 International Standard Serial Number (ISSN): 2319-8141

International Journal of Universal Pharmacy and Bio Sciences 12(5): September-October 2023

INTERNATIONAL JOURNAL OF UNIVERSAL PHARMACY AND BIO SCIENCES

IMPACT FACTOR 4.018***

ICV 6.16***

Pharmaceutical Sciences **Review Article……!!!**

"A REVIEW ON RECENT ADVANCES IN NANOTECHNOLOGY"

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ABSTRACT

Nanotechnology is gaining importance rapidly as a most powerful technology. Its immense potential promises the possibility of significant changes in near term future, once the most essential machines - called the Universal Assembler and the Nanocomputer are built. The present paper aims to reviews the previous work done and recent advancements in the field of nanotechnology. Today the products made using nanomaterial's having general as well as special applications like treating cancer, phosgene detection, energy harvesting for self-poweredNano systems, chip fabrication, batteries, aerospace materials etc. The research in the area of carbon nanotubes, nano-polymers, nano-vectors, Nano composites, nano-crystals, nanoparticles, nanofibers, nanoclays, nanotubes, nanofilters, nanohorn, nanowires, Nano springs, Nano rods etc. have been reported. Various risks involved in using nanotechnology are also discussed because it is believed that the most disruptive future changes may occur as a result of molecular manufacturing, an advanced form of nanotechnology.

KEYWORDS:

Nanotechnology, Nanoparticles, Nanomaterial, Nano medicine.

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1. Introduction[1]

A discipline of applied science and technology known as "nanotechnology" focuses on manipulating matter at the atomic and molecular level, often 100 nanometers or smaller, and creating objects or materials that fall within that size range. Future "nanotechnology" is projected to entail creating devices and systems with nanoscale dimensions, also known as Molecular Nanotechnology (MNT), which is already popular. Basically, molecular manufacturing stresses the creation of several enhanced tools and products with numerous finely engineered nanoscale features using precisely engineered, computer-controlled nanoscale instruments. Zettatechnology has recently been proposed as an alternative name to describe the original meaning of nanotechnology by the Foresight Institute. MNT is developing at the most fundamental technical level, Using other exceedingly small machines referred to as assemblers or fabricators, MNT is constructing these two things: • incredibly sophisticated and highly capable nano scale and micro-scale machines and computers, and • everyday goods.

K. Eric Drexler coined the phrase "nanotechnology." Technically, the term "nanotechnology" refers to a branch of applied science and technology that focuses on manipulating matter at the atomic and molecular level, typically 100 nanometers or less, and creating objects or materials that fall within that range.

2.SYSTEMS BASED ON PHARMACOLOGICAL NANOTECHNOLOGY[2]

Pharmaceutical nanotechnology is made up of two main types: nanomaterial and Nano devices, which are important in this industry as well as other ones.

1. Nanomaterial

These are made of biomaterials and are utilized as scaffolds for tissue-engineered products or in orthopaedic or dental implants. It is possible to modify or coat them to improve their biocompatibility with living cells. These are further divided into two groups of materials: Nano crystalline and nanostructured.

2. Nano crystalline

These are easily produced and can take the place of bulk materials that perform less well. Drug encapsulation, bone replacement, prostheses, and implants all directly utilise these materials.

3. Nanostructured substances

These are modified nanomaterials with unique shapes and capabilities. Quantum dots, dendrimers, fullerenes, and carbon nanotubes are a few of these.

4.Nanodevices

These are Nano scale-sized miniature gadgets. Micro fluidics, Nano and micro electromechanical systems (NEMS/MEMS), and micro tests are some of these. These also include diagnostic tools like biosensors and detectors.

Nanotechnology is required in the medical industry the findings related to nanotechnology and Nano drugs are so numerous and diverse. Amazing advancements in Nano medicine have elevated the drug to a new level with positive effects on healthcare.

The huge potential of nanotechnology in healthcare has to be studied. Numerous studies are being conducted in the field of medicine to determine the best procedures and approaches in nephrology, cardiovascular disease therapeutic genes, and cancer therapy.

The traditional approach has significantly advanced, and encouraging progress has been made in the quality of nanoparticles and nanotechnology.20-21 Nano medicines have also been used in gene therapy.

The uses of viral vectors thought to be drug delivery systems were the subject of several studies.22–24 Smart tablets receive data from nanobots that are targeting particular cancer cells. Researchers to guarantee that patients receive the proper care.

The potential for in-vitro diagnosis is provided by nanotechnology, which could replace current methods with less expensive, simpler methods.

Nanoparticles can work as molecular imaging agents inside those apparatuses and input cancer-related genetic changes and functional characteristics of tumor cells.

Moreover, depending on the desired function, functional nanotechnology-based coatings commonly contain the following nanomaterials: titanium dioxide, silicon dioxide, carbon black, iron oxide, zinc oxide, and silver.

The effectiveness, safety, and physio-chemical characterization of nanomaterials and nano surfaces integrated into medical device engineering are improved by instruments and techniques. Novel materials, sensors, and energy storage devices are all produced in large part by scientists.

3.Classifications of nanoparticles[3]

Nanoparticles are scale-sized microscopic particles of 1nm to 100nm . Particles such as nanocrystals, polymers, dendrimers, silica oxides, carbon, metal oxides, lipids, and quantum dots have been developed over the last few decades on based on various components, along with an increasing variety of newly developed materials . Some of the widely used nanoparticles were addressed below.

1. Fullerenes[4]

Fullerenes are nanoparticles that consist entirely of molecules formed from carbon. Their nanomedicine capabilities are extensively studied, and their use in the manufacturing sector has already been established . Carbon nanoparticles combine a broad variety of characteristics that can be useful in therapy, and regenerative medicine, including high aspect ratio, thermal, conductive and mechanical properties. One of the most commonly used nanotechnology fullerenes is Carbon Nanotubes (CNTs), which may be single or multi-walled (SW, MW). SWCNTs provide a new approach to the delivery of drugs because of their ability to reach cells in a 'needle-like' manner and by diminishing their length they can gain nuclear exposure. This phenomenon is extremely useful since CNTs can be conjugated or charged with drugs to improve therapeutic effectiveness.

2. Quantum dots[5]

Quantum dots are nanocrystals that measure between 2-10nm and can fluorescence when excited by light [18]. Their composition consists of an inorganic center, whose size defines the color of an inorganic shell emitted and an aqueous organic coating to which biomolecules are combined. It can be used as a diagnostic as well as a clinical method for biomedical purposes and can also be used for the imaging of sentinel nodes in patients with cancer to stage tumors and to scheme therapy.

3. Liposomes[6]

Liposomes are synthetic vesicles of nanoscale size and a spherical form consisting of natural phospholipids and cholesterol [20]. Liposomes were the fi rst to be tested as carriers of the drugs. They are micro-particular or colloidal carriers, typically with a size range of 80–300nm [21]. These can be used as effective systems for the administration of drugs. Cancer chemotherapeutic and other toxic medicines, such as amphotericin and hamycin, show greater efficacy and protection when used as liposomal medicines compared to traditional preparations.

4. Magnetic nanoparticles

Magnetic nanoparticles, such as iron oxide paramagnetic compounds are promising candidates for disease treatment due to the ability of antibodies to bind to their surface and the possibility of targeting using an external magnetic field . The most capable substances tend to be superparamagnetic iron oxide nanoparticles of less than 10nm in diameter and with superior magnetic properties. They are small thermally agitated magnets called "ferromagnetic fluids" or "ferrofluids" in liquids. Superparamagnetism only occurs through the presence of a magnetic fi eld; if this is removed, the magnetization will vanish, particles will cease to interact, and thus potential vascular embolization can be avoided.

5. Nanopores[7]

Nanopores were conceived by Desai and Ferrari in 1997 [24]. Consists of high porous density wafers reaching up to 20nm in diameter. The pores allow for the flow of oxygen, glucose, and other items, such as insulin. This does not require immunoglobulin’s and cells to move through them, though. Nano pores can be used as a tool to protect grafted tissues from the host defense system. βPancreatic cells may be enfolded inside the Nano pore system and inserted in the body of the recipient. This tissue sample absorbs the nutrients from the nearby tissues while remaining invisible by the defence system and hence escapes from rejection. It can serve as a newer treatment tool for insulin-dependent diabetes mellitus.

6. Nanoshells

Nanoshells had been produced in West and Halas [26]. Nanoshells consist of silica nucleus nanoparticles, and a thin metal layer covering. This can be applied to appropriate tissue using immunological methods. This technique is under analysis for tumor therapy. Used nanoshells that are designed to absorb infrared rays when bared from a source outside the body to exhibit the nanoshell's Thermo ablative property .

4. Nanotechnology in imaging and diagnosis[8]

One of the most important steps in the medical procedure is the diagnosis of a condition. All diagnosis should be made as quickly, precisely, and specifically as possible to avoid "false negative" cases. With the help of in vivo imaging, symptoms or signals can be found in a patient's live tissues without the necessity for surgery (24). Biological markers that may identify changes in tissues at the cellular level are a previous advancement in diagnostic imaging techniques. The objective of utilizing a biological marker is to identify diseases or symptoms, acting as a tool for early detection (25. It is noteworthy that some of these highly accurate molecular imaging agents have been created using nanotechnologies. Imaging is essential, as well as diagnosis.

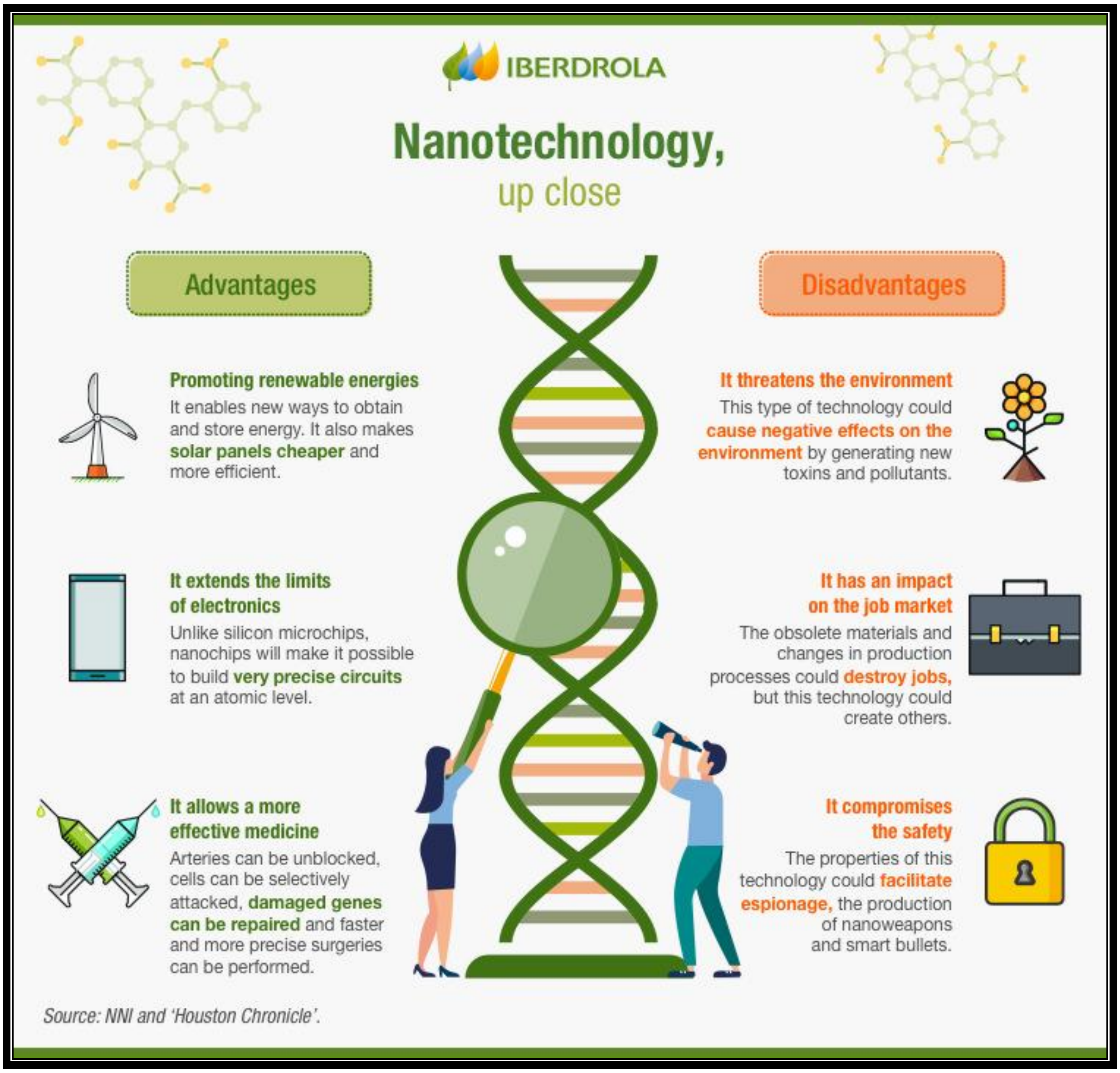
Imaging for diagnostic purposes. Imaging techniques such as X-ray, ultrasound, computed tomography, nuclear medicine, and magnetic resonance imaging have a long history and are frequently utilized in biochemical and medical research. However, these techniques can only examine changes on the tissue surface relatively late in disease progression, though they can be improved by using nanotechnology-based contrast and targeting agents to improve resolution and specificity by indicating the diseased site at the tissue level . Currently utilized medical imaging contrast agents are largely tiny compounds with quick metabolism and nonspecific distribution, which might result in unwanted toxic side effects (10).

5. Advancement in nanotechnology[9]

In all disciplines where minuscule size plays a critical role in establishing essential qualities, nanotechnology has continued to be successfully used as a result of advancements in the fields of materials science, chemistry, and engineering during the past few decades. They are employed in fields ranging from biology and medicine to physics, engineering, and chemistry. The precise labelling of biological molecules is done using cadmium telluride nanoparticles. Sunscreens mostly consist of titanium dioxide nanoparticles, which are highly effective UV radiation blockers. Harry Kroto, Richard Smalley, and Robert Curl discovered the carbon-60 molecule in 1985; in 1996, they were awarded the Nobel Prize for their efforts. Iijima discovered carbon nanotubes in the year 1991. Bottom-up nanotechnology is a branch of nanotechnology that uses biological systems' inherent abilities to self-assemble.

6. Benefits and risks of Nanotechnology.[10]

In both industrialized and developing nations, nanotechnology's wide range of applications has several advantages, including improvements to transportation systems, more affordable and clean energy, and clean drinking water because of Nano filters that can trap contaminants and toxins, an improved healthcare system made possible by the creation of tools and drug delivery systems for the detection, monitoring, and treatment of terrible diseases, a clean environment made possible by the removal of pollutants through remediation, the development of new products and the enhancement of existing ones at nanosacle, etc., all of which pave the way for an industrial revolution that could alter everyaspect of human life [53]. Despite the potential uses of nanotechnology, there are certain hazards. For example, nanoparticles such as copper, cobalt, and others can have toxic and inflammatory effects on human cells [54].



7. NANOTECHNOLOGY TYPES[11]

According to their method of operation (top-down or bottom-up) and the medium in which they operate (dry or wet), the various types of nanotechnology are categorized:

A. Descending (Top-down)

At the Nano metric scale, which ranges in size from one to 100 nanometres, mechanisms and structures are miniatured. It is currently the most common, particularly in electronics.

B. Ascending (top-down)

A larger mechanism than the one you started with is produced by mounting or self-assembling a nanometric structure, such as a molecule.

C. Dried nanotechnology

Structures made of coal, silicon, inorganic materials, metals, and semiconductors that are resistant to humidity are produced using it.

D.Wet nanotechnology

It is based on biological systems found in an aqueous environment, such as membranes, genetic material.

8. NANOTECHNOLOGY APPLICATIONS AND EXAMPLES[12]

All different industrial sectors can use nanotechnology and nanomaterial. They frequently inhabit the following places:

1. Electronics

In order to create quantum nanowires that are lighter, more conductive, and stronger, as well as smaller, faster, and more efficient microchips and devices, carbon nanotubes are quickly displacing silicon as the preferred material. Due to its characteristics, grapheme is a great candidate for flexible touchscreen development.

2. Energy

Solar panels that convert twice as much sunlight into electricity are now possible thanks to a new semiconductor created by Kyoto University. Costs are decreased, stronger and lighter wind turbines are produced, fuel efficiency is increased, and energy savings are possible due to some Nano components' ability to insulate heat.

3. Biomedicine

The properties of some nano materials make them ideal for improving early diagnosis and treatment of neurodegenerative diseases or cancer. They are able to attack cancer cells selectively without harming other healthy cells. Some nanoparticles have also been used to enhance pharmaceutical products such as sunscreen.

4. Environment

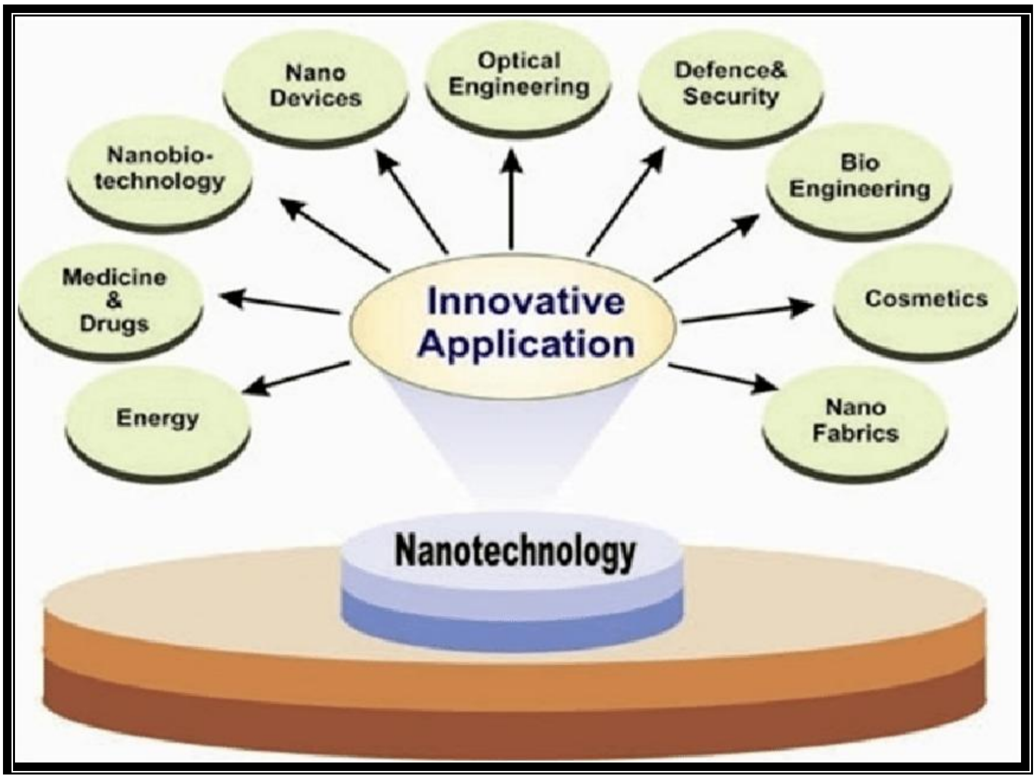
Air purification with ions, wastewater purification with Nano bubbles or Nano filtration systems for heavy metals are some of its environmentally-friendly applications. Nano catalysts are also available to make chemical reactions more efficient and less polluting.

5. Food

In this field, Nano biosensors could be used to detect the presence of pathogens in food or Nano composites to improve food production by increasing mechanical and thermal resistance and decreasing oxygen transfer in packaged products.

6. Textile

Nanotechnology makes it possible to develop smart fabrics that don't stain nor wrinkle, as well as stronger, lighter and more durable materials to make motorcycle helmets or sports equipment.



9. Techniques for Preparing Nanoparticles:

The preparation procedure is critical in acquiring the necessary characteristics for medication delivery systems. As a result, having preparation procedures on hand to synthesize PNPs with the required characteristics for a certain application is quite advantageous. A range of methods, including ionic gelation and solvent evaporation, are employed to prepare Nano sized particulate materials.

1. Ionic Gelation Method:

By combining the positive or electric charge of the hydrophilic compound with a multivalent cationic (for example, calcium chloride) or polyanionic (for example, Na tripolyphosphate), a process known as ionic gelation creates extremely glutinous gel particles with a size range that falls within the range of a metric linear unit.

2. Nano precipitation Method:

In this process, the polymer is precipitated from the organic solvent, and the organic solvent diffuses in the hydrophilic medium with or without the assistance of a surfactant. In most cases, a water-miscible solvent is employed to dissolve the polymer, resulting in the creation of nanosized particles by polymer precipitation. With stirring, this phase is now placed into a hydrophilic media containing a stabilizer, i.e. surfactant. The deposition of polymer on the interface between organic and aqueous solvents occurs as a result of the fast diffusion process, and this phenomenon leads to the development of nanosized materials. The first stage of this approach can improve nanoparticulate production by using a totally miscible solvent system for phase separation. Nanocapsules could alsoThis method could also be used to create nanocapsules by adding a tiny amount of nontoxic oil to the organic phase. This method can only be used with solvents that mix with water, as long as the diffusion rate is high enough to result in spontaneous emulsification.

3. Technique for Solvent Evaporation[11]:

In this method, polymeric solutions are prepared through emulsification using volatile solvents. Ethyl acetate is now used in place of chloroform and dichloromethane, which were primarily used in the past due to their superior toxicological profiles, for the preparation of polymer solutions. This emulsion causes the formation of Nano particulates through polymeric diffusion into the continuous phase of the emulsion through the evaporation of the solvent. After solvent evaporation, the mixture is homogenized quickly, either under reduced pressure or with continuous magnetic stirring. Ultracentrifugation is used to separate the nanomaterial, which is then followed by lyophilisation and washing with distilled water. In order to deliver sulfacetamide nanoparticles in the form of a frame called Eudragit RL-100 for ocular delivery used a solvent procedure. In order to create nanoparticles, plutonic F-109 (1% w/v) was used.For formulation optimization, different drug to polymer ratios were tried. According to the study's findings, ophthalmic bacterial treatments could use nanoparticles for drug delivery.

4. The Salting Out Method[12]:

In this technique, the water-miscible solvent system is extracted from the hydrophilic solution using the salting-out effect. Here, the API and polymers are combined with an organic solvent, which is then emulsified with aqueous solution containing salting out agents like calcium chloride, magnesium chloride, etc. and some stabilizers like hydroxyethylcellulose and polyvinyl pyrrolidone, etc. The diffusion of the organic solvent is enhanced by adding an adequate amount of aqueous solution into the emulsion, which results in the formation of nanosheres. The salting out agent determines how well the encapsulation works, so extreme care must be taken to select the right salting outagent.

5. Dialysis procedure :

This technique uses a dialysis tube with an appropriate molecular weight cutoff and an organic solvent-carrying polymer. This method could be used to create nanoparticles with a restricted size distribution. This causes the solvent inside the tube to be displaced, which causes the polymers to aggregate as a result of the solvent's loss of solubility, resulting in the formation of a Nano suspension. Numerous synthetic and natural polymeric nanoparticles were created using the dialysis method .The preparation method was founded on physiological barriers, specifically the dialysis or semi-permeable membrane through which the solvents must pass via passive diffusion, allowing the mixing of non-solvent with polymer solutions. The polymeric solutions are contained in the membrane.

6. Solvent diffusion and emulsification[13]:

This method is a modified version of solvent evaporation. Solvents that are partially hydrophilic are combined with the polymer here. Propylene carbonate and an amount ofwater equal to their respective thermodynamic equilibria were added. When an organic solvent is partially miscible with water or another organic solvent in the opposite situation, the diffusion of the solvent into the dispersed phase is facilitated, leading to the precipitation of polymers and the formation of nanoparticles. This aqueous polymer solution is emulsified with hydrophilic solution that contains stabilizers, which causes solvent diffusion towards the outer phase and results in the formation of nanomaterials according to the oil:polymer ratio. The solvent is filtered or evaporated at the final stage of the process.Supercritical fluids are safe for the environment. Common techniques involving supercritical fluids include supercritical anti-solvent (SAS), rapid expansion of supercritical solution (RESS), and precipitation with compressed antisolvent process (PCS). Two completely miscible solvents are used in the SAS technique, one of which is supercritical liquid and the other fluid. Although the solutes are insoluble in supercritical liquid, nanoparticulates form as a result of the solutes' immediate precipitation following the supercritical liquid's extraction of the fluid solvent. When using the RESS technique, the solutes dissolve into the supercritical liquid, which causes a significant loss in solvent power. As a result, the solutes precipitate when they are quickly extended via a small nozzle into the area of reduced pressure. The fundamental distinction between SAS and RESS techniques.

7.Using a mill :

Currently used for the preparation of nanomaterials or nanosuspensions are pearl mills and high shear media mills. These mills typically have a recirculation chamber, milling chamber, and milling shaft. The reduction of microsized drug materials to nanosized materials is caused by the impaction and shearing mechanisms generated by these mills. Typically, zirconium oxide, ceramic-sintered aluminum oxide, or cross-linked polystyrene resin with high scratch resistance makes up the milling media or balls. Planetary ball mills are capable of creating particles with a size of less than 0.1 m. The milling chamber is filled with the milling media, drug, stabilizer with the appropriate buffer, or water. High impact and shear stress are generated by the milling media inside the chamber.

Conclusion and Prospects for the Future:

Different aspects of nanotechnology are bringing the science of almost incomprehensibly small devices closer to reality, and at some point, developments will be so vast that they will affect all fields of science and technology. Although expectations are unrealistic, the safety of Nano medicine has yet to be fully defined. It is predicted that in the coming years, nanotechnology will evolve and expand in various fields of life sciences, with its achievements being applied in medicine such as diagnostics, tissue engineering, and patient improvement, which play critical roles in the treatment of human diseases as well as in improving human physiology.

REFERENCES:

1. Orive, G., Hernandez, R.M., Gascon, A.R. and Pedraz, J.L. (2005) 'Micro and nano drug delivery systems in cancer therapy', Cancer Therapy, Vol.3, pp.131-138.1.
2. Madani S, Naderi N, Dissanayake O, Tan A, Seifalian A (2011) A new era of cancer treatment: Carbon nanotubes as drug delivery tools. Int J Nanomed 6: 2963–2979. Link: https://bit.ly/3uDetWi
3. Beg S, Rizwan M, Sheikh A, Hasnain M, Anwer K, et al. (2011) Advancement in carbon nanotubes: Basics, biomedical applications, and toxicity. J Pharm Pharmacol 63: 141–163. Link: https://bit.ly/3uvCXAO
4. Madani S, Tan A, Dwek M, Seifalian A (2012) Functionalization of singlewalled carbon nanotubes and their binding to cancer cells. Int J Nanomedicine 7: 905–914. Link: https://bit.ly/37IkPd2
5. Iga AM, Robertson JH, Winslet MC, Seifalian AM (2007) Clinical potential of quantum dots. J Biomed Biotechnol 2007: 7087. Link: https://bit.ly/37HV9gO
6. Gao X, Cui R, Levenson W, Chung NS (2004) Invivo cancer targeting and imaging with semiconductor quantum dots. Nat Biotechnol 22: 969-976. Link: https://bit.ly/3aQFA8u
7. Akbarzadeh A, Rezaei-Sadabady R, Davaran S, Joo S, Zarghami N, et al. (2013) Liposome classification, preparation, and applications. Nanoscale Res Lett 8: 102. Link: https://bit.ly/3urUKIO
8. Sunderland C, Steiert M, Talmadge J, Derfus A, Barry S (2006) Targeted nanoparticles for detecting and treating cancer. Drug Dev Res 67: 70–93. Link: https://bit.ly/3pQ9jlS

9. McCormack B, Gregoriadis G (1994) Drugs-in-cyclodextrinsin liposome a novel concept in drug-delivery. Int J pharm112: 49-58. Link: https://bit.ly/2ZKWKhl
10. Mahmoudi M, Simchi A, Imani M, Milani A, Stroeve P (2008) Optimal design and characterization of superparamagnetic iron oxide nanoparticles coated with polyvinyl alcohol for targeted delivery and imaging. J Physic Chem B 112: 14470-14481. Link: https://bit.ly/37GPnMa
11. Cobb MD, Macoubrice J (2004) Public perceptions about nanotechnology: risks, benefits and trust. J Nanoparticle Res 6: 395-405.
12. Roco MC (2003) Broader societal issues of nanotechnology. J Nanoparticle Res 5: 181-189.
13. Oberdörster G, Oberdörster E, Oberdörster J (2005) Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles. Env Health Perspectives 111: 823-839.