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Overview Study of Nanoparticles and Nanotechnology as Promising Pharmaceutical Drug Delivery System

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Abstract: *In order to save human life, nanoparticles can exhibit a great deal of favorable physical, chemical, and therapeutic capabilities as compared to their bigger material counterparts. Particulate systems, such as nanoparticles, have recently been employed as a physical method to modify and enhance the pharmacokinetic and pharmacodynamic characteristics of many kinds of pharmacological molecules. They have been employed in vivo to protect the drug entity in the systemic circulation, limit the drug access to certain areas, and transport the drug to the site of action at a steady and regulated rate. It is evident that research on drug delivery is shifting from the micro to the nanoscale. As a result, nanotechnology is becoming a specialty in medicine that should yield major therapeutic benefits. One of the most difficult jobs for pharmaceutical formulation researchers is creating efficient nano delivery systems that can deliver a medication precisely and securely to the intended site of action. Liposomes, lipid or polymeric nanoparticles, and nano emulsions are the primary nano delivery techniques. Using particulate vesicle systems as drug carriers for both small and large molecules, a lot of research has been conducted in recent years on the basis of novel drug delivery systems. Nanoparticles have been reducing adverse effects and increasing the therapeutic impact of medications. In general, a variety of methods have been used to create nanoparticles, including ionic gelation or co-acervation of hydrophilic polymers, polymerization of monomers, and dispersion of preformed polymers.*

Keywords: Nanoparticles, Nanotechnology, Solid-lipid Nanoparticles, Dendrimers, Carbon nanotubes

1. Introduction

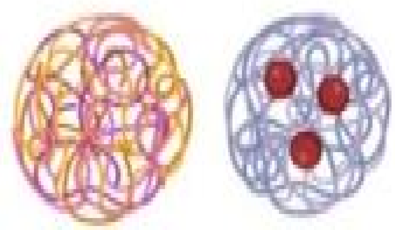
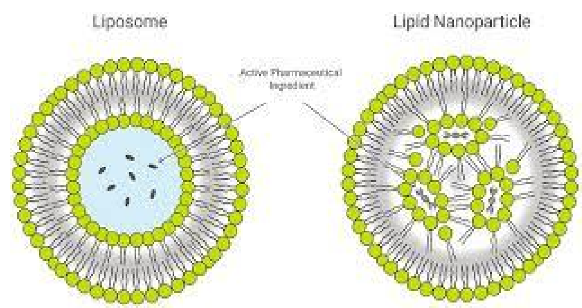
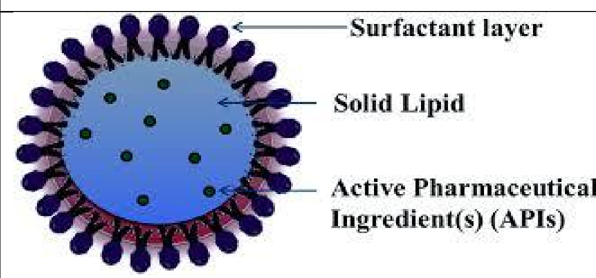
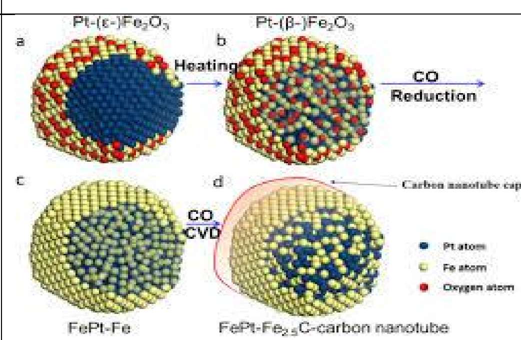
At the molecular and supra-micron level, nanotechnology a phrase derived from the Greek word "nano," which means dwarf applies the concepts of engineering, electronics, physical and material science, and manufacturing. Particulate dispersions or solid particles with a size between 10 and 1000 nm are referred to as nanoparticles.

The medication encapsulated, dissolved, entrapped, or adhered to a matrix of nanoparticles. Nanoparticles, nanospheres, or nano capsules can be produced based on the preparation technique. Because they can target a specific organ, circulate for a long time, act as a carrier of DNA in gene therapy, and deliver proteins, peptides, and genes, biodegradable polymeric nanoparticles especially those coated with hydrophilic polymers like poly (ethylene glycol) (PEG) have been considered as potential drug delivery devices in recent years.

History of Nanoparticles:

A study on nanotechnology from the middle of the 19th century was described by Petros and his colleague. The FDA approved the first controlled formulation in 1989, the first polyethylene glycol (PEG) conjugated with protein entered the market in 1990, the first liposome-based drugs were formulated in 1973, the first micelle was formulated and approved in 1983, the first controlled-release polymer device was introduced in 1964, the liposome was discovered by Bangham in 1965, and albumin-based NPs were reported in 1972.

HISTORY RELATED TO NANOPARTICLES DEVELOPMENT:

<table>
<tr><th>Name</th><th>Discovery</th><th>Scientist name</th><th>Image</th></tr>
<tr><td>Nanoparticles</td><td>1959</td><td>Richard Feynman</td><td></td></tr>
<tr><td>Liposomes</td><td>1960</td><td>Alec D. Bangham</td><td>
</td></tr>
<tr><td>Solid lipid NPs</td><td>1990</td><td>Muller and lucks</td><td>
</td></tr>
<tr><td>Carbon nanotube</td><td>1991</td><td>Lijima</td><td>
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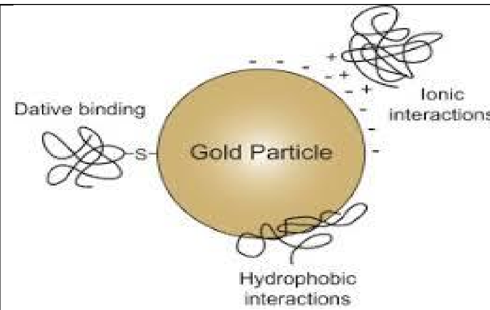
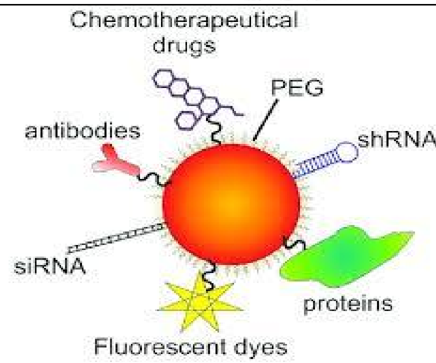
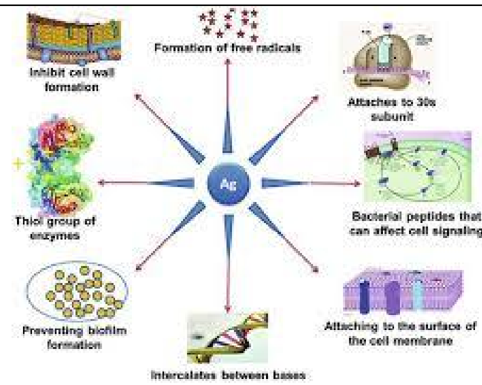
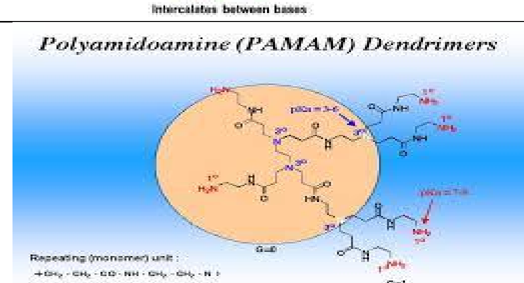
Colloidal gold NPs	2004	Michael Faraday	
Gold NPs	2007	Michael faraday	
Silver nanoparticle	2012	M. C. Lea	
Polyamidoamine	2015	Michael	

Table 1: Historical Development of Nanoparticles

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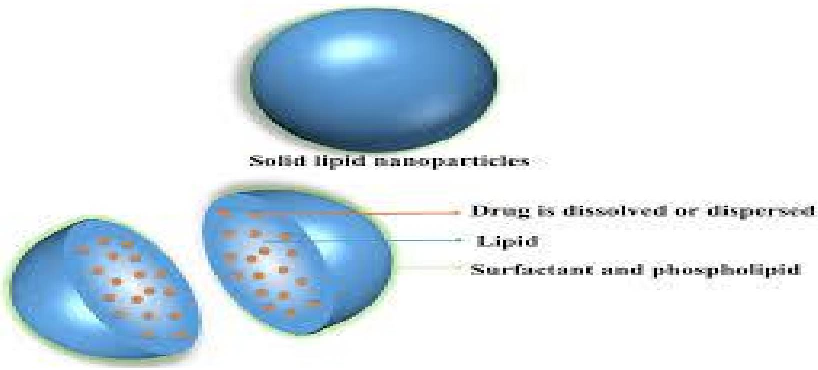
II. TYPES OF NANOPARTICLES

Solid lipid nanoparticles:

Solid lipid nanoparticles (SLNs) are prepared from lipids that are solid at room temperature as well as at body temperature. Different solid lipids are exploited to produce SLNs, such as, tripalmitin, cetyl alcohol, cetyl palmitate, glyceryl monostearate, trimyristin, tristearin, stearic acid, etc.



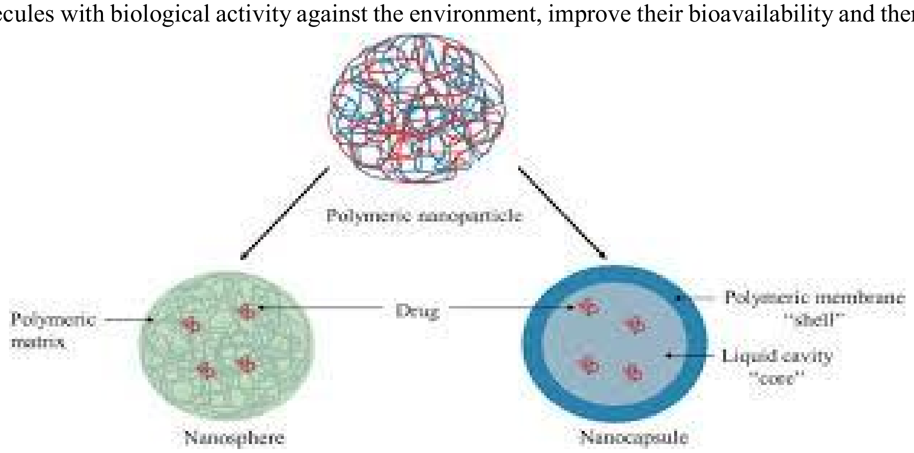
Pharmaceutical application:

They are used in various pharmaceutical formulations for delivering both hydrophobic and hydrophilic drugs. Additionally, SLNs are biocompatible, biodegradable, and have low toxicity, making them a promising option for drug delivery systems in the pharmaceutical industry.

Polymeric nanoparticles:

Polymeric nanoparticles have attracted considerable interest over recent year due to their properties resulting from their small size.

Advantages of polymeric NPs as drug carriers induce their potential use for controlled release, the ability to protect drug and other molecules with biological activity against the environment, improve their bioavailability and therapeutic index.



Pharmaceutical application:

Polymeric nanoparticles have gained significant interest in pharmaceutical applications due to their unique properties and versatile nature. Here are some common pharmaceutical applications of polymeric nanoparticles:

Drug Delivery: Polymeric nanoparticles can be used as drug delivery vehicles to improve the pharmacokinetics and bioavailability of drugs.

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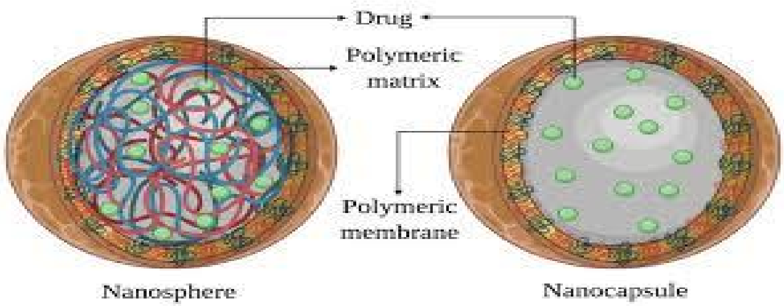
Cancer Therapy: Polymeric nanoparticles have been extensively studied for delivering anti-cancer drugs to tumor sites with improved specificity and reduced side effects.
Vaccine Delivery: Polymeric nanoparticles can serve as a platform for vaccine delivery, offering protection to vaccines from degradation and improving their stability.
Gene Therapy: Polymeric nanoparticles are used in gene delivery applications to transport genetic material into target cells for gene therapy.
Diagnosis and Imaging: Polymeric nanoparticles are employed in diagnostic imaging techniques such as magnetic resonance imaging (MRI), computed tomography (CT), and fluorescence imaging.

Nanosphere:
Nanospheres are nanoparticle systems composed of a solid core with a dense polymeric matrix. These particles have the size range between 10 and 200 nm. In general, there are two types of nanospheres, magnetic nanospheres, and immune nanosphere.



Pharmaceutical application:
Nanosphere technology has several pharmaceutical applications due to its ability to enhance drug delivery and improve therapeutic outcomes. Some potential pharmaceutical applications of nanospheres include:
Drug Delivery Systems: Nanospheres can be used as carriers to deliver drugs to specific target sites within the body.
Cancer Treatment: Nanospheres can be designed to encapsulate anti-cancer drugs and target specific cancer cells, minimizing damage to healthy tissues and reducing side effects.
Treatment of Infectious Diseases: Nanospheres can be used to deliver antibiotics and antiviral drugs effectively to infected tissues, improving the treatment of various infectious diseases.
Vaccine Delivery: Nanospheres can be used as vaccine carriers to improve the efficacy of vaccine by enhancing antigen delivery, uptake, and presentation to the immune system.
Imaging: Nanospheres can be functionalized with imaging agents to improve the visualization of diseased tissues using imaging techniques such as MRI, CT scan, or fluorescence imaging.
Modulation of Drug Release: Nanospheres can be designed to release drugs in a controlled and sustained manner, providing prolonged therapeutic effects and reducing the frequency of drug administration.

Dendrimers:
Dendrimers are nano-sized, radially symmetric molecules with well-defined, homogeneous, and monodisperse structure that has a typically symmetric core, an inner shell, and an outer shell.

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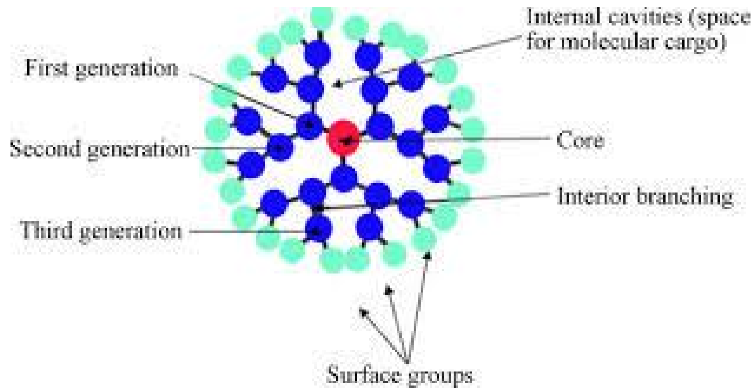
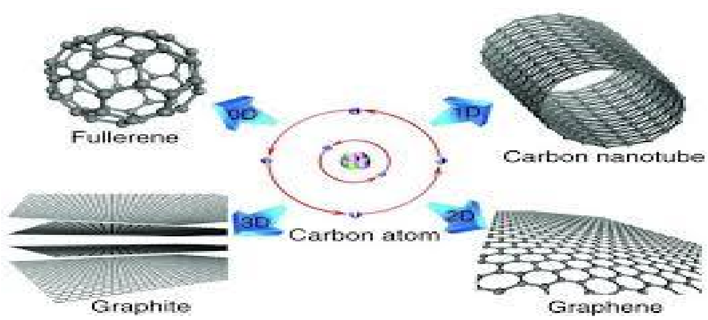


Pharmaceutical application:

Dendrimers hold promise in pharmaceuticals for drug delivery due to their unique structure with well-defined branches. They can encapsulate drugs, targeting specific tissues and controlling release rates. Additionally, dendrimers can enhance drug solubility and stability, facilitating their delivery to the intended site and improving bioavailability.

Carbon nanotubes

Carbon nanotubes are helical microtubules of carbon that are of two types- Single Walled Carbon Nanotubes and Multi walled carbon nanotubes. The former have diameters ranging from 0.4-2nm and the latter have diameters ranging from 2-100 nm.



Pharmaceutical application:

The applications of CNTs span fields as diverse as energy storage, durable goods, electronics, environmental remediation, and biomedical devices. Their unique properties make them valuable additions to a wide range of products, but the need for precision in these applications complicates their usage.

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III. TECHNIQUES INVOLVE IN NANOPARTICLES PREPARATIONS:

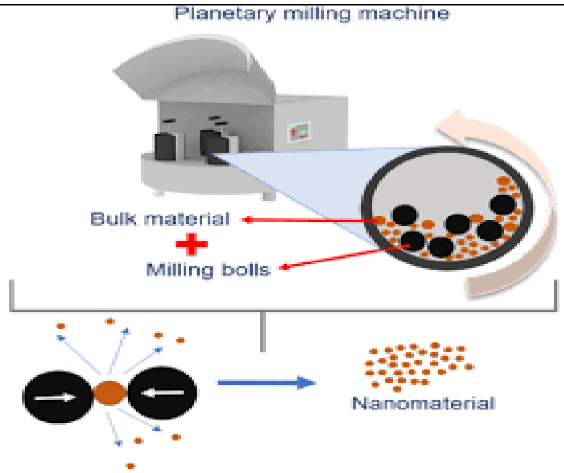
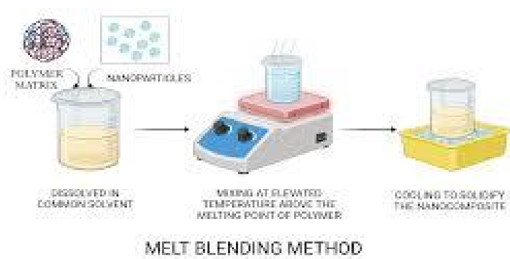
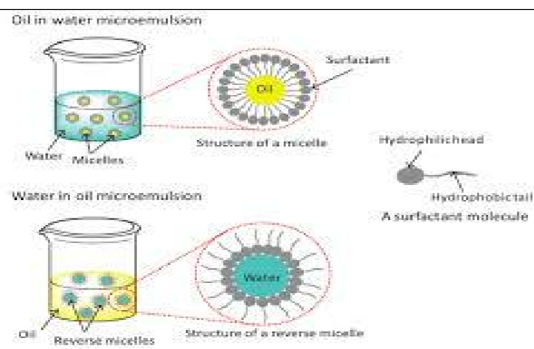
Techniques	Image	Pharmaceutical application
Mechanical/ball milling technique	 	**1**.Ball milling is employed to reduce the particle size of active pharmaceutical ingredients (APIs) and excipients. Smaller particle sizes can enhance the solubility and bioavailability of poorly soluble drugs. **2**.Ball milling can facilitate the co-crystallization of drugs with excipients or other compounds. This can improve the physicochemical properties of the drug, such as solubility and stability.
Melt blending	 	It is particularly used for organic compounds, where a sample with a known identity and melting point is mixed with an unknown purified sample to determine the melting point.
Micro emulsion	 	It finds application in polymerization and chemical reactions as media and vehicles, by introducing reactants in nanosized water droplets.

Table 2: Techniques involve in Nanoparticles Preparation

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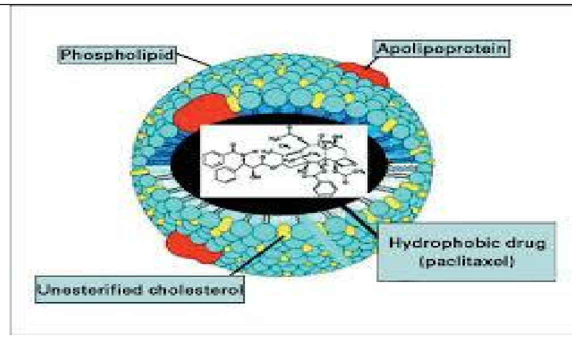
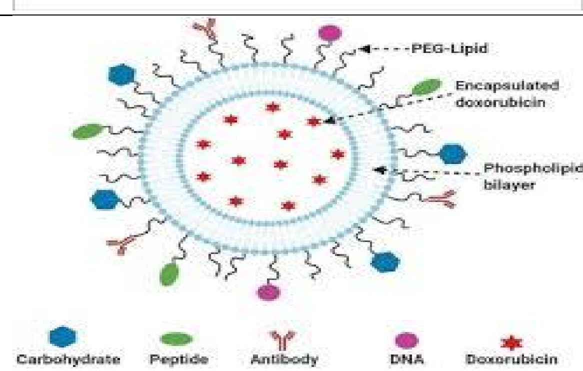
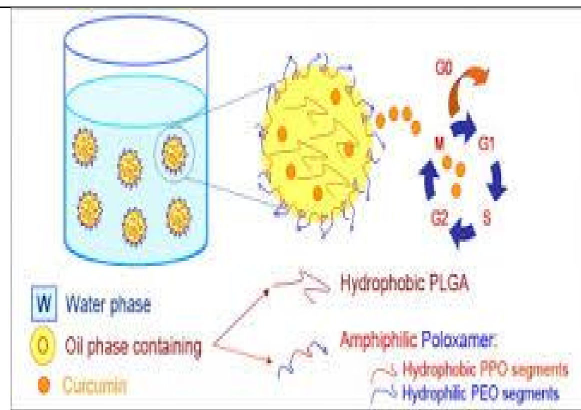
IV. RECENT STUDIES RELATED TO NANOPARTICLES:

Tittle	Place	Year	Application	Image
Paclitaxel - loaded NPs	U.S. and Europe	2024	Approved by the FDA for the treatment of metastatic breast cancer and non-small cell lung cancer (NSCLC).	
Doxorubicin-encapsulated lipid NPs	Asia and north America	2024	It may be used to treat soft tissue and bone sarcomas and cancers of the breast, ovary, bladder, and thyroid.	
Curcumin-loaded NPs	India and UK.	2024	Inhibit Staphylococcus epidermidis, which is mainly responsible for nosocomial infections	

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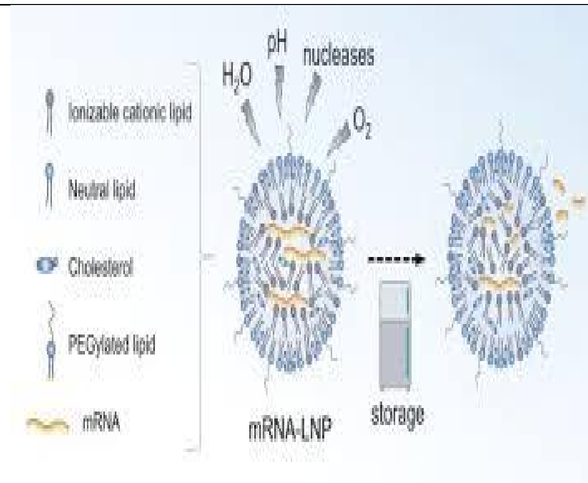
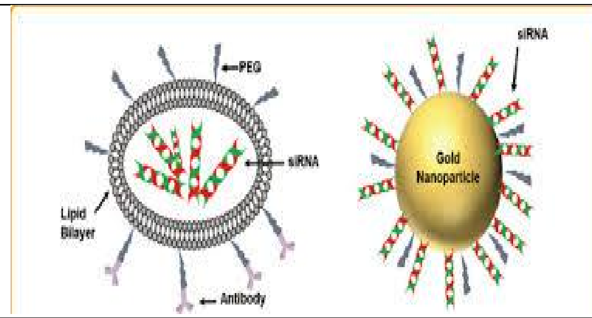
mRNA NPs	Germany and u.s.	2024	Treating neurodegenerative diseases (e.g., Alzheimer's, Parkinson's).	
SiRNA	U.S. Japan	2024	It can be used to generate therapeutic compounds for different diseases, including those that are currently 'undruggable	

Table 3: Recent Research Study related to Nanoparticles

V. CONCLUSION

The synthesis of nanoparticles using herbal reagents is a cost-effective, secure, non-toxic, and eco-friendly method that also yields more stable nanoparticles. It is expected that future studies will focus on creating nanoparticles with the strongest antibacterial capabilities and the least amount of potential toxicity. Because metallic nanoparticles are used in a wide range of applications, including the treatment of cancer, the delivery of medications, and the development of biosensors, their creation more especially, through non-toxic green synthesis techniques is extremely important.

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