IMPROVED ACTIVITIES OF NANOPARTICLE IN MEDICINE – A STUDY

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Abstract

One technique that has significantly helped people live more fulfilling lives and overcome the many obstacles posed by various ailments is nanotechnology. In plants that serve as both food and medicine, plant polysaccharides are frequently regarded as naturally active macromolecules with a variety of biological functions and positive health impacts. As new research avenues in designing and developing nanomaterial delivery systems for the cure of cancer and neurodegenerative diseases have opened up over the past 10 years, scientists have increasingly focused on understanding the role of plant polysaccharides in both healthy cellular function and disease. There are various herbal formulations that are being researched like nanodispersions, nanoparticles, liposomal, phytosomes, and microsphere. This article importance and improved activties of nano particle and it is importance in the medicine.

Introduction

The small size of nanoparticles is especially advantageous in medicine; nanoparticles can not only circulate widely throughout the body but also enter cells or be designed to bind to specific cells. Those properties have enabled new ways of enhancing images of organs as well as tumours and other diseased tissues in the body. They also have facilitated the development of new methods of delivering therapy, such as by providing local heating (hyperthermia), by blocking vasculature to diseased tissues and tumours, or by carrying payloads of drugs.

Magnetic nanoparticles have been used to replace radioactive technetium for tracking the spread of cancer along lymph nodes. The nanoparticles work by exploiting the change in contrast brought about by tiny particles of superparamagnetic iron oxide in magnetic resonance imaging (MRI). Such particles also can be used to kill tumours via hyperthermia, in which an alternating magnetic field causes them to heat and destroy tissue on a local scale.

Nanoparticles can be designed to enhance fluorescent imaging or to enhance images from positron emission tomography (PET) or ultrasound. Those methods typically require that the nanoparticle be able to recognize a particular cell or disease state. In theory, the same idea of targeting could be used in aiding the precise delivery of a drug to a given disease site. The drug could be carried via a nanocapsule or a liposome, or it could be carried in a porous nanosponge structure and then held by bonds at the targeted site, thereby allowing the slow release of drug. The development of nanoparticles to aid in the delivery of a drug to the brain via inhalation holds considerable promise for the treatment of neurological disorders such as Parkinson disease, Alzheimer disease, and multiple sclerosis.

Nanoparticles and nanofibres play an important part in the design and manufacture of novel scaffold structures for tissue and bone repair. The nanomaterials used in such scaffolds are biocompatible. For example, nanoparticles of calcium hydroxyapatite, a natural component of bone, used in combination with collagen or collagen substitutes could be used in future tissue-repair therapies.

Nanoparticles also have been used in the development of health-related products. For example, a sunscreen known as Optisol, invented at the University of Oxford in the 1990s, was designed with the objective of developing a safe sunscreen that was transparent in visible light but retained ultraviolet-blocking action on the skin. The ingredients traditionally used in sunscreens were based on large particles of either zinc oxide or titanium dioxide or contained an organic sunlight-absorbing compound. However, those materials were not satisfactory: zinc oxide and titanium dioxide are very potent photocatalysts, and in the presence of water and sunlight they generate free radicals, which have the potential to damage skin cells and DNA (deoxyribonucleic acid). Scientists proceeded to develop a nanoparticle form of titanium oxide that contained a small amount of manganese. Studies indicated that the nanoparticle-based sunscreen was safer than sunscreen products manufactured by using traditional materials. The improvement in safety was attributed to the introduction of manganese, which changed the semiconducting properties of the compound from n-type to p-type, thus shifting its Fermi level, or oxidation-reduction properties, and making the generation of free radicals less likely.

Treatments and diagnostic approaches based on the use of nanoparticles are expected to have important benefits for medicine in the future, but the use of nanoparticles also presents significant challenges, particularly regarding impacts on human health. For example, little is known about the fate of nanoparticles that are introduced into the body or whether they have undesirable effects on the body (see below Health effects of nanoparticles). Extensive clinical trials are needed in order to fully address concerns about the safety and effectiveness of nanoparticles used in medicine. There also are manufacturing problems to be overcome, such as the ability to produce nanoparticles under sterile conditions, which is required for medical applications.

Nanoparticles in the environment

Nanoparticles occur naturally in the environment in large volumes. For example, the sea emits an aerosol of salt that ends up floating around in the atmosphere in a range of sizes, from a few nanometres upward, and smoke from volcanoes and fires contains a huge variety of nanoparticles, many of which could be classified as dangerous to human health. Dust from deserts, fields, and so on also has a range of sizes and types of particles, and even trees emit nanoparticles of hydrocarbon compounds such as terpenes (which produce the familiar blue haze seen in forests, from which the Great Smoky Mountains in the United States get their name).

Human-made (anthropogenic) nanoparticles are emitted by large industrial processes, and in modern life it is particles from power stations and from jet aircraft and other vehicles (namely, those powered by internal-combustion engines; car tires are also a factor) that constitute the major fraction of nanoparticle emissions. Types of nanoparticles that are emitted include partially burned hydrocarbons (in soot), ceria (cerium oxide; from vehicle exhaust catalysts), metallic dust (from brake linings), calcium carbonate (in engine lubricating oils), and silica (from car tires). Other sources of nanoparticles to the environment include the semiconductor industry, domestic and industrial wastewater discharges, the health care industry, and the photographic industry. However, all those emission levels are still considered to be lower than the levels of nanoparticles produced through natural processes. Indeed, recent human-made particles contribute only a small amount to air and water pollution.

Understanding the relationship between nanoparticles and the environment forms an important area of research. There are several mechanisms by which nanoparticles are believed to affect the environment negatively. Two scenarios that are under investigation are the possibilities (1) that the mobility and sorptive capacity of nanoparticles (natural or human-made) make them potent vectors (carriers) in the transport of chemical pollutants (e.g., phosphorus from sewage and agriculture), particularly in rivers and lakes, and (2) that some nanoparticles are able to reduce the functioning of (and may even disrupt or kill) naturally occurring microbial communities, as well as microbial communities that are employed in industrial processes (e.g., those that are used in sanitation processes, including sewage treatment).

Nanoparticles also can have beneficial impacts on the environment and appear to contribute to natural processes. Thus, in addition to the potential use of nanoparticles to remove chemical contaminants from the environment, scientists are investigating how nanoparticles interact with all life-forms—from fungi to microbes, algae, plants, and higher-order animals. That type of study is essential not only to improving scientists' knowledge of nanoparticles but also to gaining a more complete understanding of life on Earth, since the soil is naturally full of nanoparticles, in a richly diverse.

Health effects of nanoparticles

Examining whether e-cigarettes are safer than tobacco cigarettes. See all videos for this article

Humans have evolved to cope with most naturally occurring nanoparticles. However, some nanoparticles, generated as a result of certain human activities such as tobacco smoking and fires, account for many premature deaths as a result of lung damage. For example, fires from the types of cooking stoves used in developing countries are known to emit fine particles and lead to early mortality, especially among women who routinely work near the stoves.

Laboratory and clinical investigations of the effects of nanoparticles on health have been somewhat controversial and remain largely inconclusive. Most studies in animals have involved nanoparticle inhalation, and the dosages have been very large. The results of those studies have indicated that large quantities of nanoparticles can cause cellular damage in the lungs, with lung cells absorbing the particles and becoming damaged or undergoing genetic mutation. Animal studies involving the ingestion of nanoparticles in food or water suggest that nanoparticles can also affect health in other ways. For example, consumption of the food additive E171, which consists of titanium dioxide nanoparticles, is associated with changes in gut microbiota (bacteria occurring in the gut), potentially contributing to the development of conditions such as inflammatory bowel disease.

In humans, the health effects of typical exposure levels—those that are encountered by most persons during daily activities—remain unknown. Nonetheless, there is a general awareness of the problems that might occur upon excess exposure to nanoparticles, and, thus, most manufacturers of such particles take serious precautions to avoid exposure of their workers. Efforts have been made to educate the public in the use of nanoparticle-containing products. The existence of pressure groups has also helped to ensure nanoparticle safety compliance among manufacturers. However, nanoparticles offer tremendous potential for new or improved forms of health care treatment. That has spawned a new field of science called nanomedicine.

Nanoparticle Applications in Medicine

Cancer medication delivery using polymeric micelle nanoparticles. The potential for improved treatment of persistent bacterial infections via using nanoparticles made of iron oxide coated with polymers to disperse bacterial clusters. Research has shown that protein-filled nanoparticles may alter their capacity to elicit immunological responses by surface modification. Inhalable vaccinations might make advantage of these nanoparticles. When a patient has a traumatic injury, the oxygen free radicals in their circulation may be neutralized by the antioxidant properties of cerium oxide nanoparticles. Nanoparticles are able to take in oxygen free radicals and then release it in a safer form, allowing them to take in even more free radicals. Carbon nanoparticles, also known as nanodiamonds, are being explored for potential medicinal uses by researchers. In order to promote more bone formation around dental or joint implants, for instance, Nanodiamonds that have protein molecules attached may be used. The usage of nanodiamonds connected to chemotherapeutic medications for the treatment of brain cancers is now under investigation. Nanodiamonds coupled to chemotherapeutic medications are being investigated by other researchers as a potential treatment for leukemia.

Nanoparticle Applications in Manufacturing and Materials [49]

Magnesium mixed with ceramic silicon carbide nanoparticles makes for a lightweight but sturdy material. Researchers have shown that a synthetic skin with pressure sensing and self-healing capabilities might be useful in prostheses. The substance is a combination of polymer and nickel nanoparticles. Holding the material together after a cut allows it to self-heal in about 30 minutes. In addition, the material's electrical resistance varies in response to pressure, providing it with a tactile feel. A plastic sheet may have silicate nanoparticles added to it to provide a barrier against gases (like oxygen) or moisture. This has the potential to delay the deterioration or drying out of food. Industrial coatings using zinc oxide nanoparticles may shield wood, plastic, and textiles from ultraviolet radiation.Tennis racquets may be made stronger by using crystalline nanoparticles of silicon dioxide to fill the spaces between carbon fibers.Clothes treated with silver nanoparticles are odor-resistant because they destroy germs.

Nanoparticle Applications and the Environment [49]

To create biodegradable chemicals from oil, scientists are using photocatalytic copper tungsten oxide nanoparticles. This grid of nanoparticles is ideal for removing oil from spills since it has a large surface area for the reaction, can be triggered by sunshine, and works in water.Scientists have developed a catalyst that can break down volatile organic pollutants in the air at room temperature; it consists of gold nanoparticles encapsulated in porous manganese oxide.To remove carbon tetrachloride from contaminated groundwater, scientists are turning to iron nanoparticles.One method for removing arsenic from water wells is the use of iron oxide nanoparticles.

Nanoparticle Applications in Energy and Electronics [49]

Nanotetrapods, which are nanoparticles studded with carbon nanoparticles, have been used by researchers to create inexpensive fuel cell electrodes. A potential alternative to the costly platinum used in fuel cell catalysts is this electrode. A new technique for printing prototype circuit boards using regular inkjet printers has been developed by researchers from Microsoft Research, the University of Tokyo, and Georgia Tech. The conductive lines required by circuit boards were created using silver nanoparticle ink. A transistor called a NOMFET (Nanoparticle Organic Memory Field-Effect Transistor) is made by combining organic molecules with gold nanoparticles. An remarkable property of this transistor is its ability to mimic the behavior of synapses, which are found in the nervous system. A fuel cell catalyst using platinum-cobalt nanoparticles is now under development; this catalyst outperforms pure platinum by a factor of twelve. Researchers obtain this performance by annealing nanoparticles into a crystalline lattice, which increases their reactivity and decreases the distance between platinum atoms on the surface. Scientists have shown that focused sunlight on nanoparticles may efficiently generate steam. Water purification and dental equipment disinfection are only two examples of the many potential uses for the "solar steam device" in underdeveloped nations without access to reliable power. A lead-free solder that utilizes copper nanoparticles and is dependable enough for use on space missions and other high-stress conditions. Anode coatings of lithium-ion batteries using silicon nanoparticles may enhance battery output while decreasing recharging time. One method for producing inexpensive solar cells is by using semiconductor nanoparticles in a low-temperature printing technique. In a hydrogen sensor, palladium nanoparticles are arranged in a thin layer with very small gaps between them. The palladium nanoparticles enlarge and create gaps between themselves when they absorb hydrogen. The palladium layer's resistance is reduced by these shorts.

Applications of Metallic Nanoparticles [50]

The following table summarises the varied properties of distinct nanoparticles in comparison to bulk metals.

Optical function:

Surface absorption plasmon of Ag and Au may display a spectrum of colors when the particle size, shape, and condensation rate are varied. A new paint might be made that combines the longevity of an inorganic pigment with the vivid hues of an organic base. A material with high penetrating conductivity (low absorption, dispersion, and reflection) may be made using nanoparticles whose wavelengths are shorter than the wavelength of light.

Catalyst function:

Such nanoparticles, like gold nanoparticles, have a huge specific surface area in comparison to other particles, which allows for higher reaction efficiencies. If the surface terrace is regular down to the atomic level, it is possible to construct a hyperactive catalyst with excellent selectivity.

Thermal function:

Particles less than 10 nm have a lower melting point than large metal chunks. Electronic circuits may be constructed using nanoparticles containing polymers or other materials with a low boiling point.

Since the superconductivity transition temperature increases to a point where the particle diameter is minuscule (less than 1 nm), it might be used to make high-temperature superconducting material.

Mechanical function:

Because the mechanical properties of nanoparticles improve, mechanical strength may be dramatically increased by combining them with metals or ceramics.

Magnetic function:

The production of soft-magnetic materials as an alloy of nanoparticles is made possible by reducing the particle diameter of a magnetic metal, which increases the metal's attractive force. It is also possible to produce a permanent magnet by using nanoparticles that are smaller than the magnetic domain.

Application in Chemical Catalysis [51]

Ni, Pd, Ag, and Pt are some of the metals that have been used as catalysts in chemical reactions. Nevertheless, it is not feasible to conduct dissociative adsorption of oxygen or hydrogen molecules onto a flat surface of Au below 200°C. Consequently, this gold has no function as an oxidation or hydrogenation catalyst. But as Haruta found out, Au nanoparticles work effectively as catalysts when used in this way. The ratio of the corner-to-edge ratio of a few nanometer-sized Au nanoparticle becomes important when contrasted with bigger Au particles. This enhances the catalytic and adsorption capabilities of the Au surface. An icosahedron containing 2054 Au atoms has a surface-to-volume ratio of 15% in Au nanoparticles with a size of 4.9 nm (external diameters), but 52% (309 Au atoms) in nanoparticles with a size of 2.7 nm. If the amount of gold atoms in a nanoparticle is further decreased, the electrical structure of the nanoparticle will become discontinuous, limiting the number of atoms and electrons in the whole. This state's physical properties exhibit a clustering pattern and a quantum size impact becomes apparent.

Instabilities in environmental conditions are common for metals that aggregate into clusters of this size. The stability of Au clusters, however, makes them a potential catalyst. In catalyzed oxidation reactions, the catalytic activity is rapid due to the small size of the Au nanoparticle. For instance, a temperature of 100 °C is necessary to oxidize CO using a Pt catalyst. But reactions may occur at temperatures lower than 0 °C when an Au nanoparticle acts as a catalyst. These effects are caused by changes in the so-called surface plasmon resonance, which is seen at the frequency of conduction electron oscillation in response to the alternating electric field of the input electromagnetic radiation. Metals with free electrons, such as alkali metals, silver, copper, and gold, are the only ones that can exhibit plasmon resonances in the visible spectrum, giving them their vibrant colors. In elongated nanoparticles (such as nanorods and ellipsoids), two distinct plasmon bands associated with transverse and longitudinal electron oscillations may be seen.

Application of Nanoparticles in Medical Treatments [52]

To the same extent as the surface plasmon resonance of a metal nanoparticle increases as the number of nanoparticles increases, so does the scattering intensity. This property is expected to be used for targeted chemical detection in live human tissue. For instance, it becomes possible to distinguish between healthy and cancerous cells by covering their surfaces with antibodies attached to the Au nanoparticle. While the Au nanoparticle-antibody junction is uniformly distributed in healthy cells, in cancer cells, antibodies tend to be localized near the Au nanoparticle. Changing the nanoparticle's form enables imaging at various wavelengths. In addition, by attaching a protein and a functional molecule to the Au nanoparticle, it might be used to scan cells other than cancer cells. Additionally, near-infrared lasers may be used to cure cancer since Au nanorods aggregate at the periphery of an abnormal cell and exhibit a plasmon resonance in this region.

Development of Herbal medicines

Despite the long history of herbal medicine usage by many cultures, modern scientific research on plant products is essential to the development of new herbal remedies. A scientific method has only just been proposed to address this issue; preliminary results show that most phyto-products need a lot more data to confirm their effectiveness. Even while it's not the case everywhere, certain countries put herbal medicines through rigorous development processes. For instance, in Germany, herbal remedies are marketed as "phyto-medicines" and are expected to fulfill the same criteria for quality, safety, and effectiveness as synthetic pharmaceuticals. In contrast, the majority of herbal products supplied and controlled in the US fall under the category of nutritional supplements, which, according to the aforementioned criteria, does not need prior permission.

In 1965, the European Commission said that all Member States must approve medicinal items before they may be sold. When it comes to medicine, these natural remedies mostly adhere to the guidelines established by national medical legislation. Medicinal herbs have a precise meaning in the European Union Guideline, which is titled "Quality of Herbal Medicinal Products." Everything derived from plants, including their active ingredients and any therapeutic treatments, falls under this category. Many different medical therapies based on herbal medicines are either already available or are in the works. Consequently, most of the newly-introduced herbal remedies derived from plants are novel and provide a substantial addition to the advancement of existing therapies.in the 53rd

Since medicinal plants are a great source of biologically active phytochemicals, herbal medicines that are both highly effective and have few side effects might be a useful tool in the quest to produce new drugs. More and more studies are documenting the bioactivities of several therapeutic herbs. It is not feasible to isolate the action of a single phytochemical from a mixture of plant extracts due to the fact that their efficacy is due to the combined effects of a wide variety of these compounds. Herbal remedies are effective because they include a wide range of active components, many of which work together in a synergistic way. Since most medicines derived from plants have poor solubility and a rapid rate of removal from the system, requiring repeated or larger dose administration, these herbal treatments are less effective for acute medical needs. These drawbacks make herbal medicines an unattractive option for medical use.

Consequently, developing herbal products to improve their effectiveness and bioavailability is one of the main topics of plant study right now.[54] The

A new trend in the creation of herbal medicines has been the use of nano-based pharmaceuticals, with producing plant-derived nanoparticles gaining immense relevance. One of the most promising areas of medicinal research is the production of plant-based products that include self-fabricated nanoparticles. Here, phytoconstituents affect the efficiency and properties of nanoparticle synthesis, while nanoparticles enhance the bio-efficacy of the plant.

There has been little usage of nanoparticles in the production of herbal medicines, despite their versatility and many other applications, such as in vitro diagnostics. It is believed that drugs attached to nanoparticles have advantages over more conventional drug delivery systems. Medications attached to nanoparticles may transport a potent dose of medicine precisely where it is required, have a longer half-life in the body, and last longer in circulation. Modifying the drug nanoparticle's size and surface characteristics yields the desired delivery characteristics. The drug coupled to the nanoparticles has fewer side effects and can reach a high localized concentration where it is required since it cannot circulate broadly. Drug loading may be fairly high with nanoparticles due to their extremely high surface area to mass ratio. Drugs attached to nanoparticles have the unique ability to dissolve easily in liquids and access even the deepest tissues and organs. Based on the advantages associated with pharmaceuticals connected to nanoparticles, the present effort aimed to generate herbal remedies with higher efficacy and bioavailability by creating phytoconstituents tied to nanoparticles. [55]

Green synthesis of Nanoparticles [56]

One of the most pressing needs in nanoscience is the creation of reliable and ecologically friendly methods for making metal nanoparticles. An effective living factory for green synthesis of metal nanoparticles has evolved in the plant system to fulfill this need. Green synthesis of metal nanoparticles using plants has several advantages, including being inexpensive, non-toxic, fast, and able to be done at room temperature. Plant enzymes, leaves, stems, and bark are just some of the plant components that have been used to effectively synthesize metal nanoparticles. Moreover, from a business perspective, the plant system offers a desirable nonpathogenic biological platform for the manufacture of environmentally friendly metal nanoparticles.

Multiple processes have led to the development of environmentally friendly methods for producing nanoparticles. However, plants provide a more appealing option due to their quickness, cheap cost, lack of environmental impact, and the fact that they may be used as a one-pot approach for the synthesis of biological nanoparticles, which enables efficient synthesis on a wide scale. With the rise of green synthesis techniques and other aspects of nanoscience, phyto nano synthesis has been in the spotlight as of late. When plants facilitate the synthesis of nanoparticles, their proteins act as both stabilizing caps and reducing agents. The advantages of improved bioactivity over the conventional drawbacks of herbal treatments, such as limited solubility and bioavailability, bode well for the future of plant-derived nanomedicines.

A typical step in biosynthesis using plants is a rapid reaction between a water-based plant extract and a corresponding metal salt in a room-temperature aqueous media. Manganese, tin, gold, and other metal nanoparticles have all been synthesized using this process. Proteins and phytoconstituents are the primary biological molecules that trigger the process, which serves as both a capping agent and a reducing agent. These secondary metabolites serve as stabilizers after the creation of nanoparticles generated from plants. This biosynthetic method is simple and takes place at a pleasant room temperature. It has been shown that temperature, pH, type of metal salt, and concentration of phytoconstituents in plant extract are the factors that affect the quantity, pace, and properties of Nanoparticles that are formed.

Among all metal nanoparticles, AgNP has become the most popular due to its numerous unique characteristics and wide range of uses. It is well-known that antimicrobial compounds may be made from silver. The antimicrobial effects of silver are attributed to the fact that its cation, Ag^+, forms robust connections with oxygen, sulfur, and nitrogen groups, which are electron donors in biological molecules. Nanoparticles made of silver that have a greater surface-to-volume ratio outperform larger metal molecules and exhibit more desired qualities. Their mechanism of action involves biosynthesizing Ag^+ to Ag^0, which causes the nanoparticles to self-assemble and aggregate in colloidal solutions. This means that AgNP may be used for a variety of purposes in the medicinal and biological fields.

Conclusion

A nanoparticulate drug delivery system based on herbs was to be designed, developed, and characterized. Examining Syzygium samarangense via macro and microscopical lenses was part of the pharmacognostic study. The yield and phytochemical content of the various extracts were among the many attributes studied. Pharmacological and antimicrobial/anti-inflammatory activity screenings, as well as preliminary phytochemical screenings, were also a part of the research. The current work is up to par, as it included extraction, separation, and pharmacological analysis. The following are some of the research's potential prospects. After fractionation of eluents by spectral analysis, the research can be expanded to identify more compounds.

References

1. *Ezike TC, Okpala US, Onoja UL, Nwike PC, Ezeako EC, Okpara JO, Okoroafor CC, Eze SC, Kalu OL, Odoh EC, Nwadike U. Advances in drug delivery systems, challenges and future directions. Heliyon. 2023 Jun 24.*
2. *Petrovska BB. Historical review of medicinal plants' usage. Pharmacognosy reviews. 2012 Jan;6(11):1.*
3. *Ramawat KG, Arora J. Medicinal plants domestication, cultivation, improvement, and alternative technologies for the production of high value therapeutics: an overview. Medicinal Plants: Domestication, Biotechnology and Regional Importance. 2021 Sep 2:1-29.*
4. *Perreau J, Moran NA. Genetic innovations in animal–microbe symbioses. Nature Reviews Genetics. 2022 Jan;23(1):23-39.*
5. *Ravishankar B, Shukla VJ. Indian systems of medicine: a brief profile. African Journal of Traditional, Complementary and Alternative Medicines. 2007;4(3):319-37.*
6. *Firenzuoli F, Gori L. Herbal medicine today: clinical and research issues. Evidence-based complementary and alternative medicine. 2007 Sep 1;4:37-40.*
7. *Rizvi SA, Einstein GP, Tulp OL, Sainvil F, Branly R. Introduction to traditional medicine and their role in prevention and treatment of emerging and Re-emerging diseases. Biomolecules. 2022 Oct 9;12(10):1442.*
8. *Samy RP, Gopalakrishnakone P. Current status of herbal and their future perspectives. Nature precedings. 2007 Sep 28:1-.*
9. *Wijesekera RO. Plant-derived medicines and their role in global health. InThe medicinal plant Industry 2017 Jul 12 (pp. 1-18). Routledge.*
10. *Roy A, Das SK, Tripathi AK, Singh NU, Barman HK. Biodiversity in North East India and their conservation. Progressive Agriculture. 2015;15(2):182-9.*