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Review Article

NANOTOOLS FOR TARGETED DRUG DELIVERY AND THERAPEUTICS

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ABSTRACT

Nanotechnology is becoming expeditiously advancing field which inculcates an extensive range of disciplines within it. The astonishing resemblances in the aspects of nanomaterial's with those of biological macromolecules have adjoined interesting aspects to its uses in biological systems involving cell and developmental biology. The implementation of nanotechnology is procuring immense response in biology due to its potentiality to avoid barrier that are otherwise connected with conventional methods. In the upcoming years, the advancement in this area is sensed to develop and show potent lifesaving medical advancing technologies and treatment methods. In addition to the conventional methods, nanotechnology-based tools are advanced for knowing about the multifaceted characteristic of cell and developmental biology and assist us to solve some of the issues linked with it. Some of the examples involve Nano sensors that can identify minute changes in metabolites or messenger molecules within cells, nanomaterial based bio imaging tool which are more methodical in comparison to traditional organic dyes and Nano carriers which support in targeted drug delivery reign. Targeted delivery of therapeutic and imaging agents performs an important role in prior diagnosis and intensifies therapeutic effect to overcome the side effects connected with conventional methods.

Keywords: Nanoscience, Immunomodulatory nanomaterials, Bio imaging, Nano sensors, Therapeutics

1. INTRODUCTION

Nano medicine is an emergent approach for the execution of Nano technological systems in the disease diagnosis and therapy. This area of nanotechnology can be divided into two major classes: Nano devices and nanomaterials as shown in Fig. 1. Nano devices are diminutive devices at Nano scale including microarrays [1, 2] and some inventive machines like reciprocates [3]. Nanomaterial having particle size lesser than 100 nanometres (nm) should be at least in one dimension. In the last few decades, the advancement of novel approaches for building of nanomaterials for the efficacious transport of drug molecules provides a wide range of Nano technological applications [4, 5]. Agile nanostructured materials can transport drugs to the target sites with lower dosage frequency and in a (spatial/temporal) inhibited manner to alleviate the side effects experienced with conventional therapies. Correlation of therapeutic agents with nanomaterial showing definite organoleptic effects which shows growth in their passage for providing a extensive range of molecules to fixed location in the body [6]. On the other side, combination of therapeutic nanoparticles with dissimilitude agents gives a direction of tackling their path and imaging their delivery location in in vivo system. So, here we summarise the biophysical properties of nanomaterial making them pivotal source in Nano medicine and give a review on therapeutic and their targeted delivery solicitation in various disorders like as cancer and neurodegenerative diseases.

2. NANO TOOLS FOR EARLY DIAGNOSIS OF DISEASES

Foundation of nanotechnology in pharma industries has made Nano carrier an efficient nano tool for the treatment of numerous diseases. Although favourable outcomes were obtained at laboratory scale, pharmaceutical formulation failed when ascended to industry level. The practical obstruction is making use of synthetic chemistry and noxious material which makes the formulation clinically perilous. Moreover using modern formulation procedure makes the cost of treatment extravagant. Nevertheless of these issues many Nano tools have been efficacious in the markets for chronic diseases like cancer. With expanding rise in the utilization of biostable materials for the growth of novel Nano carriers the overhead issues are prophesy to get rectified. So there is need for advancing Nano tools

which will replace conventional methods for diagnosis of disease. Utilization of integrative Nano tools can help ameliorate the formulation approaches and other characters. In past few years, utilization of biostable adjuvant has become importance Nano tool in the area of pharmaceutical drug delivery. This review exactly deals with studies showing the potentiality of prefabricated Nano carriers which are made up of biostable inclusion or modification. With extensive improvement in nanotechnology the current and future perspective of Nano tools using materials that are not noxious and scalable can prove to be a strong contender for early diagnosis of a disease.

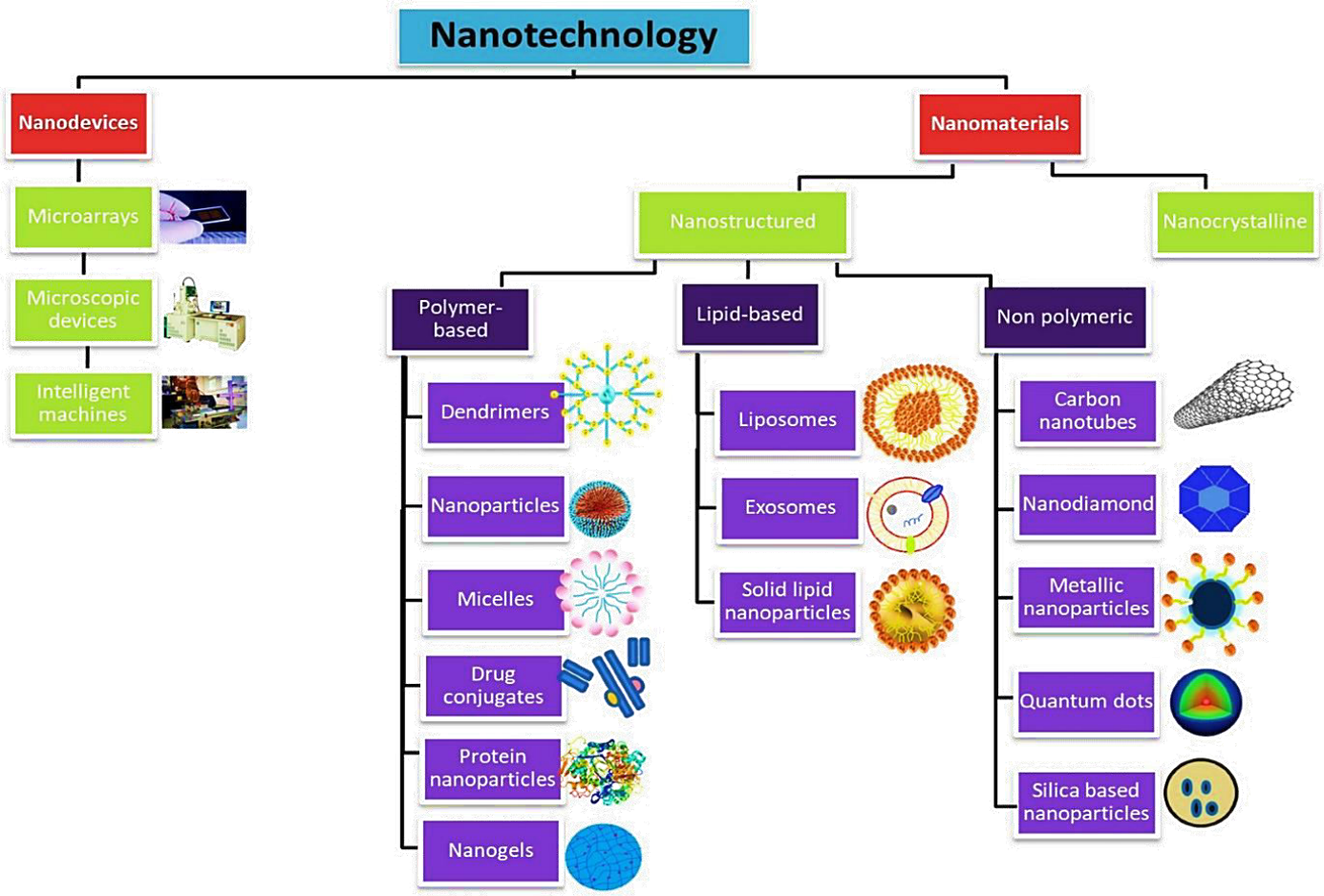

Fig. 1: Components of nanotechnology used in therapeutics application

3. APPLICATIONS OF FLUORESCENT NANO-MATERIAL'S IN BIO IMAGING/BIOLA-BELING

Fluorescent nanomaterial have gain success in a variety of application because of their advantageous potentiality which enables [7] and gives:

1. Largeoptical contrast in contrast-free samples.
2. Detection of specific components of complex biological systems
3. Presentation of nanostructures with high spatial and resolutions, far below 100nm with time scale of milliseconds
4. Delivery of payloads according to targeting

Fluorescent nanomaterials undergoes extensive scrutiny as imaging agents for biological applications, as they have efficient biocompatibility, high brightness and easy bio functionalization. Most of the Fluorescent nano-materials (NPs) (involves dye-doped polymer, semicon-ducting polymer NPs, small molecule organic NPs, Nano gels, micelles, biomaterial based NPs can be encapsulated from the standpoint of preparation, method, structure, optical property. Depending on optical properties of Nano-sized imaging agents, their utilization are revived in terms of *in vitro* imaging, in vivo imaging, bymeans of specific or non-specific targeting.

4. NANOMATERIAL FOR TARGETED DELIVERY OF THERAPEUTIC AGENTS

Drug delivery systems of chemotherapeutic agents shows as many problem related with the sensitive, toxicity, poor specificity, and drug resistance induction which decreases the therapeutic efficacy of numerous drug systems. This nanostructured prototype has enabled effective delivery of active (including anti-cancer) drugs into the diseased tissue. Fundamental goal of the use of nanomaterials in drug delivery applications for the efficient treatment of a disease with decreasing side effects, with the goal of a susceptible improvement in therapeutic results by using the (patho-) physiology of a diseased tissue. Drugs and other therapeutic agents are regulated to treat certain diseases and disorders with goal of achieving coveted pharmacological effects with lowered side effects. The use of an administered drug delivery system is a key plan for increasing the therapeutic efficiency and safety of therapeutic molecules [12, 13]. The foremost rationale of using a satisfactory drug delivery system is its potentiality to ensure a greater period of drug bioavailability and thereby increases therapeutic efficiency [14,15]. Distinct materiald with distinct structural forms are connected with drugs for making nano drug delivery systems. Most widely used drug delivery vehicles include nano-particles. (*E.g.* polymeric, ceramic, and metallic), [16] liposomes, [17] and dendrites [18] as shown in fig. 2. A considerable number of preclinical and clinical outcomes suggest their convenience for the treatment of various diseases. [19-21]. The number of materials used in drug delivery applications is growing rapidly, and these materials have demonstrated potential diagnostic and therapeutic efficacy [22, 23]. Nanoparticles made up of distinctive structure and surface charge profiles can specifically home to lymphoid organs that is spleen and generate immunomodulatory effects.

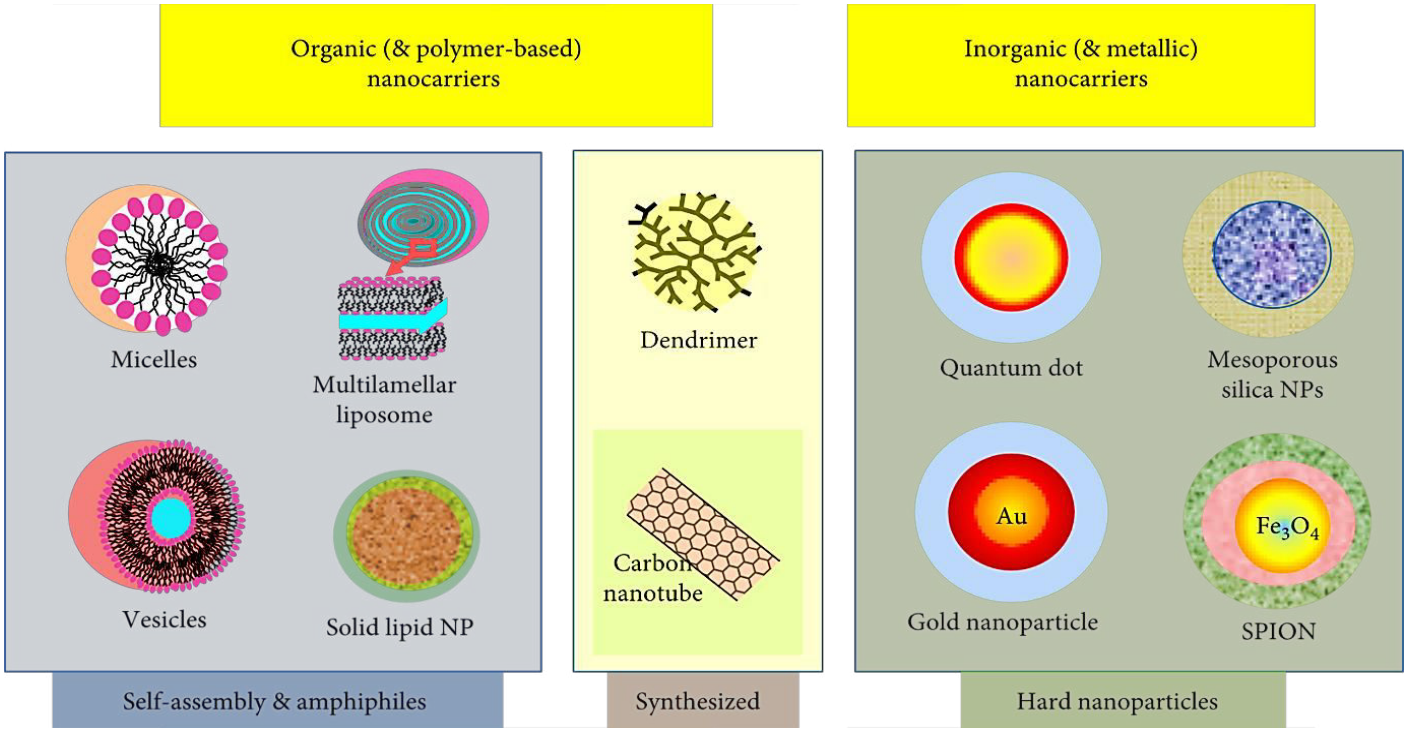

Fig. 2: Example of most employed organic and inorganic Nano carriers for smart application in drug delivery.

5. THERANOSTICS NANOMATERIAL

Theranostic nanoparticle has the capacity to transform future disease management. Efficient positioning of theranostic nanoparticles **a**t the tumour site is key for diagnostic and therapeutic purposes as shown in figure 3.Theranostic nanoparticles have multifaceted systems, which are well evolved for more distinct disease management by combining diagnostic and therapeutic potentiality into single biocompatible and biodegradable nanoparticle [24]. Optimal theranostic nanoparticles

must be safer to humans and be able[24] to speedily and particularly accumulate in targets of interest, [25] outline biochemical and morphological characteristics of diseases, [26] Efficient to provide a sufficient amount of drugs on-use without damaging healthy organs and [27] be out from body within hours or biodegraded into nontoxic by-products. Chemotherapeutic agents consisting of nanomaterials can be introduced into neutrophils, which are then registered in the resection bed of brain tumours using post operative inflammatory cytokines to release drugs that reduce recurrences [28]. But, problems still occurs in the development of biocompatible theranostic nanoparticle, with highly specific in vivo tumour targeting potentiality [29].

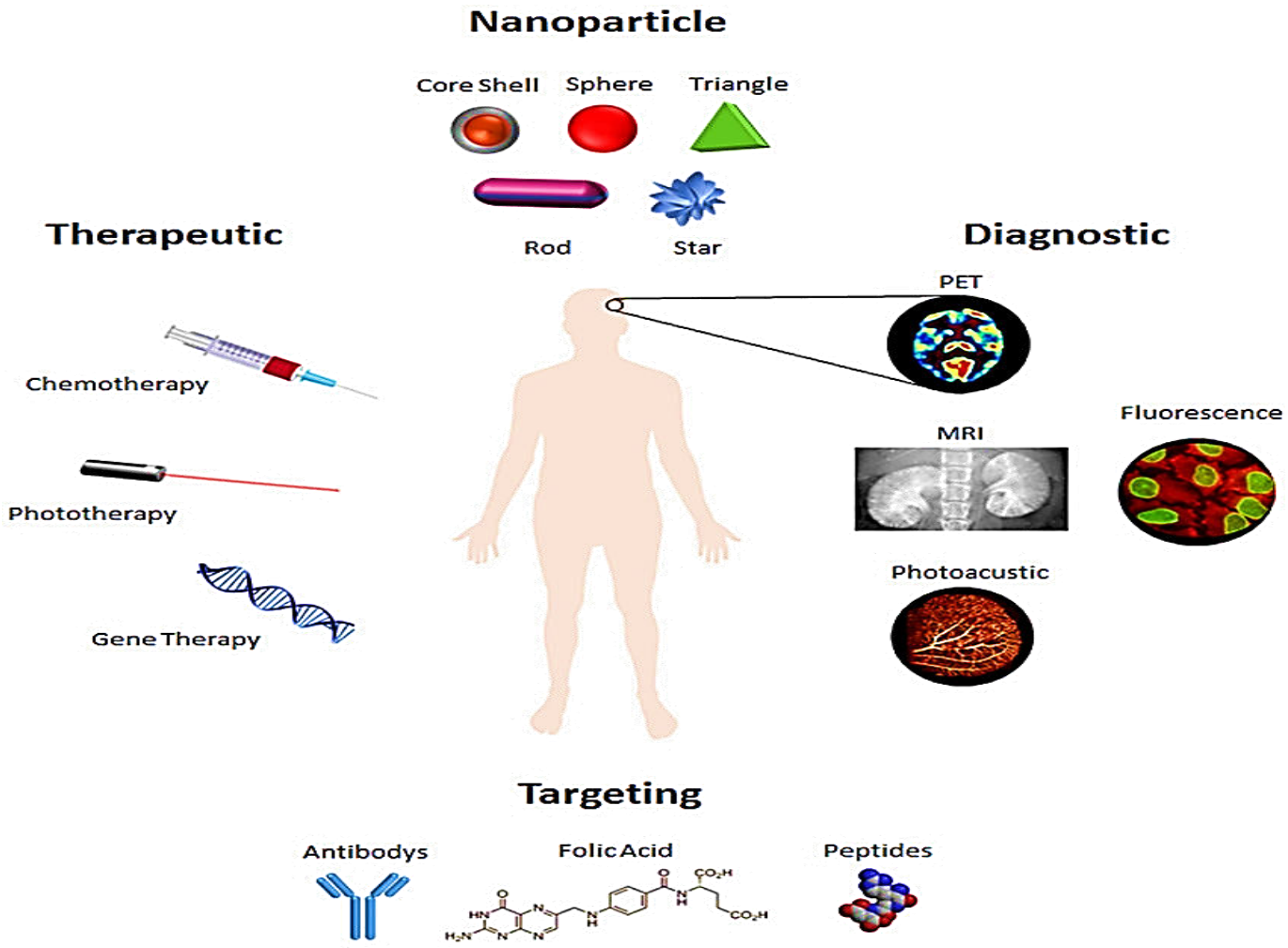

Fig. 3: Different types of nanoparticles and their applications in theranostic. Schematic overview of the possible functionalization and application of gold nanoparticles (AuNPs) as Nano carrier for theranostics

6. PERSONALIZED NANO MEDICINE

Personalized Nano medicine can be discussed as a healthcare plan that aims at developing particular treatments for each patients, taking into consideration genetic, phenotypic, and environmental factors that can make the outcome more efficient and safer for the therapy [30]. The use of Nano medicines in this area has also accomplished an exponential increase since it shows a chance to treat one or group with common pattern (cohort) by considering requirements defined in their genome [31]. In this article, the use of Nano medicines as therapeutic agents is shown for developing personalized therapies, and their use as novel treatments by pharmaceutical companies. Personalized Nano medicine is development of novel nanomaterials with growing binding affinity, controlled navigation, release of drug, improved biocompatibility and increased therapeutic efficiency which are important for potential

theranostic approaches [32]. The evidence shows that personalized Nano medicine can be a tool that can be used to make new drugs and advance delivery systems. Many studies were reported to be successful *in vitro*, but not successful in preclinical and human models. More or less personalized Nano medicine is the most effective tool for everyone today, but more research is needed to move forward. This new category of immune Nano medicine regulates important signaling pathways within the characteristics immune cell population through their material composition, geometry or surface modification in order to achieve strong growth effects.

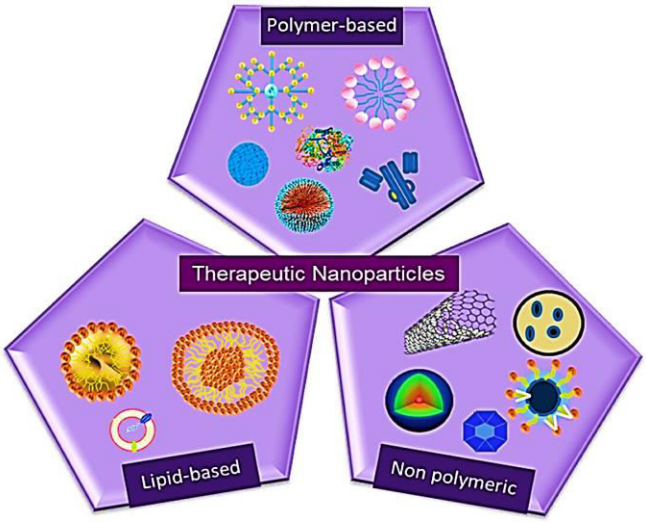

Fig. 4: Diagrammatic representation therapeutic nanoparticles

7. CONCLUSION

During the last few decade, advancement of nanoparticle-dependent therapeutic agents has been substantially developed, and Nano-delivery systems are the area of major importance for precisely targeting the preferred area in the treatment of many disease. Recently, the maximum of nanoparticles which are used for targeting delivery approach are developed of polymers or lipids as shown in figure (4). Even this polymeric nanoparticles show distinct relief in disease therapy, but they have some problems regarding scaling up, usage of organic solvents in their reaction process, biocompatibility, immunogenicity. On the other hand due to their similarity to the cell membrane lipid depended nanoparticle show the potential to cross hard-to-reach places without any surface functionalization. So Lipid-based Nano-delivery system can be contemplated as the future of therapeutics. As of now, therapeutic nanoparticles are mostly advanced for the treatment of only one disease. But, scientists have started to combine various drug molecules as well as various nanoparticles, thereby, in next few years therapeutic nanoparticles will move towards multi-therapeutics for the treatment and prevention of more than one disease. If we then know the properties of nanoparticles and their interaction with their biological environment which are linked to their target receptors or mechanism of action in diseases pathology we can overcome the boundaries and can develop new strategies for the treatment , prevention and diagnosis of many diseases mainly which cannot be treated. Nano medicine in few years will be future of medicine, and nanoparticle-based therapeutics will be more advanced. Most importantly, long-term safety/ morbidity of the nanoparticles should be scrutinized. In mean while the invention on disease mechanism and new drugs will exhibit ways of showing more potential and safer nanoparticle-based therapeutics in treatment process.

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