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Review RRJoMST

Uses of Nanotechnology in Medical Diagnostic Applications

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Abstract

Nanoparticle and nanodevice is a boon for mankind to treat and deal with disease and medical diagnosis respectively. Nanotechnology is formed by the unity of chemistry, engineering, biology and medicine restricted to the nanoscale (about 1–100 nanometer (nm)). For example, early detection of malignant tumors and cancer biomarkers, which is impossible using conventional technologies. In here we will discuss nanosized sensors to identify different pathological parameters, foreign antigen and toxic chemicals involved. Like developing bio barcodes based on Anti-Prostate Specific Antigen antibodies. Nanowires are used to detect viral antibodies. Nano crystal semiconductors such as Quantum Dots are used to detect oncogenes and other Infectious diseases that are diagnosed with fluorescence leveled liposomes. In this paper, we will put forth a general discussion about nanowires, cantilevers, quantum dots etc. Some applications of mentioned nanotools will also be discussed. At the end, the future prospects of nanotechnology in diagnostics will be provided.

Keywords: Nanoparticle, Bio-barcode, Anti-Prostate Specific Antigen, Fluorescence leveled liposome, Nanocrystal.

INTRODUCTION

Nanotechnology is the interlinked bridge among engineering, chemistry, medicine and biology. The strategy behind nanotechnology is to scale up materials into nanometric order or to reduce bulk material into Nanoparticles. Fundamentally nanoparticles are approached in two ways: [1] 'Top-down'-In this approach the bulk material is broken down into nano scale particles. This technique is extended to produce micron size particles. For example, integrated circuit fabrication, formation of TiO_2, nano gold and nano silver, carbon nano tubes using graphite all are examples of top-down nanotechnology [2]. 'Bottom-up'-This technique is the reverse of Top-down technique, it approaches to form material by atom by atom, molecule by molecule or cluster by cluster. The application of nanotechnology shows the light of hope within the scientific community for the development of novel cancer therapeutic strategies. 55% of death cases are found in gastrointestinal cancers tremendous therapeutics methods have been made on novel diagnostics to improve patients' quality of life and lengthening the survivals. Nanodevices such as quantum dots (QDs), carbon nanotubes (CNTs), nanoparticles of paramagnetic nature, gold NPs (GNPs) and novel nanoparticle methods are specifically used in oncological applications.

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Review of Literature

Uses of Nanowires Used in Medical Diagnostics

Nanowires used in nanoelectronics bias as a connector for transportation of electrons. More specifically a double stranded DNA is metallized by silver or gold coat between the poles of electrodes to form tableware nanowires [1]. Nanowires are made using different ways. Generally, they are semiconductor or essence

(Gold, Silicon, Copper, Cobalt) and they're single demitasse with dimension at 10 nm. The process of formulation of polymeric integrated nanowires devices are by nanowire deposition on the device, then comes a processing step where the nanowires are aligned in a well-defined direction of the device, a last step to detect the sensitivity for the purpose of the diagnostic application. In detection of protein markers involved in oncological diseases. The detection is mainly of two types, first one is to determine the DL detector which is based on Silicon Nanowires normally, this technique is used in detection (limit must be lower than femtomolar concentration) at an early stage [2]. If the diameter of nanowires is reduced from 200 mm to 50 mm then the concentration detection limit will become 206 times lower. The polycrystalline Si-NW-sensors are used to detect p16INK4a involved in cervical cancer at the threshold concentration 100 femto gram/liter. The si-nanowires is used in diagnosis of PSA (Prostate-specific antigen, or PSA, is a protein produced by normal as well as malignant cells of the prostate gland (Figure 1). The PSA test measures the level of PSA in a man's blood. The microRNA (miRNA)(non-coding sequences between 21 to 25 bases) due to it is high stability in blood it is used in control of oncoprotein expression in the form of cancer biomarker. Integration of a Si-NW-sensor with two PDMS (polydimethylsiloxane**)** channels allowed to lower the discovery limit for PSA and the marker of the non-small cell lung cancer — 19 CYFRA21-1 (cytokeratin scrap) till 1 fg/mL [3]. Semiconductor nanowire-based FETs (Field effect transistors; transistors which use an electric field to control the flow of current in a semiconductor) are used for ultrasensitive label-free detection of biomolecular interactions [4]. To detect the specific DNA molecule PNA (Peptide nucleic acid probes are immobilized onto nanowires surface)-modified nanowires are used. The main theory behind this detection is that the binding of target molecules onto the surface of nanowires causes accumulation or depletion of charges resulting in change in channel conductance. This technique is used to detect ions, proteins and viruses with high sensitivity.

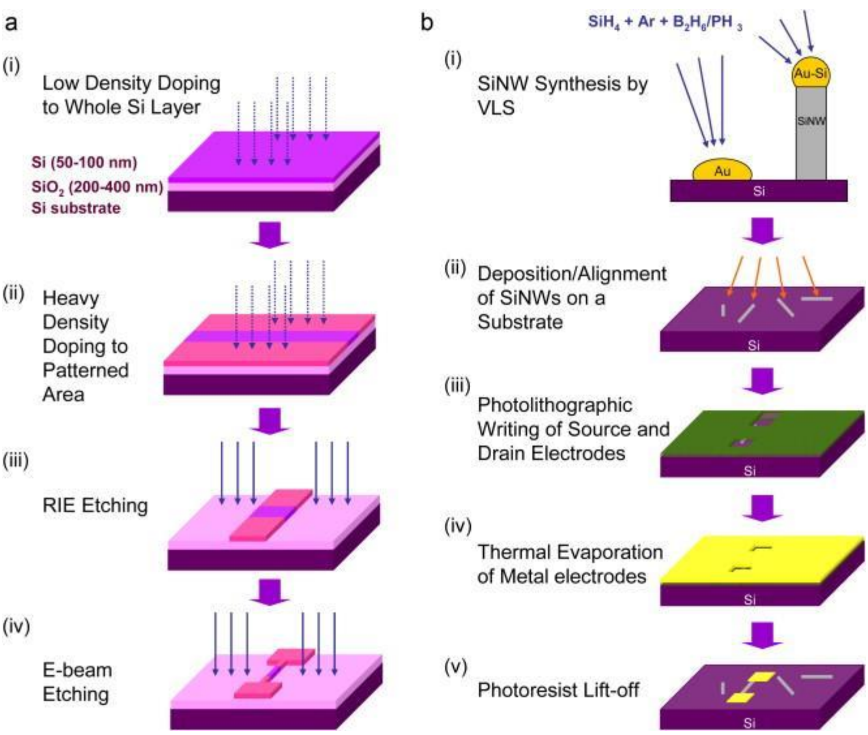

Figure 1. Silicon nanowire field-effect transistor-based biosensors for biomedical diagnosis.

Bio-Barcode

Bio-barcode may be a bioinformatics platform to be used as a rendering system using nanotechnology. In BCA (bio-barcode amplification) grounded assays, barcoded DNA and nanoparticles are used that can decry trace proteins, cytokines, and some neurotransmitters (Figure 2). With the rapid development of nanotechnology, the bio-barcode assay (BCA), as a new individual tool, has been traditionally applied to the discovery of protein and nucleic acid targets and small-patch composites. BCA has the advantages of high perceptivity, short discovery time, simple operation, low cost, good repetition and good direct relationship between discovery results [5]. After further than ten times of development and disquisition, BCA technology has enabled the establishment of a simple and dependable high-effectiveness system for the single-residue or multi-residue discovery of macromolecular substances, similar as proteins, and the single-residue discovery of small motes. As they've high perceptivity and particularity, these styles have demonstrated strong advantages for operations in clinical complaint opinion, food safety testing, and chemical adulterant testing. A classic example of BCA technology is nanogold technology since AuNP has certain criteria like a high electron density, dielectric and catalytic property that can be implemented to biological molecules without interfering with any biological property. Mainly used of two probes are found: Monoclonal antibodies are coated onto the surface of magnetic beads for the proteins, and magnetic probes are produced which can adsorb onto the target protein. The second probe is preparation of AuNP by trisodium citrate reduction method and coated with anti-target protein antibody and thiol-modified barcode DNA [6]. After that magnetic flux are often implemented to make sandwich-like complexes with two probes containing test samples (target protein) forming a “magnetic microsphere-target protein-AuNP”. After performing dissociation of the labeled DNA barcode strands on the gold nanoprobes through de-hybridization elution release, determination of targeted protein can be done fluorescence labeling, biochip and other detection methods. Earlier we have talked about protein detection, it is a main constituent of human cells and tissues, the detection of protein biomarkers has a great role in the field of clinical diagnostics and treatment. In the case of some early stages of disease the concentration of protein markers is considerably low, so ELISA methods are not fit for detection of various kinds of diseases [7]. On the other hand for detection of such kind of diseases Bio-barcode detection technology is 5–6 orders of magnitude more sensitive than conventional ELISA, BCA technology is also being used for detection of Hepatitis B Virus DNA within a very low limit between 10–15 mol/l.

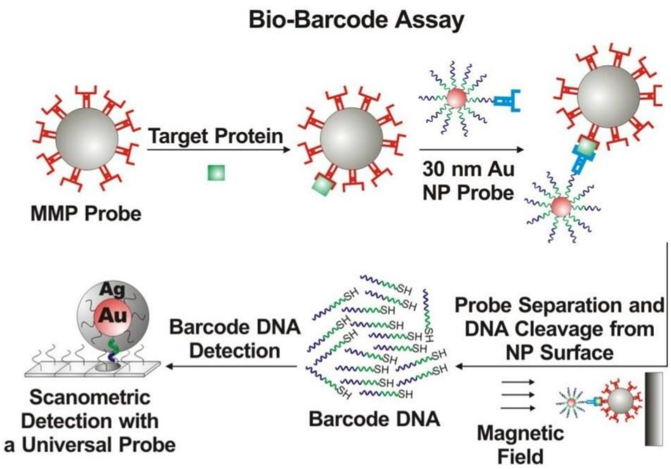

Figure 2. Bio Bar Code based DNA detection with PCR-like sensitivity.

Nanocrystals

Nanocrystals are aggregates of atoms that combine into a cluster with at least one dimension measuring less than 1000 nanometers (nm), where 1 nm is defined as 1 thousand-million of a meter (10–9 m). Nanocrystals with it types based on size, morphology, physical and chemical properties). A Carbon-based material such as (a) carbon nanotubes and fullerenes; (b) Metal-based materials such as Au, Ag, metal oxides and quantum dots; (c) Dendrimers or nanosized polymers; (d) Composites combining nanoparticles with other nanoparticles. Nanotechnology will affect our lives contemporaneously over the coming decade in veritably different fields, including drug and drugstore. The industrially applicable product technologies, plum milling and high-pressure homogenization, are reviewed. Exemplifications of products in the development channels (clinical phases) are presented and the benefits for in vivo administration of medicine nanocrystals are epitomized in an overview. On basis of its future aspects Nanocrystals are used as a medicine-delivery platform for inadequately water-answerable medicines and have had marketable success in oral medicine delivery [8].

Quantum Dots

Quantum dots (QDs) are man-made nanoscale charges which will transport electrons. When UV light hits these semiconducting nanoparticles, they will emit light of varied colors. These artificial semiconductor nanoparticles that have plant operations in mixes, solar cells and fluorescent biological markers. Graphene quantum dots (GQDs). These nanomaterials effectively improve the detector performance with respect to their reproducibility, selectivity as well as perceptivity. In particular, graphene amount blotches (GQDs), which are immaculately graphene fractions of nanometer size, constitute separate features similar as acting as seductive fluorophores and excellent electro-catalysts owing to their print-stability, water-solubility, biocompatibility, on-toxicity and lucrativeness that make them favorable campaigners for a wide range of new biomedical operations. Due to the dimensional resemblance of biomolecules such as antibodies, proteins and small nucleic acids GQDs also can be grafted with these. QDs are often conjugated to biological molecules like proteins, targeting and imaging agents, oligonucleotides, and little molecules, which are utilized in the direct binding of QDs to areas of interest for biolabeling, biosensing, targeting and imagining. Semiconductor QDs have attracted tremendous interest for and bioimaging applications due to their considerable advantages over conventional organic dyes, such as high QY, size-tunable emission, photostability, and improved signal brightness. For DNA and oligonucleotide sensing QD is also used. Given below a Table 1 of uses of QD available commercially [9, 10].

Table 1. Quantum dots available commercially from companies in the U.S.

Company	Product Line	Composition	Excitation (nm)	Emission (nm)	Solvent	Formulation	Product Notes
Cromoz	CDot20				water	dry powder	conjugated with cancer therapeutic agents
	CDot10					dry powder	
Crystalplex	Trilite™	CdSeS		490–665	water	solution	composition rather than size dependent; carboxyl, amine, hydroxyl, alkyl functionalized surface
Nanoaxis	AxiCad™	CdTe/ZnTe	500–700	530–740	water	dry powder or solution	conjugated with antibody and peptide
NN-Labs, LLC	Line 10	CdTe	620	640	organic	solution	photovoltaic application

Cantilevers

Mechanical Cantilevers consists of a fixed and a movable part. The movable part can be divided into three segments :(i) thin membrane (ii) plate or beam (iii) fixed at one or both ends. It is generally made up of silver. The concept behind is that the formation of molecule layers on the cantilever surface will generate surface stress, eventually resulting in a bending of the cantilever, provided the adsorption preferentially occurs on one of the surfaces of the cantilever. Coating a thin layer of molecule at one side of the cantilever which shows affinity to molecules in the environment and other side is uncoated or it can be coated with a layer which does not show any affinity with the environment. Cantilevers may be deflected from atomic force microscopy for real time imaging. Moreover, one advantage is that it does not require any sort of fluorescent or radioactive labeling to detect cancer. It is coated with specific receptors and provides high sensitivity and rapid detection of disease-specific molecules, such as DNA or protein of disease.

DISCUSSION

In some sub sets of medical field like diagnosing, efficient drug delivery, making of artificial cells here nonmaterial shows it practical faces. Advantageous of nanoparticles is their area to volume ratio which is respectively high resulting in a high loading capacity for diverse imaging probes, targeting ligands and therapeutic formulations. as an example Carbon nanotubes has same volume because the typical protein offers a 15-fold larger area compared with the protein. This enlarged expanse allows coupling of an outsized amount of targeting ligands to the nanoparticle, which can significantly enhance target binding. It must not be ignored that nanoparticle size, surface Texture because it interferes with the in vivo behavior and biology of cells because it internalize within the cell. To support the above statement, polyethylene glycolylated rod-shaped gold nanoparticles and their polyethylene glycolylated spherical counterparts showed that the gold nanorods were obsessed to a lesser extent by the liver and macrophages and showed longer circulation times and the next accumulation in tumors tissue compared with the spherical nanoparticles.

CONCLUSION

There's little question that nanotechnologies have helped to boost the standard of lifetime of patients. it's a replacement helpful technology which will be the answer for several activities. Its application in medication is secured and becomes the new hop in identification, treatment, and interference. Applied science has extended its arm toward the combination of medical specialty, medicine and more improvement of modify medication. Nanoparticle of order but 5nm may be used as molecular diagnostic of additional system. In future there'll be measure device supported applied science which may build thousands of measure relaxed, more adding boon towards medical society.

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