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Review Article

A Comprehensive Review on Disease Related Applications of Nanotechnology

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Abstract: Nanotechnology serves as a new approach in the treatment of many diseases which has very large number in the morbidity and mortality. Biosensing and molecular imaging assisted with nanotechnology helps in identifying and diagnosis of many diseases. These nanomaterials also helps in the targeted drug delivery to the specific region. The existence of nanomaterials have become increased over the period of 40 years. Nanoparticles helps in the diagnosis of several diseases especially detection of cancer biomarkers. This technology also has a greater ability in the management of neurodegenerative diseases such as Alzheimer's disease, autoimmune diseases, skin diseases, renal diseases, tuberculosis and cancer. It also extended its application to targeted drug delivery, diagnosis and pharmacogenetics to individualize the treatment options for several diseases and disorder. Apart from this, nanoparticles also showed more efficiency for antimicrobial, antifungal and antiviral therapies. Nanotechnology has greater applications in the medical and pharmaceutical field due to its unique characteristics. Due to their smaller size, these nanomaterials have the ability to penetrate deeper into the biological tissues or skin and can elicit their therapeutic activities. Nanotechnology extended its application in the recent pandemic COVID-19 by the production of vaccines using lipid nanoparticles and also conquered the difficulties faced by the normal drug delivery systems. In this article, we can discuss about the various types and applications of nanotechnology.

Keywords: Nanotechnology, Nanoparticle, Nanosystem, Drug Delivery System, Pharmacogenetics.

INTRODUCTION

Nanotechnology serves as a new approach in the treatment of many diseases which has very large number in the morbidity and mortality. Biosensing and molecular imaging assisted with nanotechnology helps in identifying and diagnosis of many diseases. These nanomaterials also helps in targeted drug delivery to the specific region and sows therapeutic effect. The existence of nanomaterials have become increased over the period of 40 years [1]. The structure of nanomaterials have the capacity to interact with the biological processes as the structures are less than 100 nm.It is present in various shapes such as rods, spheres and dendritic. They have variety of applications such as food, goods, sports, cosmetics, engineering and waste disposal etc. is also played a vital role in day-to-day activities. The extension from this applications, nanotechnology applies its application to the medical field. It includes drug delivery system to the targeted site, diagnosis of diseases, disease management, biomarkers detection, new drug and vaccine development and etc. [2, 3]. The distinctive properties possessed by the nanomaterials includes their solubility level, recommended size and their ability to pass through the blood brain barrier and its level of reactivity. [4]. Although, nanotechnology have many advantages in the diagnosis, treatment and prevention, the use of nanotechnology with regards to immune system is still a question mark. These nanomaterials contain proteins which is identified by several immune cells and they influence the action of nanoparticles with the component off blood. [5, 6]. At present day, the technique of nanotechnology has been wisely improved to many areas of medical field including the alteration in the immune responses related to the treatment of the diseases. [7] In this article, we can study about the application of the nanotechnology in the field of

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medicine including the diagnosis and treatment of many diseases.

Nanopartcles in the Clinical Settings

The purpose of nanotechnology in the clinical settings are shown in fig.1. [8].

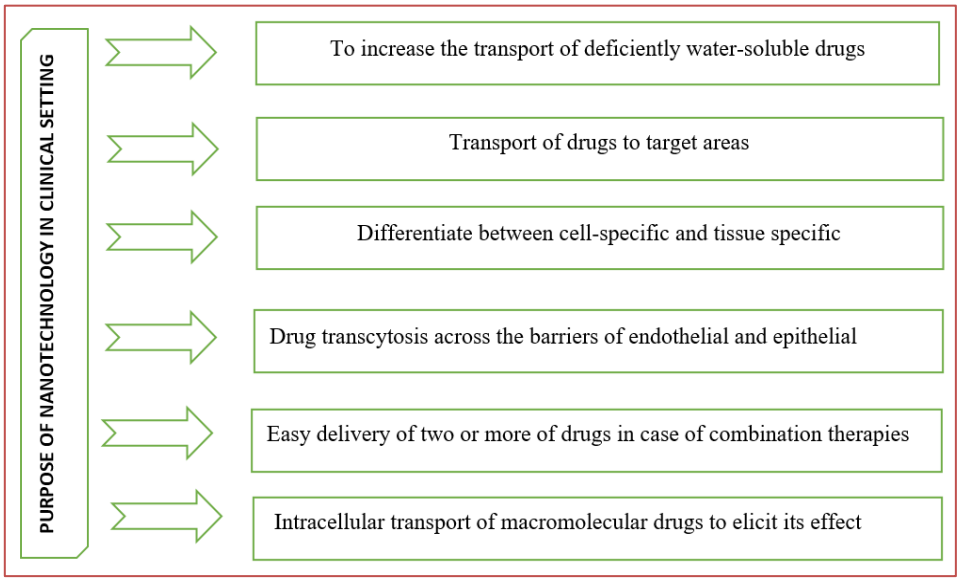


Fig. 1: Purpose of nanotechnology in clinical setting

Nanoparticles in Diagnosis

The nanoparticle which is used in the magnetic resonance imaging as contrast agent is Fe2O3 nanoparticles. [9] This nanoparticle can also be used as magnetic drug delivery systems, vehicles and may also be used in combination with superconductors. Apart from transferring and delivering drugs in tumorous tissues in higher concentration, it also has an ability to produce heat. [10].

Atherosclerosis is a cardiovascular disease usually characterized by formation of plaque formation in the arteries or blood vessels. It is usually diagnosed by imaging techniques such as angiogram. But this angiogram does not allow to gather more information on plaque formation like the composition of plaques. But the application of nanotechnology helps to overcome this problem. [11].

The nanotechnology also has an application in the diagnosis of tumor and treatment. [12]. It has a greater advantage of cancer diagnosis in its initial stage which helps to treat immediately and cure the patient. It also helps in detection of tumor biomarkers. With the use of nanotechnology, many carriers of biomolecules have been developed that helps in the detection of biomarkers. They are gold nanoparticles, gold nanowires, magnetic nanoparticles and quantum dots. The biomolecules which are involved for tumor monitoring and detection are RNA and DNA fragments, proteins and antibodies. The nanomaterials used in the detection of cancer biomarkers are shown in the fig. 2. [13].

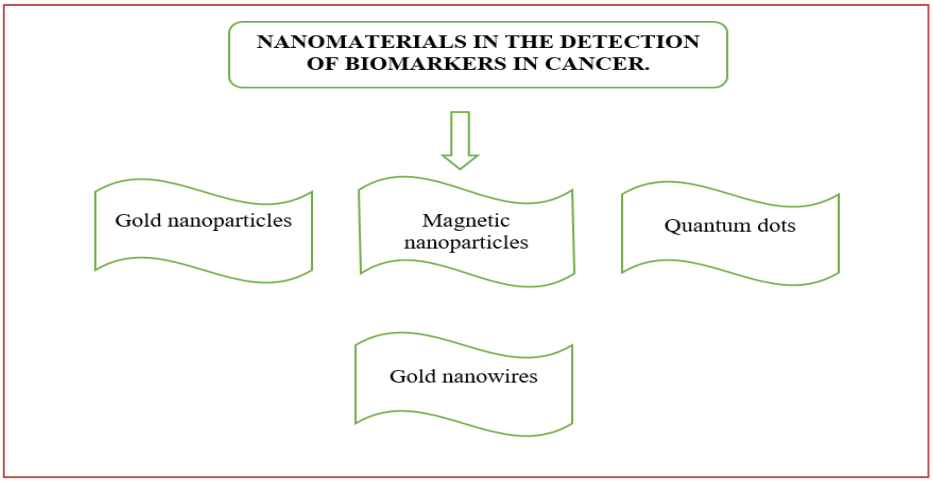


Fig. 2: Nanomaterials used in the detection of cancer biomarkers

Nanotechnology in Drug Delivery System

Nanotechnology paves the way to use the nanoparticles in the field of medicine to cure or prevent different diseases. It includes neurodegenerative diseases like Alzheimer's disease; infectious diseases like tuberculosis; skin diseases; renal diseases and different types of cancers. It also helped to a greater extent in the COVID-19 vaccination. [14] Nanoparticles are used in drug delivery systems because of its two important characteristics which includes its particulate size and use of biodegradable materials. (15, 16) Due to its nano particle size, it has greater solubility and appreciable bioavailability. [17]. Despite of this, their tendency to absorb in the compact areas of endothelial tissues, transportation through blood brain barrier and passing through pulmonary system has greater advantage then conventional drug molecules. Another advantage of nanoparticle is that it allows the accumulation of active substance in target areas by absorption through different kind of cells. [18, 19] Nano particles also has an ability for administration in the intravenous route than the conventional drug particles. [20] The drug particles currently available are not formulated in their most effective form. So, to pave way for most effective carrier system for drug delivery, the substances containing nucleic acids or proteins should be formulated using nanoparticles to overcome instability and to achieve efficient activity. [21]. The different types of pharmaceutical Nano systems are shown below: [16].

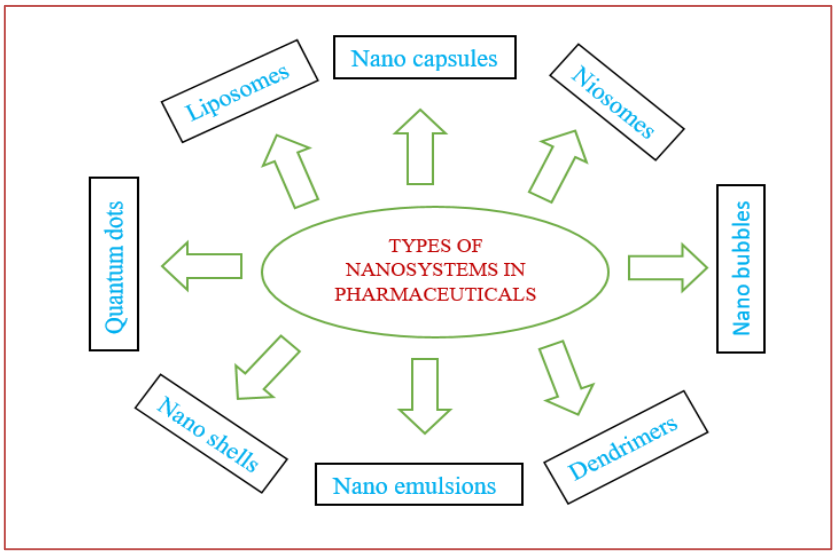
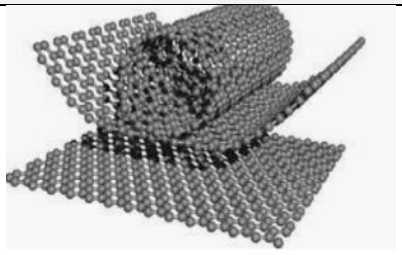
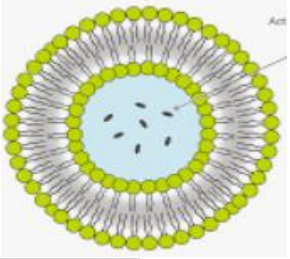
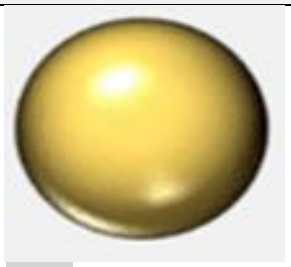
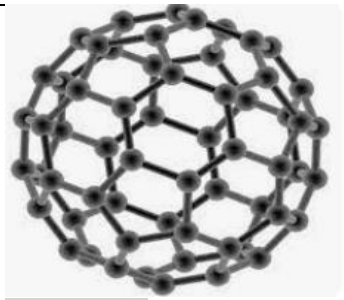
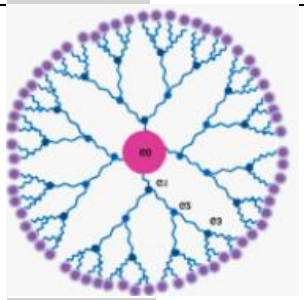
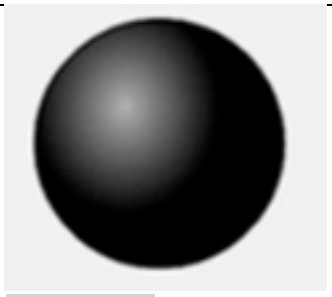
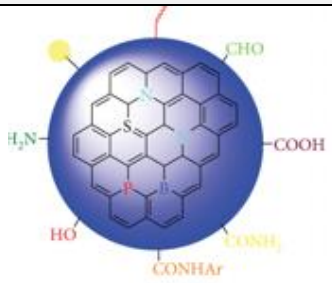
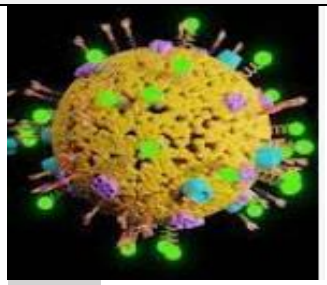
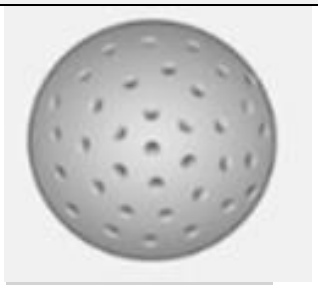
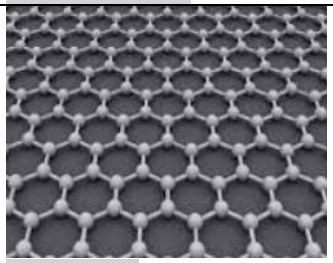
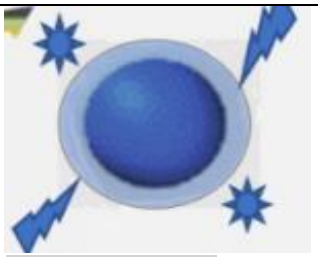


Fig. 3: Different types of pharmaceutical Nano systems

Table 1: Carbon nanomaterials, organic nanomaterials and inrganic nanomaterials

S.NO	CARBON NANOMATERIALS	ORGANIC NANOMATERIALS	INORGANIC NANOMATERIALS
1.	 CARBON NANOTUBE	 LIPOSOMER	 GOLD
2.	 FULLERENE	 DENDRIMER	 IRON OXIDE

S.NO	CARBON NANOMATERIALS	ORGANIC NANOMATERIALS	INORGANIC NANOMATERIALS
3.	 CARBON DOTS	 HYBRID	 MESOPOROUS SILICA
4.	 GRAPHENE	 POLYMER	 QUANTUM DOTS

Role of Nanotechnology in Various Diseases and Disorders

Nanotechnology in Autoimmmune Diseases

The treatment for the autoimmune diseases, is still a complex approach. But, the concept of nanotechnology helps in decreasing the signals stimulated by the immune cells and thereby induce adaptive autoimmune responses. [22]. In the study conducted by Nils Schweingruberin relation with the experimental autoimmune encephalomyelitis, it is found that the glucocorticoid loaded liposomes found to be more potent than the conventional therapy. [23]. The pMHC coated nanoparticles up regulates the CD4+ regulator T cells even with low acidic range. [24]. The autoimmune diseases will be able to treat better with the development of new nanoparticles such as multiple surface nanoparticles which helps to innovate new drugs through nanotechnology. [25, 26]. The intravenous injection of titanium oxide nanoparticle resulted in the initial immune response in lungs and then after some days, it also had an increasing effect on the inflammatory cells. [27].

Nanotechnology in the Management of Tuberculosis

Nanotechnology helped in developing treatment options for tuberculosis by its improved technology. The anti-tuberculosis medications have improved efficiency due to the incorporation of PLG nanoparticles. This helped to increase in the therapeutic concentration in the plasma. That is, after the intravenous administration, the normal anti-tuberculosis drugs lasts for around one day in plasma whereas the these nanoparticles incorporated drugs has shown ten days of therapeutic concentration in the plasma or tissues [28, 29].

Nanotechnology in the Management of Neurodegenerative Diseases

The treatment for neurodegenerative diseases have become very complicated as the most important barrier in the treatment of Parkinsonism, Alzheimer's and Huntington's disease is the blood brain barrier. This barrier does not allow many drugs to travel though this barrier and makes it hard to act on brain. So, this nanotechnology proved in many studies that this nanomaterials can easily cross the blood brain barrier or it changes the conduct of the blood brain barrier. Apart from this, this also aids in the protection of drug molecules from the action of chemical reactions or enzymes and helps in the release of drug for longer period of time. [30, 31].

Nanotechnology in the Management of Cancer

The application of nanotechnology in the field of oncology helps in minimizing drug resistance and targeting of cancer cells. The polymer used in the manufacture of nanoparticles for cancer drugs is PLGA. An anti-cancer medication, doxorubicin is used in the treatment of wide range of cancer. But, this medication has an adverse effect of affecting the other tissues such as kidney and heart rather than affecting the cancerous tissues. To overcome this problem, the liposomal form of doxorubicin were developed which minimized the accumulation of doxorubicin in the kidney and heart. [32].

Nanotechnology in Pharmacogenetics

In the treatment of several diseases and disorders, the management may not be similar for all the patients. The dosage and other factors may vary for each and every patients. In that case, there is a need for pharmacogenetic testing for each individual. The genes of the individual patient is tested to provide personalized diagnosis and specific care. It helps in faster and safer cure in patients. This is done by

nanoparticles because it has an ability to sequence genetic materials using nano devices. [33]. The nanoparticles investigated in the field of pharmacogenetics are:

- Iron nanoparticles
- Silver nanoparticles
- Gold nanoparticles
- Polymeric nanoparticles. [34].

The list of nanoparticles and their applications were listed in the table below:

Table 2: List of nanoparticles and their applications

S.NO	NANOPARTICLES	APPLICATIONS
1.	Silver nanoparticles	Anti-viral and bactericidal activity.
2.	Nano zinc oxide	Bactericidal, treats skin infections.
3.	Nano silica	Gene therapy, cell therapy, drug delivery imaging, bio-catalysts, bio-analysis.
4.	carbon nanotubes	Anti-oxidant and anti-microbial.
5.	Quantum dots	Immunoassays, gene therapy, cancer treatment.
6.	Nano shells	Drug targeting and luminescence feature improvement.
7.	Nano bubbles	Cancer treatment.
8.	Paramagnetic nanoparticles	Specific organ identification.
9.	Liposomes	Cancer therapy, transfer of genetic materials.
10.	Niosomes	Drug of anti-cancer and anti-viral medications.
11.	Dendrimers	Gene therapy, drug delivery, contrast agent in MRI scans.

Nanotechnology in Nephrology

Nanoparticles is very important in the treatment of diseases and disorders related to kidney. For the treatment of kidney diseases in the patients who do not have the ability to produce erythropoietin with end-stage or chronic kidney disease, the drug ferumoxytol is used as nanoparticles. [35] For the improvement in therapeutic effects and distribution of drug in the kidney, the nanoparticles were developed about 75 nm which is helpful for targeted drug delivery in the renal system. The nanoparticles developed for the treatment in the renal system are Rhein and PEGylated gold nanoparticles. [36].

Nanotechnology in Dermatology

In the treatment of skin diseases the most commonly used nanoparticle is PNPs. [37]. In particular, the PNPs made of alginated and chitosan showed advanced anti-biotic efficiency in the treatment of acne vulgaris when compared to benzoyl peroxide which is caused by propionibacterium acnes. [38, 39]. Another nanoparticle which helps in dispersion of medications including hydrophilic and hydrophobic in topical administration is electro-spun fiber mats. Nanoparticles such as nano-structured lipid carriers, liposomes and solid lipid nanoparticles bind tightly to the skin allowing it to stay medications for a longer time on the surface of the skin. [40, 41]. It is also found that release of drug is more rapid when retinol is incorporated into compritol based SLN when compared with conventional carrier. [42- 44]

CONCLUSION

Nanotechnology has greater applications in the medical and pharmaceutical field due to its unique characteristics. It has better approaches to treat or prevent diseases and disorders. This is because due to their smaller size, these nanomaterials have the ability to penetrate deeper into the biological tissues or skin and can elicit their therapeutic activities. More research works are needed to study the effect of nanoparticles in the therapeutics due to their distinct characteristics, specifically in immunotherapy. Nanotechnology extended its application in the recent pandemic COVID-19 by the production of vaccines using lipid nanoparticles and also conquered the difficulties faced by the normal drug delivery systems. It is concluded that vast research studies and efforts are encouraged on nanotechnology related to the field of medicinal and pharmaceutical sciences due to their differential characteristics and looking forward for the approval of more nano drugs by FDA in diagnosis and treatment of several diseases.

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