INTERNATIONAL JOURNAL IN PHARMACEUTICAL SCIENCES

Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

Review On Nanomedicines

Babasaheb R. Jadhav*, Khandre R. A.

Pratibhatai Pawar college of Pharmacy Wadala mahadev shrirampur

ARTICLE INFO

Received: 20 Dec 2023
Accepted: 24 Dec 2023
Published: 30 Dec 2023

Keywords:
Nanomedicine,
Nanotechnology,
Nanoparticles,
Nanostructures.

DOI:
10.5281/zenodo.10444876

ABSTRACT

Nanotechnology is being utilized in developing nations to aid in the treatment and prevention of diseases, thereby addressing healthcare concerns. Commonly referred to as nanomedicine, this field of medicine incorporates the principles and techniques of nanotechnology to combat various disease conditions. Ongoing efforts are being made to investigate novel treatments in order to tackle these difficulties. Hence, the focus lies on developing therapies that are scalable, efficient, and secure, while also being easily accessible to developing nations. Nanotechnology not only serves as a remarkable instrument for creating material structures that imitate biological ones, but it also offers the potential of delivering efficient systems. Since their initial introduction in the market, nanomedicines have undergone significant advancements and now exist in a multitude of forms such as dendrimers, nanocrystals, emulsions, liposomes, solid lipid nanoparticles, micelles, and polymeric nanoparticles. Therefore, nanomedicine has the potential to attain equivalent therapeutic outcomes with reduced dosages compared to traditional treatments, presenting remarkable solutions for a range of life-threatening illnesses. This review offers a current comprehension of nanomedicines in terms of their delivery and pharmacokinetics. It elucidates the procedure and benefits of the nanomedicines that have been approved by the FDA and EMA.

INTRODUCTION

Nanotechnology refers to the deliberate creation, analysis, manufacturing, and utilization of materials, structures, devices, and systems by manipulating their size and shape within the range of 1 to 100 nanometers. This field holds great promise in the medical realm due to the similarity in scale between nanomaterials and biological molecules and systems, as well as the ability to engineer nanomaterials with diverse functionalities. Nanomedicine, a branch of nanotechnology, strives to leverage the unique properties and physical attributes of nanomaterials to diagnose and treat diseases at the molecular level. (1)Since ancient times, scientists have harbored a longstanding desire to manipulate

***Corresponding Author:** Babasaheb R. Jadhav
Address: *Pratibhatai Pawar college of Pharmacy Wadala mahadev shrirampur*
Email : aartibhaware5@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

matter at the atomic and molecular level. This aspiration gained significant momentum in 1959 when Richard Feynman delivered a renowned speech at the annual meeting of the American Physical Society. In his talk, Feynman outlined a visionary concept of manipulating and controlling objects on a minuscule scale. Subsequently, nanoscience flourished with key milestones such as the discovery of molecular beam epitaxy in 1968 at Bell Laboratories, the generation of nanoparticles, and the invention of the Scanning Tunnel Microscope (STM). These advancements propelled nanoscience into a robust and widely accepted field within the scientific community. (2)Nanotechnology, a technique that emerged in 1959, traces its roots to a lecture delivered by Richard Feynman, an esteemed American physicist and Nobel laureate in physics, at the American Physical Society congress. The lecture, titled "There's Plenty of Room at the Bottom," marked the early stages of this nascent field. (3)The scope and diversity of potential applications of nanotechnology are so extensive that discussing them in detail would be impractical. However, it is undeniable that one of the most significant contributions of nanotechnology will be in the field of medical advancements, particularly in the development of innovative and efficient treatments known as nanomedicine. (4)Nanomedicine presents a promising opportunity to revolutionize the treatment of human diseases and enhance human biological systems. The utilization of Diamonded-based medical nanorobotics holds the potential for significant advancements in capabilities, surpassing the achievements attainable through tissue engineering and biotechnology. (5)Over the past ten years, there has been extensive research on the use of nanotechnology in therapeutics. Delivery systems based on nanotechnology have demonstrated promising outcomes by specifically targeting diseased tissue, thereby enhancing the effectiveness of treatments and minimizing potential side effects. (7)Nanotechnology encompasses the process of reducing the size of large structures to the smallest structures, employing both top-down and bottom-up approaches. For instance, in nano electronics and nano engineering, photonics applications can be utilized to manipulate individual atoms and molecules, transforming them into nanostructures. This process closely resembles the principles of chemistry and biology. (28)Henceforth, the pivotal role in future therapy will be assumed by targeted delivery systems and regenerative medicine aided by nanotechnology. This chapter delves into the diverse nanostructures and their utilization in the diagnosis and treatment of diseases. (6) Moreover, the vast array of illnesses and the abundance of resources result in an astronomical number of potential uses. Providing a comprehensive account of each application would require an entire book. Additionally, due to the countless combinations of tools, it is possible that we may have overlooked significant aspects, and for that, we extend our apologies. (7)

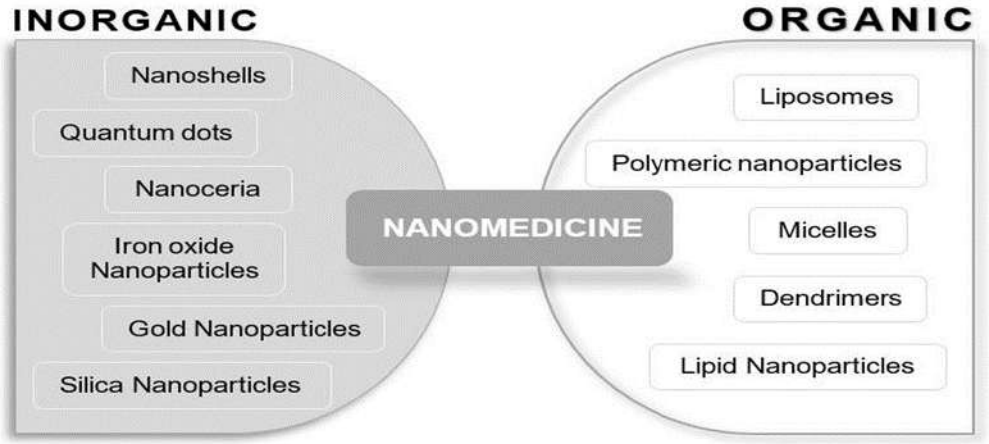
- **European Science Foundation (ESF)—European Medical Research Council (EMRC):**

Nanomedicine is a discipline that encompasses the scientific and technological aspects of disease diagnosis, treatment, and prevention, as well as pain relief and the enhancement of human health. It relies on the utilization of molecular tools and an in-depth understanding of the human body at a molecular level.(8)The Food and Drug Administration (FDA) has refrained from creating its own interpretation of terms such as "nanotechnology," "nanomaterial," "nanoscale," and others. Instead, the FDA has embraced the definitions commonly used in the field of material engineering, which pertain to substances with dimensions ranging from approximately 1 nanometer (nm) to 100 nm.(9)Nevertheless,

nanomedicine is primarily considered an academic concept rather than an industrial one. The medical industry prioritizes finding effective solutions for patients, irrespective of the underlying technology. As a result, nanomedicine is occasionally categorized as part of the "advanced medical technologies" field by the industry.(10)At present, nanomedicine encompasses the identification of particles, the development of drug delivery systems, emulsions, and carriers for administering vaccines, as well as the creation of nanofabricated biomaterials that possess unique attributes such as strength, hardness, decreased friction, and enhanced biocompatibility (11).

- **Classification of Nanomedicine:**

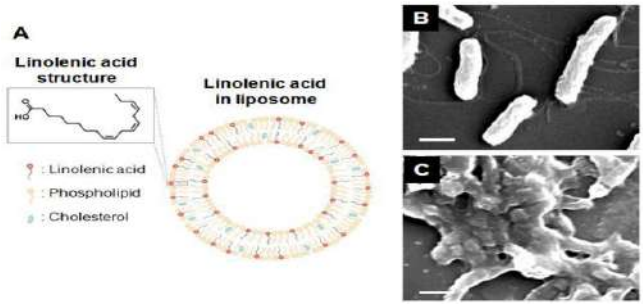
Nanomedicines can be categorized into two primary classes: inorganic nanoparticles, such as gold, silica, and iron oxide, and organic nanoparticles, such as polymeric, liposomes, and micelles. These nanoparticles find extensive applications in therapeutic and diagnostic fields. Inorganic nanoparticles have been utilized for various purposes, including lymph node imaging, hyperthermia, and anemia treatment.



- **Organic nanomedicine:**

1. Liposome-based nanomedicines:

Liposome-based nanomedicine refers to a drug formulation technique in which a drug is enclosed within the phospholipid bilayer structure. This approach aims to improve the drug's bioavailability and therapeutic effectiveness. Liposome formulations have a long-standing history in the field of nanomedicine and are widely recognized for their efficacy. Numerous research endeavors have been dedicated to utilizing liposomes as carriers for various cargos, including small molecules like doxorubicin, nucleic acids such as RNAs, and biological molecules like vaccines for hepatitis a virus. (12) The core-shell design of liposomes in drug delivery systems is their main advantage. For instance, a typical liposome made of phospholipids has a smart design that enables a more effective strategy for encapsulating drugs and achieving sustained release. The hydrophilic or aqueous core of the phospholipid-based liposome allows for the encapsulation of hydrophilic drugs, while the lipid membrane can encapsulate hydrophobic drugs. (13)



diameters of 100 nm or smaller can easily merge with bacterial or fungal membranes, leading to cellular damage. As a result, these sub-100 nm conventional liposomes are particularly valuable for antimicrobial treatment. An example of this is liposomal amphotericin B, which includes brands such as Amisom®, Abelcet®, and Aphotic®. These liposomes incorporate drug molecules within their lipid bilayer membranes. Studies have demonstrated that these liposomes have a preference for fusing with fungi, thereby enhancing the permeation of amphotericin B into cellular membranes and increasing its anti-fungal activity. A similar approach has recently been employed for delivering free fatty acids (FFAs), a class of naturally derived molecules known for their selective antimicrobial properties. The amphiphilic nature of FFAs makes them well-suited for encapsulation within liposomes. By loading FFAs into the lipid bilayers, their poor water solubility can be overcome, they can be protected from degradation, and they can be transported into bacterial membranes for bioactivity. Various FFAs, including lauric acid, oleic acid, and linolenic acid, have been successfully loaded into liposomes, resulting in formulations that exhibit potent antibacterial effects against Propionibacterium acnes, methicillin-resistant Staphylococcus aureus (MRSA), and Helicobacter pylori (H. pylori). (14) Liposomes exhibit a wide range of sizes, spanning from approximately 10 nm to 2500 nm (or 2.5 µm). Nevertheless, liposomes commonly employed for drug delivery purposes typically fall within the size range of 50 to 450 nm. It is worth noting that liposomes with significantly larger dimensions can also find utility in medical applications. Additionally, liposomes primarily consist of phospholipids [15].Liposomes have been recognized for their ability to enhance drug solubility and improve pharmacokinetic properties. These properties include increasing the therapeutic index of chemotherapeutic agents, accelerating metabolism, reducing harmful side effects, and enhancing both in vitro and in vivo anticancer activities. (6)

2. Lipid-based nanomedicine:

Lipid nanosystems, such as nanoemulsions and solid lipid-based nanoparticles, represent an alternative type of nanomedicine. These systems are commonly employed to encapsulate hydrophobic cargos, aiming to enhance

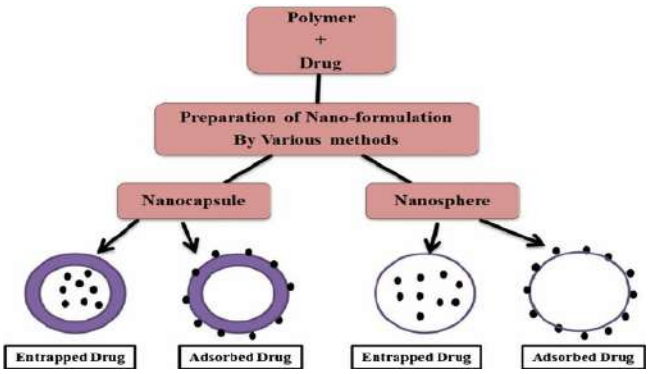
permeation and control release profile. To achieve a uniform dispersion, a surfactant is typically utilized. Additionally, lipid nanomedicine can also serve as a carrier for gene therapeutics like siRNA or contrast agents used in imaging, such as F-butane. In general, lipid nanomedicine not only improves the pharmacological effect but also exhibits biocompatibility, thereby facilitating drug accumulation in targeted tissues. (12)

- **Gastrointestinal Absorption of Nanoparticles:**

Lipid digestion occurs within the gastrointestinal tract (GIT). It involves a intricate fusion of biochemical and physiochemical procedures. Absorption can occur through transport by enterocytes or through the intestinal lymphatic system. The lymphatic system consists of a vast network throughout the body, enabling the bypassing of initial metabolism and the specific targeting of diseases that spread through the lymphatics, such as lymphomas and HIV. (14) Certain drugs that are taken orally have low bioavailability because they undergo presystemic, or first-pass, metabolism. (16)

3. Polymeric Based Nano-medicine:

Polymeric nanoparticles are extensively utilized in drug delivery as nanosystems. Various polymers such as ethyl cellulose, poly(lactic-co-glycolic acid), polylactic acid, cyclodextrin, alginate, and chitosan have been employed for this purpose. Depending on the polymer's characteristics, whether it is hydrophilic or hydrophobic, different techniques have been employed to fabricate polymeric nanoparticles. (12) Nanomedicine, a branch of nanotechnology, pertains to precise medical interventions at the molecular level to treat diseases or restore injured tissues. Polymer-based nanomedicine, which encompasses the utilization of polymer-DNA complexes (polyplexes), polymer-drug conjugates, and polymer micelles carrying hydrophobic drugs, has gained significant recognition in recent times due to its potential in enhancing the effectiveness of cancer treatments(17).Polymeric nano-carriers play a crucial role in the production of drugs and can be classified into two categories: liposomes and lipid-based polymers, as well as carbohydrate and lipid-based polymers. (13) Polymer nanoparticles are resilient, colloidal formations that exist as nanospheres and nanocapsules. They can originate from both synthetic and natural polymers. Polymers, derived from the Greek word "polymers" meaning multi-part or made of many parts, are chemical compounds that consist of numerous repeating structural elements known as mers. Examples of synthetic polymers include polycaprolactone, polyacrylamide, and polymethyl methacrylate. Conversely, natural polymers primarily encompass gelatin, heparin, chitosan, and albumin. (3) Various polymers can be utilized in the production of nanoparticles. Synthetic polymers such as polylactide-polyglycolide copolymers, polyacrylates, and polycaprolactones are available options. On the other hand, natural polymers like albumin, gelatin, alginate, collagen, and chitosan are also commonly used. It is worth noting that polylactides and poly(DL-lactide-co-glycoside) polymers have the ability to undergo hydrolysis when implanted, resulting in the formation of biologically compatible fragments. These polymers are primarily investigated for their potential in drug delivery applications. (19)



4. Polymeric micelles:

Polymer micelles represent a category of nano-colloids that can be created through the self-assembly of amphiphilic block copolymers in a water-based solution. (52) Within these micelles, hydrophobic drugs are enclosed within the hydrophobic core, while the hydrophilic shell contributes to the stability of the particles, rendering them suitable for intravenous administration. (18)

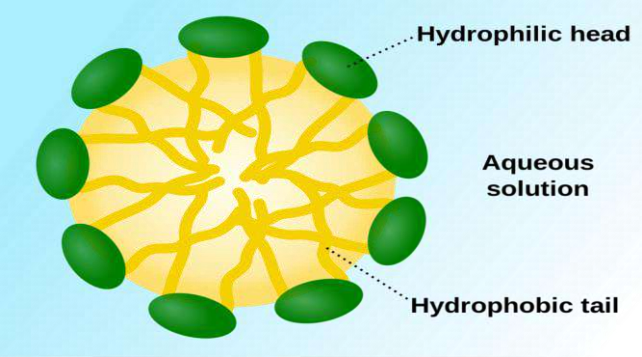


Fig 1. Polymeric Micelles

Micelles are spherical lipid nanoparticles composed of two distinct parts, namely hydrophobic and hydrophilic regions, resembling a folded sheet. Depending on the surrounding environment, micelles can either form or reverse micelles. In an aqueous medium, micelles retain their hydrophobic chains on the inside while exposing the polar heads on the outside. Conversely, in an organic medium, the composition of the micelle is reversed, resulting in the formation of reverse micelles. In this case, the polar heads are located in the interior, surrounded by molecules and surface molecules. (13) Micelles are nanostructures formed by amphiphilic molecules, consisting of a hydrophilic part and a hydrophobic part. These self-assembled nanosystems offer numerous advantages, such as enhanced drug solubility and permeability, leading to improved drug bioavailability. However, they do have certain limitations, including inadequate control over drug release and potential cytotoxicity due to the use of amphiphilic molecules that interact with cell membranes. Despite the utilization of block copolymeric micelles in various studies to enhance the bioavailability and reduce clearance of chemotherapeutic agents and other drugs, there are currently no approved micelle-based nanomedicines available. (12) Micelles possess the ability to be easily modified by incorporating small functional groups, thereby improving their targeting efficiency. The accumulation of these modified micelles in pathological tissue is primarily due to their small size. Additionally, external factors like pH, temperature, ultrasound, etc., can also influence the behavior of micelles. (6)

5. Dentrimers:

In 1978, Vogtle made a groundbreaking discovery of nanoscopic polymers that are three-dimensional, well-organized, and highly branched. These polymers, which are smaller than 10 nm in size, serve as innovative and efficient nanotechnology platforms for drug delivery. The construction of these polymers involves two distinct approaches: the divergent method and the convergent approach. A typical dendrimer structure comprises three main components: a core molecule and multiple layers or generations of branched structures. (13) Dendrimers, derived from the Greek word "dendrons" meaning tree, are polymers that have a size of approximately 20 nm. They possess a unique, branched, three-dimensional structure that resembles a sphere. Within this structure, there is a multifunctional core from which the dendrimer branches extend. These branches, known as dendrons, have free functional groups at their ends. These functional groups can be modified with various substituents, thereby altering the properties of the dendrimers. There are generally two types of dendrimers: half and complete. Half dendrimers terminate with a carboxyl group (-COOH), while complete dendrimers possess amino (-NH2) and hydroxyl (-OH) groups, among others.

The chemical structure of the dendrimer plays a crucial role in determining its shape and level of activity. The presence of cavities within the dendrimer structure allows it to act as a reservoir for different molecules, making it possible to deliver drugs directly to specific affected areas. Extensive research and publications have shown that dendrimers are primarily utilized as drug carriers for substances like cisplatin and doxorubicin. (3) Poly(amidoamine)dendrimer containing flurbiprofen is a solution that can be injected intravenously. This formulation has the ability to distribute more effectively to the site of inflammation and also has an extended retention time in the body. On the other hand, there are two other intravenous formulations available. One is a PEGylated polyline dendrimer combined with methotrexate, which provides prolonged systemic exposure. The other formulation is a lactoferrin-conjugated dendrimer combined with methotrexate, which leads to increased accumulation in the lungs. Lastly, there is a poly(amidoamine) dendrimer combined with piroxicam, which offers increased systemic exposure. (20)The surface properties of dendrimers, which can be easily molded, allow for their simultaneous attachment to different types of molecules, including therapeutic drugs, targeting ligands, and imaging contrast agents. This results in the creation of a multifunctional drug delivery system based on dendrimers. (6)

6. Quantum Dots:

Nanostructured materials are of great interest due to their ability to bridge the gap between bulk and molecular levels, opening up new possibilities for applications in electronics, optoelectronics, and biology. When a solid exhibits distinct variation in optical and electronic properties with a particle size below 100 nm, it is referred to as a nanostructure. Nanostructures can be categorized as two-dimensional (such as thin films or quantum wells), one-dimensional (such as quantum wires), or zero-dimensional (dots). Over the past two decades, significant attention has been given to studying the optoelectronic properties of nanostructured semiconductors or quantum dots (Qdots), as many of their fundamental properties are size-dependent within the nanometer range.(21)The utilization of quantum dots can enhance the identification of various cancer biomarkers in blood tests or when examining cancer tissue samples. Currently, one of the rapidly advancing areas in nanotechnology involves the application of highly durable, water-soluble, and modified quantum dots for biological and medical purposes. Quantum dots present novel opportunities for visualizing live cells, conducting in vivo imaging, and facilitating diagnostics due to their enduring fluorescent characteristics. (6)

- **Structure Of QDs:**
  - **Quantum Vs bulk properties:**

QDs, which stands for quantum dots, are arrangements of atoms or molecules that adhere to the principles of quantum mechanics. Typically, QDs consist of a semiconductor core and a separate shell material that acts as a surface passivation layer. The core and shell can vary in size and shape, allowing for customization to suit specific needs. For example, spherical QDs exhibit different optical and electrical properties compared to rod- or disk-shaped QDs. The core of a QD determines its electrical and optical characteristics, while the shell governs its stability and interactions. Ultimately, the structure of QDs plays a crucial role in determining the electrical and optical properties necessary for a particular application. (22)

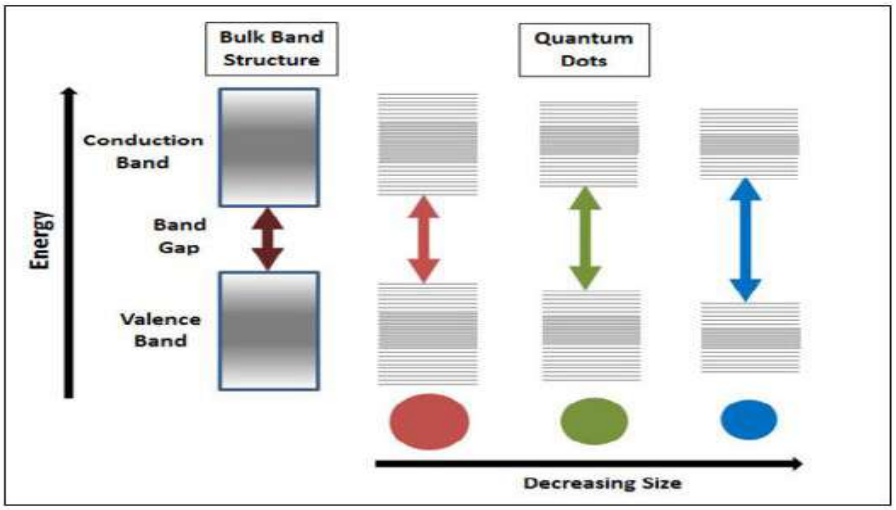


Fig 2. Structure of Quantum dots

The controlled size of quantum dots offers a significant advantage as it allows for precise control over the conductive properties of the material. Quantum dots (QDs) are especially important in optical applications due to their high extinction coefficient. The ability to adjust the size of quantum dots is beneficial for various applications. For example, larger quantum dots exhibit a greater spectrum-shift towards red compared to smaller dots and demonstrate less pronounced quantum properties. (23)

7. Gold Nanoparticles:

- **Background and Successes in Preclinical Studies**

Nanoparticles of noble metals, such as platinum, gold, and silver, possess a distinctive characteristic that sets them apart from other types of particles, whether organic or inorganic. This unique feature is known as surface plasmon resonance (SPR), which is a result of the confinement of photons at the nanoparticle scale. (17) AuNPs offer distinct advantages for drug delivery, diagnostics, and therapeutics (4,17,18). Their unique properties, such as light-scattering, enable various therapeutic opportunities, including imaging. (24) GNPs can be synthesized using a combination of physical, chemical, and biological methods. Initially, physical methods are employed, but they yield a low amount. Chemical methods, on the other hand, utilize different chemical agents to reduce metallic ions into nanoparticles. However, these methods have drawbacks, such as the use of toxic chemicals and the generation of hazardous by-products. The field of medicine saw a significant increase in the application of nanoparticles when the biological approach for nanoparticle synthesis gained attention. (23) Gold nanoparticles (AuNP`s) are the most commonly used metal-based nanoparticles as they are nontoxic and biocompatible and because of their negative charge they are easily functionalized by various biomolecules (Bhattacharya et al., 2007; Hainfeld et al., 2006). AuNP`s also have a diverse drug delivery application. (6)

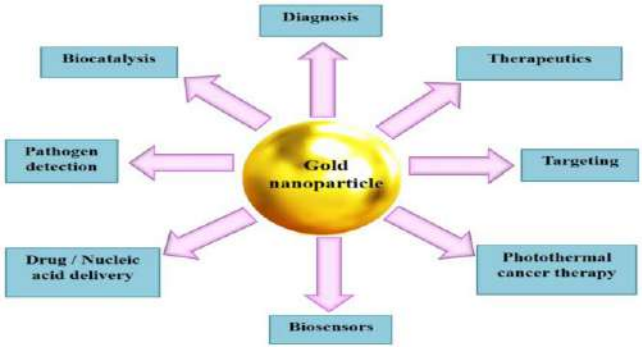


Fig 3. Gold Nanoparticles

8. Iron oxide nanoparticles (INPs):

The synthesis of magnetic nanoparticles in the nanometer range is a challenging task, and several

chemical pathways have been suggested for their development. These approaches encompass micro emulsions, sol-gel synthesis, sonochemical reactions, hydrothermal reactions, thermolysis of precursors, flow injection syntheses, and electrospray synthesis. Nevertheless, the chemical co-precipitation technique of iron salts remains the most widely used method for producing magnetite nanoparticles. (23)

- **Clinical Trials and Approved Products:**

IONPs, among all inorganic nanoparticles, have undergone extensive testing and some formulations have received FDA approval for the purpose of imaging various pathologies and treating iron deficiency (Table II). However, despite these initial successes, the majority of approved IONPs have been discontinued in clinical settings more frequently than any other type. In fact, numerous IONPs have been authorized for clinical use specifically as diagnostic and imaging agents (Table II). For instance, a significant number of IONPs have been approved for this purpose. (24)

- **Iron-replacement nanoparticle therapies:**

Nanomedicine has found another surprising application in the field of iron-replacement therapy for treating anemia. The use of nanoscale iron-oxide colloid systems has proven to be significant in enhancing iron absorption in the body. One of the main advantages of using iron-oxide nanomedicine is that it eliminates the need for injecting free iron, which can be toxic. To reduce the toxicity of iron, most of these nanosystems are coated with either polysaccharide or polymer. In 1996, Cosmo Fer® became the first iron dextran colloid to be approved by the FDA. More recently, in 2013, Injectate® received FDA approval as an iron carboxylates colloid. (12)

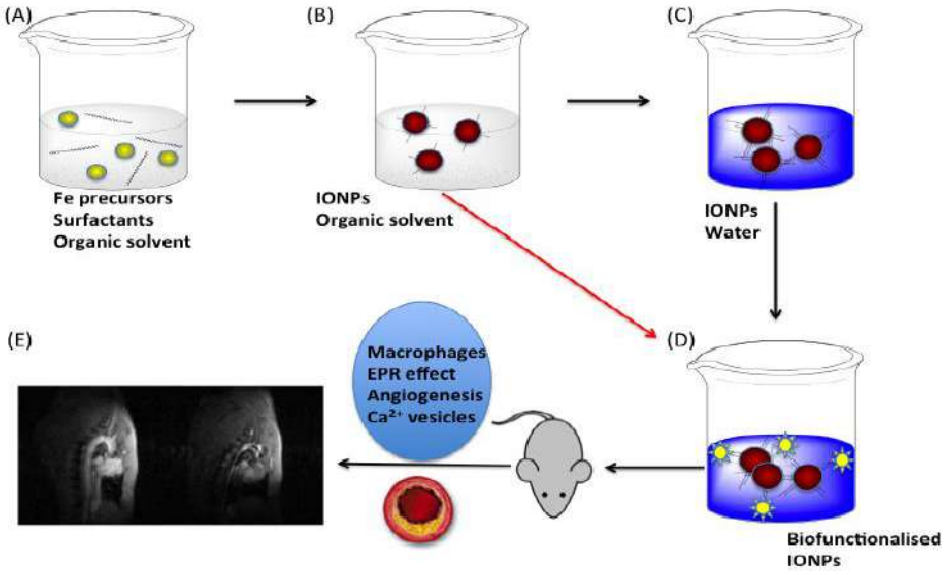


Fig 4. Synthesis of IONPs

9. Silica Nanoparticles:

Silica nanoparticles (NPs) hold great promise as potential candidates for enhancing drug delivery systems. By loading drug molecules into silica NPs and modifying their surfaces with bio recognition entities, it becomes possible to specifically target certain cells or receptors within the body [50]. Once the target is recognized, the NPs can release the drug payload at a controlled rate, achieved by tailoring the internal structure of the particles to achieve the desired diffusion and release profile. Furthermore, it is feasible to create multifunctional silica NPs that possess innovative optical, chemical, and magnetic properties, all integrated into a single nanostructure. (23)

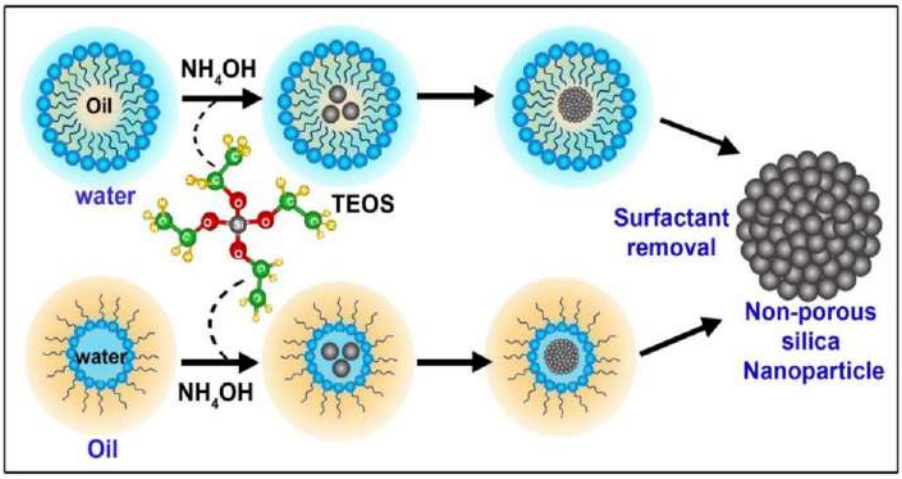


Fig 5. Synthesis of Silica Nanoparticles

- **Current clinical trials:**

Nanoparticle drug delivery systems primarily composed of SNPs have not yet had a significant impact in the medical field. However, there is currently one SNP being investigated in clinical trials that shows promise for imaging and diagnosing tumors. This imaging technique offers several advantages over traditional CAT and MRI scans. The original formulation of C-Dots, which was developed approximately 10 years ago, involved synthesizing 30 nm diameter fluorescent core-shell SNPs using a modified Stöber method. These C-Dots were found to be 20 times brighter than the constituent fluorophore. (24)

- **Mechanism of Action Nanomedicine:**

- **Mechanism of targeting by nano drug vehicle:**

The efficiency of targeting cancer tissue in a specific manner and minimizing side effects on normal tissue is a crucial factor in selecting a nanomedicine formulation for cancer therapy. Different nano-formulations employ diverse targeting mechanisms to deliver anticancer drugs to tumor sites. The drug delivery mechanism and advantages of nanocarriers differ depending on the

carrier. Nanocarriers directly transport therapeutic agents to the bloodstream and reach the intended area. (25)

- **Cancer Nanomedicine on the Market:**
  - **Liposomal Anthracyclines:**

Various types of cancers can be effectively treated using liposomal encapsulation of anthracyclines, as there are numerous nanoparticle technologies available for this purpose. These technologies utilize the potent cytotoxic properties of anthracyclines to combat cancer cells.

- **Doxil:**

Doxil vesicles depend on a passive targeting mechanism to gather at tumor sites. Although this targeting mechanism is not exclusive to the Doxil formulation (as indicated by the other technologies mentioned below), the main reason for accumulation and distribution across tumor sites is thought to be the result of a combination of factors. These factors include the extended circulation time (with a half-life of 2-3 days for clearance), the presence of microvasculature in tumors, and the enhanced permeability and retention (EPR) effect.

- **Myocet:**

Myocet, a liposomal doxorubicin nanomedicine, differs from Doxil in that it does not have PEG functionalization on the particle surface. The formulation offers several advantages primarily related to toxicity. Due to the absence of PEGylation, the circulation time of Myocet is considerably shorter than that of Doxil (approximately 2.5 hours), and the liposomes are not "invisible" to the RES. As a result, Myocet does not cause PPE, which is the dose-limiting toxicity of Doxil, and it also exhibits a significantly lower incidence of mucositis compared to Doxil.

- **Rexin-G:**

The liposome platform for cancer collagen matrix targeting nano-medicine is equipped with a collagen-binding motif that exhibits a strong affinity for collagen. This motif is derived from coagulation von Willebrand factor (vWF) and has been genetically engineered into the surface proteins of the liposomes. The main product of this platform, known as Rexin-G, is a proprietary product developed by Epeius. It is a retro vector that specifically targets the tumor matrix (collagen) and is replication-incompetent. Rexin-G encodes a mutant form of the cyclin G1 gene with potential antineoplastic activity. (26)

- **Fungal and bacterial infection:**
  - **Amphotericin B:**

Amphotericin B is employed in the management of invasive fungal infections (Delattin et al. 2014). It functions by attaching to sterols within the cell membrane of vulnerable fungi, leading to a subsequent alteration in membrane permeability.

- **Amikacin:**

Pulmonary non-tuberculous mycobacterial disease is a persistent infection characterized by necrotizing inflammation, bronchiectasis, and cavitation, resulting in irreversible lung damage and higher mortality rates. In order to enhance effectiveness and minimize toxicity, a liposomal amikacin for inhalation (LAI) called Arikace® (approximately 300 nm in size) has been created using DPPC and cholesterol. Out of the five patients, none experienced any adverse effects associated with the treatment, while three patients demonstrated improvement in their pulmonary function test results and clinical symptoms. (27)

- **Advantages of Nanomedicine:**

1. Precise drug delivery to the designated site.
2. In order to minimize the occurrence of fewer adverse effects.
3. Determine the most suitable pharmaceutical agents for treating the current condition or specific pathogens.
4. Dispense the ideal mass dosage of matched biological compound to the specific target location.
5. Locate, embed, or attach integrated or enter target tissue; configurations or pathogens.(28)

- **Disadvantages of Nanomedicine:**

The progress of nanotechnology could potentially lead to a decline in the value of oil and gemstones due to the possibility of developing alternative and more cost-effective sources of electricity that do not rely on the burning of fossil fuels. This could also mean that diamonds may lose their value as they can now be manufactured overseas, thanks to the ability to create goods at the cellular level. Additionally, nanotechnology has the potential to make atomic weapons more easily accessible, destructive, and devastating. One participant pointed out that inhaling these tiny particles could pose health issues, similar to the risks associated with breathing in microscopic asbestos nanoparticles. Nanotechnology is currently quite expensive and its production can be costly and challenging, partly because nanotechnology-based products tend to be more expensive. (29)

- **Application of nanomedicine:**

Contrast agents for cancer cell imaging.

The cadmium selenide nanoparticles, also known as quantum dots, exhibit luminescence upon exposure to ultraviolet lights. Once administered, they permeate cancerous tumors, resulting in a conspicuous glow. This luminous tumor serves as a valuable reference point for surgeons, aiding them in performing precise tumor extraction techniques.

- **Therapeutics for treating the cancer diseases.**

The Gold nano shells have the ability to selectively attach to cancerous cells. By utilizing infrared lasers to irradiate the tumor area, the surrounding flesh remains unheated while the gold is effectively heated, leading to the destruction of cancer cells.

- **The Nano electronic biosensors Diagnostic devices.**

The utilization of arthroscopes equipped with lights and cameras in surgeries has been significantly enhanced by nanotechnology, enabling surgeons to perform procedures with smaller incisions.

- The physical therapy applications.

In photodynamic therapy, a minute particle is inserted into the body and illuminated externally. This external light is absorbed by the particle, and in the case of a metallic particle, it generates heat that affects both the particle and the surrounding tissues. (28)

FUTURE PROSPECTS OF NANOMEDICINE:

Considerable advancements have been achieved in the real of nano-medicine-based formulations over the last few decades, resulting in numerous approvals from regulatory bodies like the FDA and EMA. It is worth noting that nanomedicines offer diverse possibilities for addressing intricate and challenging diseases, including cancer, lung diseases, and ophthalmic conditions. The prevalent commercially accessible nanomedicine-based formulations primarily encompass lipid-based nanomedicines, polymer-based nanomedicines, nanocrystals, inorganic nanoparticles, and protein-based nanomedicines. (30) Nanomedicine, a captivating field of study, has witnessed significant advancements in the past two decades. This progress is evident through the filing of 1500 patents and the completion of numerous clinical trials. Cancer, as highlighted earlier, serves as a prime example of a disease that has greatly benefited from nonmedical technologies in terms of both diagnosis and treatment. By utilizing diverse types of nanoparticles, it becomes possible to deliver precise amounts of medication to affected cells, specifically cancer or tumor cells, while preserving the normal cells' physiological balance. Undoubtedly, the application of nanomedicine and nano-drug delivery systems will continue to dominate the realm of research and development for many years to come. It is worth noting that the nanoparticles showcased in this communication

exhibit varying sizes, with some measuring in nanometers and others in sub-micrometers (over 100 nm). Further research should focus on materials that offer more consistent uniformity, as well as enhanced drug loading and release capacities. (31) The primary objective of nanomedicine is to develop a nanocarrier capable of effectively and selectively transporting therapeutic agents to specific locations within the body. Additionally, for efficient and targeted delivery, the nano-carrier must possess the capacity for easy modification. In this area of research, there has been a growing interest in substituting synthetic materials like porous hollow silica nanoparticles, single-wall nanotubes, and fullerenes with natural materials that are better tolerated by various organisms.(32)Nanomaterials are commonly utilized in fundamental research to investigate the molecular mechanisms underlying diseases or to demonstrate their potential medical applications. For instance, fluorescence microscopy has revealed the binding and transportation of Qdots coated with epidermal growth factor to ErbB/Her receptors that are overexpressed in breast and ovarian cancer. This has enabled researchers to identify the specific receptor subtype responsible for this molecular interaction. Nanomaterials are currently being explored for various purposes, such as screening cells and tissues, as well as targeting tumors in vivo using nanoparticles coated with antibodies, peptides, or complex structures known as aptamers formed by oligonucleotides. (1) In the realm of medicine, nanomedicine encompasses the forthcoming advancements that will rely on the construction of nanorobots. These nanorobots possess the potential to be programmed for the purpose of mending particular afflicted cells, akin to the role antibodies play in our innate healing mechanisms. The field of nanotechnology is poised for significant growth in the near future. Scientists are currently working on tailoring nanoparticles, which are as tiny as molecules, to transport medications directly to the cells affected by diseases within your body. (4)

CONCLUSION:

Nanomedicine, a novel field of nanotechnology, has significantly revolutionized human existence. Extensive research and studies have enabled the utilization of nanomedicine in diverse medical applications, including drug delivery systems, cancer therapeutics, tissue engineering, and more. Nanomedicine has demonstrated immense promise in tackling critical illnesses. It has the ability to enhance the effectiveness of clinical outcomes for patients and make healthcare more affordable for society. By enabling early diagnosis and improved therapy, nanomedicine has the potential to revolutionize the care process.

REFERENCES

1. Betty Y. S. Kim, M.D, et al. Nanomedicine. The new england Journal of medicine N Engl J med 2010; 363 :2434-2443 DOI: 10.1056/NEJMra 0912273 December 16, (2010) page no.2434-2443
2. Kristina Riechelmann, Stefan W. schneider, et al. Nanomedicine-Challenge and Perspectives Angew chem Int Ed Eng. Author manuscript available in PMC 2014 Sep 26. published in final edited form as Angew chem Int Ed. Eng 2009;48(5):872-897 doi:10.1002/anie.
3. Klaudia Dynarowicz, David Aebisher Nanomedicine – a review European Journal of Clinical and Experimental Medicine Eur J Clin Exp Med. ISSN 2544-1361 doi: 10.15584/ejcem.2022.1.14 Received: 30.12.2021 / Revised: 10.02.2022 / Accepted: 13.02.2022 / Published: 30.03.2022
4. DebjitvBhowmik1, Chiranjib, R. Margret, et al. Nanomedicine-An Overview International Journal of PharmTech Research CODEN(USA): IJPRIF ISSN: 0974-4304 Vol.2, No.4, pp 2143-2151 Oct-Dec 2010

5. Moni Saha Nanomedicine: Promising Tiny Machine for the Healthcare in Future Saha.M.OMJ.24,242-247(2009); doi:10.5001/omj.2009.50
6. Roy Gaurab Yadav Amit Nanomedicine: Therapeutic Applications and Limitations DOI:10.4018/978-1-4666-6363-3.ch005
7. Kenza Snoussi and Michael Kann Nanomedicine General Considerations and Examples page no.129-133
8. European Science Foundation (ESF). 2004. Nanomedicine—An ESF–European Medical Research Councils (EMRC) Forward Look Report. Strasbourg cedex, France
9. Sara Soares 1, João Sousa1,2, Nanomedicine: Principles, Properties, and Regulatory Issues doi: 10.3389/fchem.2018.00360
10. Patrick BOISSEAU*1, Bertrand LOUBATON2 Nanomedicine, Nanotechnology in medicine HAL Id: hal-00598930 https://hal.science/hal-00598930
11. K. John Morrow, Jr, Ph Da, Raj Bawa, Recent Advances in Basic and Clinical Nanomedicine doi: 10.1016/j.mcna.2007.05.009
12. Islam Ahmed Hamed Khalil, Islam A. Arid Introductory Chapter: Overview on Nanomedicine Market DOI: 10.5772/intechopen.91890
13. Saad S. M. Hassan, [a] Ayman H. Kamel, Heba M. Hashem[a] DRUG DELIVERY SYSTEMS BETWEEN METAL, LIPOSOME, AND POLYMER-BASED NANOMEDICINE: A REVIEW DOI: http://dx.doi.org/10.17628/ecb.2020.9.91-102
14. Weiwei Gao, Che-Ming J. Hu, Ronnie H. Fang Liposome-like Nanostructures for Drug Delivery Mater Chem B Mater Biol Med 2013 December 28; 1(48): . doi:10.1039/C3TB21238F.
15. Foad Rommasi and Neda Esfandiari*Liposomal Nanomedicine: Applications for Drug Delivery in Cancer Therapyhttps://doi.org/10.1186/s11671-021-03553-8
16. Filipe Fernandes 1, Mónica Dias-Teixeira 1,2, Critical Review of Lipid-Based Nanoparticles as Carriers of Neuroprotective Drugs and Extracts https://doi.org/10.3390/nano11030563
17. Jae Hyung Park a 1, Seulki Lee b copolymeric nanomedicine for cancer therapyhttps://doi.org/10.1016/j.progpolymsci.2007.09.003
18. Hongyun Lu1, Shengliang Zhang1, Jinling Wang2* and Qihe Chen1*A Review on Polymer and Lipid-Based Nanocarriers and Its Application to Nano-Pharmaceutical and Food-Based Systems doi: 10.3389/fnut.2021.783831
19. Agha Zeeshan Mirza • Farhan Ahmed Siddiqui Nanomedicine and drug delivery: a mini review DOI 10.1007/s40089-014-0094-7
20. Young Hee Choi1. Hyo Kyung Han1 Nanomedicines: current status and future perspectives in aspect of drug delivery and pharmacokinetics Journal of Pharmaceutical Investigate on https://doi.org/10.1007/s40005-017-0370-4
21. Debasis Bera *, Lewisian, Quantum Dots and Their Multimodal Applications: A Review Materials 2010, 3, 2260-2345; doi:10.3390/ma3042260
22. Kushagra Agarwal, Himanshu Rai and Sandip Mondal Quantum dots: an overview of synthesis, properties, and applicationshttps://doi.org/10.1088/2053-1591/acda17
23. PARIJAT PANDEY, MANDEEP DAHIYA *A BRIEF REVIEW ON INORGANIC NANOPARTICLES Journal of Critical Reviews ISSN- 2394-5125 Vol 3, Issue 3, 2016

24. Aaron C. Anselmo1 and Samir Mitragotri1,2A Review of Clinical Translation of Inorganic Nanoparticles DOI: 10.1208/s12248-015-9780-2
25. M. Joyce Nirmala, a Uma Kizhuveetil, et al. Cancer nanomedicine: a review of nano-therapeutics and challenges ahead Received 9th December 2022 Accepted 7th March 2023 DOI: 10.1039/d2ra07863e
26. Ruibing Wang, Paul S. Billone, et al. Nanomedicine in Action: An Overview of Cancer Nanomedicine on the Market and in Clinical Trials Volume 2013, Article ID 629681, 12 pages Received 22 October 2012; Accepted 9 November 2012
27. Esteban Beltrán Gracia1, Adolfo López Camacho1, et al. Nanomedicine review: Beltrán Gracia Nanomedicine review: clinical developments in liposomal applications Beltrán Gracia. Cancer Nano (2019) 10:11https://doi.org/10.1186/s12645-019-0055-y
28. Mrs. K. Usha Rani Review Article Nanomedicine JNPE, JUNE 2017, Vol. 3, Issue 2, pp.37–40 ISSN No.2395-1974 on 16-January-2020 https://www.researchgate.net/publication/338621537
29. Wesam R Kadhum1, Muqdad Alhijjaj2, et al. Nanomedicine and Drug Delivery Systems: Roles, Advantages and Disadvantages International Journal of Current Pharmaceutical Review and Research 2022; 14(4); 1-6 ISSN: 0976-822XReceived: 14-11-2022 / Revised: 25-11-2022 / Accepted: 05-12-2022www.ijcpr.com
30. Raj Kumar Thapa1 · Jong Oh Kim2Nanomedicine based commercial formulations: current developments and future prospects Journal of Pharmaceutical Investigation (2023) 53:19–33 https://doi.org/10.1007/s40005-022-00607-6 Received: 21 November 2022 / Accepted: 10 December 2022 / Published online: 19 December 2022
31. Jayanta Kumar Patra1 , Giti Shree Das1,etal.Nano based drug delivery systems: recent developments and future prospects, published by Journal of Nanobiotechnology (2018) 16:71 https://doi.org/10.1186/s12951-018-0392-8
32. Zbynek Heger1, Sylvie Skalickova, et al. Apoferritin applications in nanomedicine 10.2217/NNM.14.119 © 2014 Future Medicine Ltd. (2014) 9(14), 2233–2245 ISSN 1743–5889-pageno.2233.

HOW TO CITE: Babasaheb R. Jadhav*, Khandre R. A., Review on Nanomedicines, Int. J. in Pharm. Sci., 2023, Vol 1, Issue 12, 949-963. https://doi.org/10.5281/zenodo.10444876