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Potential Application of Nanotechnology in Health Care: An Insight

Wali Muhammad [a,] *, Muhammad Haroon [a], Muzamil Shah [a], Muhammad Asad Ullah [a], Iqra Haleem [b]

[a] Department of Biotechnology, Quaid-i-Azam University, Islamabad 45320, Pakistan.
[b] Department of Pharmacy, Quaid-i-Azam University, Islamabad 45320, Pakistan.

***Corresponding Author**
wali.biotech5511@gmail.com
(Wali Muhammad)

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ABSTRACT: Nanotechnology uses very small molecular and intracellular structures ranging from 1 to 100-nanometer in size to create, employ and qualify materials and devices. It is a well-established branch of science having significant applications in wide range of medicine. It has wide usage in pharmaceutics for targeted delivery of drugs and genes into cells. Various targeted procedures in the animal body have been accomplished using nano instruments, especially nano-robotics. Scientific bodies have also set the status of nanomedicine in health fields especially neurological and cancerous antidotes. Thus, nanoparticles of extremely small size have vast prominence in almost all medical fields for facilitating mankind..

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Keywords: ZnTe Nanotechnology, Medicine, Cancer, Diseases

Wali Muhammad *is an M.Phil scholar in Department of Biotechnology, Quaid-i-Azam University, Islamabad, Pakistan. His research interest lies in the biological synthesis of metallic nanoparticles and nanoparticle alloys using medicinal plants and the exploitation of nanoparticles as novel bactericidal, antifungal, antileishamnial and anticancer agents.*

Muzamil Shah *is PhD Scholar in Department of Biotechnology, Quaid-i-Azam University, Islamabad, Pakistan. He is interested in exploring the biological potential of nanoparticles synthesized via green route by employing native medicinal plants as stabilizing and reducing agent for antileishamnial, anticancer and photocatalytic agents*

Muhammad Haroon is an M.Phil scholar in Department of Biotechnology, Quaid-i-Azam University, Islamabad, Pakistan. His research interest lies in molecular virology. He intends to study the interaction of nanoparticles with viruses and their potential anti-viral action.

Muhammad Asad Ullah is an M.Phil scholar in Department of Biotechnology, Quaid-i-Azam University, Islamabad, Pakistan. His research interest lies in exploring therapeutic potential of medicinal plants, enhancing secondary metabolite content of plants using cell and tissue culture techniques and nanoparticle synthesis from these invitro established cultures.

Iqra Haleem *is Pharmacist in Department of Pharmacy, Quaid-i-Azam University, Islamabad, Pakistan. Her research interest lies in nanomedicine, antimicrobial drug delivery and drug designing.*

1 Introduction

The foundation of the medical world contains the science and routine practice of diagnostic, therapeutic and prophylactic strategies developed to combat life-threatening diseases. Several healthcare practices are included in the medicines which are evolved significantly to restore and maintains health by prevention and treatment of all the emerging and re-emerging diseases. The twentieth century is innovatively revolutionized by the foremost advancement in the field of nanotechnology and its applications, especially in the medical world. Nanotechnology has emerged as one of the key areas in modern research dealing with structures of nano-dimensions [1]. Their synthesis and structural manipulations lead to the diverse changes in their physical, chemical and biological properties. The change in properties occurs both on the atomic level as well as their bulk counterparts [2, 3].

These changes, in turn, result in the emergence of novel applications possessed by these nanomaterials. The novel applications based on morphology, size and distribution of nanomaterials has diversified a variety of fields including healthcare, biomedical research, drug and gene delivery systems [4], cosmetics, optics, food and feed, environment, chemical industries, mechanics, electronics, catalysis, space industries, light emitters, single electronic transistors, energy sciences, non-linear optical devices and several other scientific disciplines [2, 5]. Nanotechnology is the science of dealing matter at the nanoscale (1-100nm). It has wide-ranging applications and can be utilized for the development of several forms of nano-sized materials and devices. The brief introduction gives a full platform to researchers how nanotechnology plays its role in the medical world.

Various methods used for nanoparticles synthesis

A variety of methods are utilized for the synthesis of nanoparticles including physical, biological and chemical each having their own pros and cons. Some of the methods are composed of various physiochemical processes and poses a great threat to the living environment. The synthesis through biological processes is considered as environmentally friendly, simple, safe and non-toxic. The green synthesis can be completed in few hours at room temperature and all which is required is the plant extract and the metal salt. The extract helps in the reduction of the metallic salt into its respective nanoparticles. Researchers have focused significantly toward the synthesis of nanoparticles through greener route in the last few decades. Various physical methods utilized for the synthesis include sonication, radiation and laser ablation while chemical method includes condensation, sol-gel method, and reduction. The biological methods which are used for nanoparticles synthesis are shown in (Fig 1) [6-8]. Each method possesses its own pros and cons.

Application of Nanotechnology in various fields

Nanotechnology plays a vital role in different fields including physics, chemistry, and biology. Nowadays the focus is shifting toward the use of nanoparticles in the drug delivery system. The nascent system possesses novelty over the current delivery strategies because of two significant properties. First because of the nano dimension these particles can penetrate easily through small capillaries and are readily taken up by the living cells which enhance the drug accumulation process at the target sites. Secondly, for the preparation of nanoparticles, biodegradable materials are utilized which prolong the drug release process at the target site for days or even weeks. These properties are not only exploited to be utilized for medical purposes but also for other different fields including chemical industries, engineering, electronics, drink, and food industries [9-11]. The lists of the areas where nanotechnology introduce its applications are summarized as below.

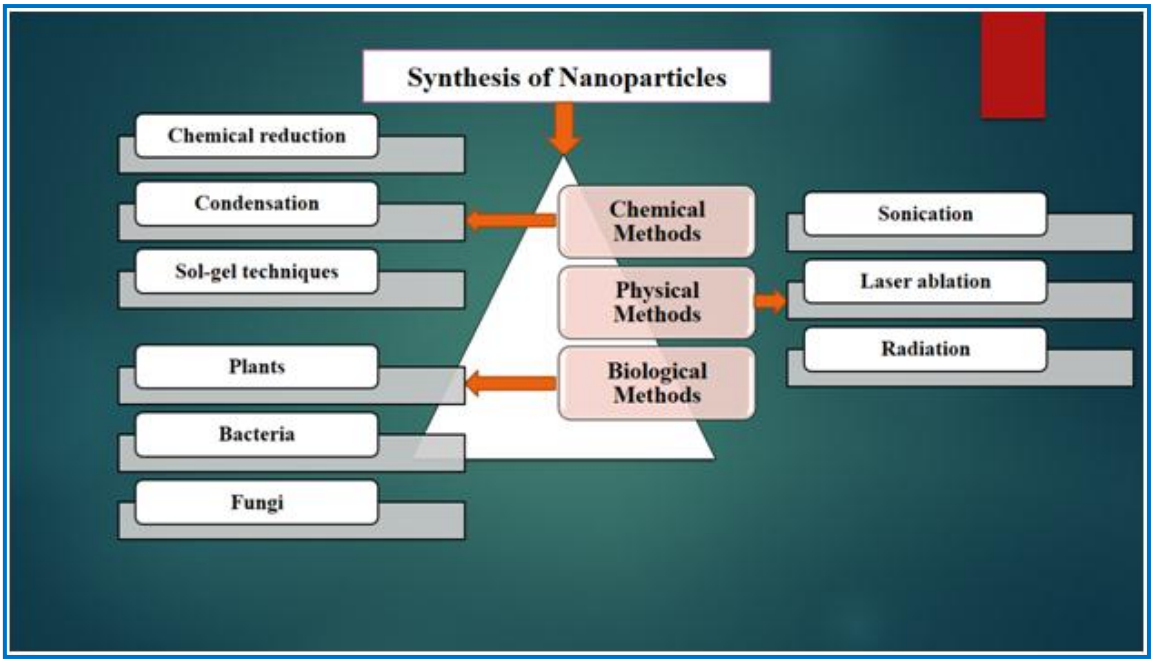

Fig. 1 various methods for making nanoparticles

Nanotechnology in medicine

The applications of nanotechnology in the field of medicine are known as "nanomedicine" and it deals with the diagnosis, treatment, monitoring, and prevention of the diseases. Nanomedicine is considered to be a relatively novel field but the basic nanotechnology-based approaches have emerged a few decades ago. In 1965 first lipid-based vesicles mainly known as liposomes were introduced [12]. The first polymer system used for the controlled release of macromolecules was introduced in 1976 [13], the first polymer based long circulating stealth nanoparticles were introduced in 1994 [14], the first bioconjugate of quantum dots was described in 1998 [15, 16] while the first nanosensors were introduced in 2001 [17].

The focus has been shifted toward the application of nanoparticle contrast agents in the early characterization of diseases at the cellular and molecular levels such as atherosclerosis and cardiovascular abnormalities. The advancement in the nano-based strategies might assist in combining the imaging techniques with conventional drug delivery systems to expedite the personalized medicine [18]. Moreover, the development of nano-based highly efficient markers and detection devices for the early diagnosis and Monitoring therapy response will have a significant role in patient management, lowering mortality rates and improving life quality of the patients in case of deadly diseases like cancer and Alzheimer disease.

Table 1. Overview of the applications of nanomaterial-based products in different areas

Energy	**Food and Drinks**	**Cosmetics**
✓ Fuel cells	✓ Package materials	✓ Sun protection
✓ Solar cells	✓ Storage life sensors	✓ Lipsticks
✓ Batteries	✓ Additives	✓ Skin creams
✓ Capacitors	✓ Clarification of fruit juices	✓ Tooth paste
Medicine	**Chemical Industry**	**Engineering**
✓ Drug delivery system	✓ Fillers for paint system	✓ Wear protection for tools and machines (Ant blocking coatings, Scratch resistance coatings on plastic parts, etc)
✓ Active Agents	✓ Coating systems based on nanocomposites	
✓ Contrast medium		
✓ Medical rapid tests	✓ Impregnations of papers	

✓ Antimicrobial agents and coatings ✓ Agents in cancer therapy	✓ Magnetic fluids	✓ Lubricant-free bearings
Electronic Industry ✓ Data memory (MRAM, GMR-HD) ✓ Displays (OLED, FED) ✓ Laser diodes ✓ Glass fibers ✓ Optical switches	**Automotive Industry** ✓ Lightweight construction ✓ Catalysts ✓ Painting (Fillers, Base coat, Clear coat) ✓ Sensors ✓	**Textile/Fabrics/non-wovens** ✓ Surface processed textile ✓ Smart clothes

Presentations in cancer therapy

In recent past, a tremendous advancement has been achieved in the development of cancer therapeutics and novel drug delivery strategies. Based on the individual genomic variations and alteration in the behavior of cancers, the routine conventional treatment may not yield the same results in the treated patients [19]. Early diagnosis and effective treatment will be possible with a personalized approach to understanding the cancers at the molecular level. Nanobiotechnology has brought a tremendous advancement in the molecular diagnostic era For the early detection of cancer through the development of nano-biosensors and nanoimaging diagnostic techniques. These strategies are referred to as nano diagnostic techniques. Further with the rapid advancement in proteomics has also revolutionized the diagnosis of cancers by using the nanoscale protein analysis technique as a substitute for the conventional biopsy methods. The applications of protein technologies in oncology are referred to as onco-proteomics which can be utilized to design novel drugs according to the specific molecular profile of the cancer cells. By merging these advanced diagnostic, therapeutic and drug delivery mechanisms, the management of the cancer patients can be predicted via personalized medicines [19].

Nanotechnology in targeted drug delivery

Nanotechnology may modify pharmaco-kinetics and delivery refining effectiveness and lessen side effects [20, 21]. The size and surface properties enrich drug portability, mobility, flexibility and thus enhance selective confinement in tumor tissue making them potentially operative tumor delivery vectors [22]. Nanoparticles including metallic and semiconductor nanoparticles enlarge useful abilities for contemporaneous targeted drug delivery and imaging [23, 24].

Nanotechnology in liver diseases

Liver diseases like, hepatocellular carcinoma, hepatitis and liver cirrhosis has become a leading health challenge worldwide. Many innovative nanoparticle-based therapies have been studied by using nanocarriers, such as the inorganic nanoparticles which include bio-nanocapsules and human serum albumin (HAS) metal-based inorganic nanoparticles, polymers and lipids [25]. Many treatments like targeting hepatitis B virus (HBV) in the liver by adefovirdipivoxil with monostearin-containing solid lipid nanoparticles [26], in vivo delivery of siRNA against liver fibrosis [27], lipid-based carrier treatments, OX-loaded nanoparticles in overwhelming HCC drug resistance have been used for various treatments [28].

Nanotechnology allows primary detection of Alzheimer's disease

The brain is one of the most complex systems and the abnormalities associated with it offer quite great challenges in the field of biomedicine. Improved early diagnosis and more effective therapeutic strategies are offered by the field of nanotechnology for the treatment of neurodegenerative diseases like Alzheimer. It will be possible after the understanding of the brain functioning significantly. With the current diagnostic strategies, the disease cannot be early diagnosed and is the most

dominant problem for the effective treatment. It is crucial for the diagnostic techniques to have more than 80% specificity and sensitivity range for the early diagnosis of the disease and then it will be considered as the ideal diagnostic tool. Early diagnosis is necessary for the AD because the neurodegeneration process starts before the appearance of the disease symptoms. The potential of nanotechnology for early detection of AD emerged after two studies conducted in February 2005. The proposed strategies for disease detection in those studies were Localized Surface Plasmon Resonance (LSPR) and Bio-Barcode assay (BCA) [29].

Applications of nanotechnology in cardiology

Nanotechnology has applications in cardiology and various vascular processes which can be diagnostic and therapeutic both. Radiolabeled nanopolymers conjugates with biospecific antibodies can be utilized for the diagnosis of cardiovascular diseases. They are used to target atherosclerotic lesions which are further detected by imaging techniques. Genes associated with coronary artery diseases (CAD) can be detected by employing biosensors composed of carbon nanotubes which can interact with the DNA. From the nanotube-DNA interactions, multiple genes can be identified significantly. To overcome the acute recoiling and high restenosis rate of the balloon angioplasty, stent implantation method was developed. Drug-eluting stents (DES) have emerged as one of the foremost advanced technology, which is having applications in the field of interventional cardiology. However, in recent past studies have shown that the DES is associated with the increased risk of late-stent thrombosis. Currently among the most popular DES commercially available includes paclitaxel, sirolimus, and zotarolimus. The use of nanoparticles as drug delivery helps in the availability of the anti-restenotic drugs for all the lesions. It might assist in the removal of anti-proliferative agents from the tissue layer surface into the vascular wall which could facilitate the rehealing process of the endothelium [30].

Role of nanotechnology in molecular imaging

In cancer therapy, conventional imaging methods are used to study the pathological changes in various affected organs, shrinkage of the tumors in the response to the treatment and various biochemical changes at the molecular level. Molecular imaging techniques provide the possibility for detecting the disease at the molecular level before the appearance of clinical symptoms. Specific imaging molecules conjugated to the nanoparticles can be employed to target the specific ligands or receptors associated with a particular disease. Recently quantum dots (QD's) are used as more effective imaging tools which are nanosized, nontoxic and are quite stable to photobleaching as compared to the fluorescent dyes [31].

Antimicrobial activities of NPs

Nanoparticles have a greater surface-area-to-volume ratio as compared to their bulk materials, which results in the precise physiochemical characteristics and increased reactivity. As silver has antimicrobial properties, it has been in use since early times in the form of metallic silver, silver nitrate, silver sulfadiazine to control burns, wounds and several bacterial infections [32]. Studies have shown that silver, zinc, gold and magnesium NPs possess strong antibacterial activities. Silver nanoparticles have proved to be the most effective antimicrobial Agentsagainst bacteria, viruses and other eukaryotic micro-organisms [33]. Inorganic nanoparticles also demonstrate greater durability, less toxicity, heat resistant and better selectivity [34].

Conclusion

Nanoparticles have greater surface area and significant outcomes as compared to the particles in their bulk form. Consequently, they are utilized as a promising tool for the development of drug and gene delivery systems, diagnostic sensors and biomedical imaging devices. Nanomaterials have different organic properties and variable chemistry as compared to the macro-sized materials. The active penetration and prolong residing capability of the nanoparticles inside the living cells will have a significant impact on the interaction between them and the biomolecules. Their discriminative characteristics such as small size, availability in various forms, variable chemistry, shape, higher solubility, and agglomeration have made it more promising in the medical world. With their vast applications in various fields, nanoparticles can be used in diagnostic imaging for early detection of tumors and in highly efficient drug delivery systems such as

carbon nanotubes for the transportation of various biomolecules into cells. The future of the nanotechnology seem to be extremely bright and crucially holds a promising role after its merging with other conventional technologies to forecast the development of complex and modern hybrid technologies. Regenerative medicines, stem cells approaches, and neutraceuticals are some sectors currently predicted to be highly improved by innovations in nanotechnology. More ever further advancement in the field will revolutionize the human civilization from every aspect.

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Conflict of interest

There is no potential conflict of interest in authors regarding publication of this paper.

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