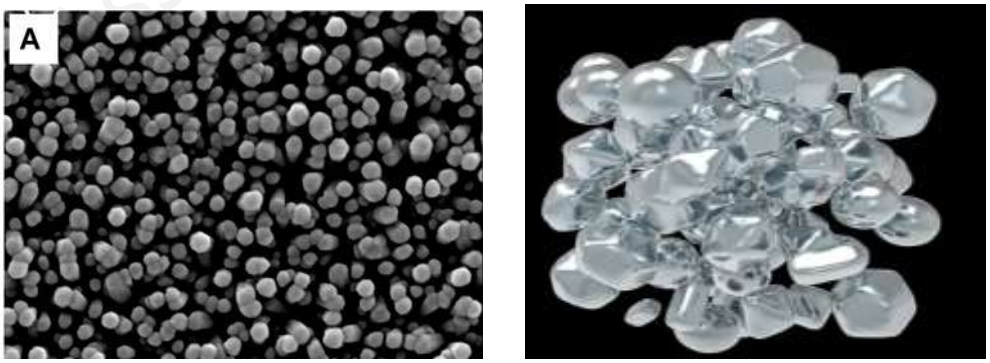


Carbon nano-tubes

Nano Crystal

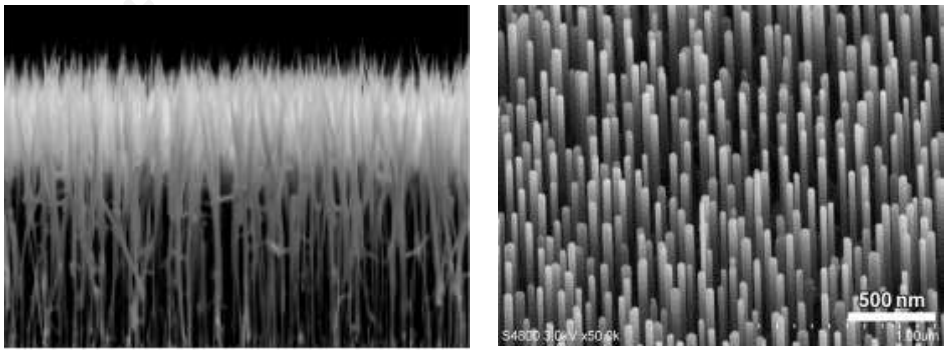
They are crystalline materials with at least one dimension being less than 1μm and their properties, both electrical and thermodynamic, are size dependent. An example of these crystals is that of Elan pharma International Limited based in Ireland involved in nanoparticle drug formulation. Nanocrystals are good semi-conductor in the 10 nm and show a loose microstructure, with nanopores situated between the crystals. The surfaces of the pores are modified such that they could adsorb protein, due to the addition of silica molecules. Bone defects can be treated by using these hydroxyapatite nanoparticles. An international co-funding arrangement in nano drug development will equally be a good step in expanding treatment



Nano Crystal

Nanowires

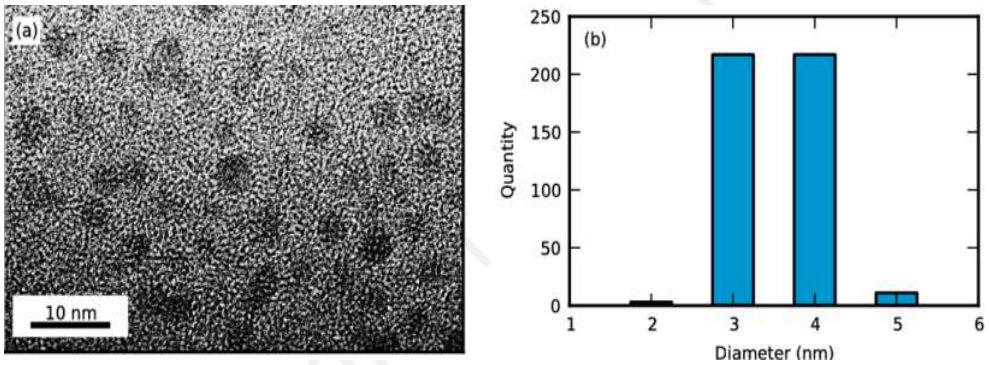
Nanowires (NW) are nanosized channels that allows passage of electrical current at very low amplitude and can be constructed from carbon nanotubes, metal oxides or silicon. Their very small size and minute diameter, usually 10nm, makes them sensitive to any minute change in electrical properties at any slight adjustment for example when an additional molecule is bonded to it. Antibodies could be attached to surface of nanowires and used as detectors such that when the antibodies interact with biomolecules of target, they undergo a conformational change which is picked up as electrical signal on the nanowire. Thus when several nanowires with different antibodies attached are integrated into a single device, they can be employed as detectors for diseases like cancers. Examples include Silicon nanowire (SiNW) used in sensors as Field Effect Transistors. FET-SiNWs have been reportedly used to detect several prostate cancer biomarkers, such as PSA (Prostate-Specific Antigen) at very minute level and for monitoring prostate cancer, predicting earlier, before full manifestation, the risk of biochemical relapse. Furthermore, as published in literatures, using nanowire technology (seen in nCounter Analysis System), ribonucleic acid (RNA) expression levels of CTAs (cancer-testis antigens) have been measured, as biomarkers for aggressive prostate cancer. Nanowires of Silicon and Zinc oxide have also been used to detect ssDNA, because the binding of this negatively charged polyanionic macromolecule to p-type NW surfaces leads to an increase in conduc tance. These DNA biosensors have been used to detect mutations related with cancer types. For example, a nanowire platform functionalized with ssDNA detected the BRAF mutation for breast cancer



Nanowires

Quantum Dots

These are inorganic crystalline nanomaterials that are fluorescent. When irradiated with low energy light, quantum dots emit fluorescent light whose colour (or frequency) depends on the size of the dot. These dots of different size could be embedded into a given microbead, producing distinct spectrum of colours once excited. With just such simple excitation, high sensitivity and broad spectra of excitation is achieved which makes it quite useful in genotype determination, image guided surgery and molecular diagnostics. Quantum dots have been conjugated with other diagnostic techniques bringing together diagnostics and therapeutics. For instance, quantum dot can be linked covalently with fluorescence microscopy to observe cells in living animals; immunofluorescent labelling of breast cancer marker Her2 have been achieved with the specific cancer antibodies covalently linked to quantum dots covered by polyacrilate cap and quantum dots with detectable luminescence encapsulated in carbohydrate are useful in cancer imaging



Quantum Dots