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A BRIEF OVERVIEW OF NANOPARTICLE

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Abstract-
This review provides a detailed overview of the synthesis, properties, and applications Nanoparticles (NPs) come in many forms. NPs are small substances ranging in size from 1 to 100 nm and can be divided into various classes based on their properties, shape, or size. Various groups include fullerenes, metallic NPs, ceramic NPs, and polymeric NPs. NPs have unique physical and chemical properties due to their large surface area and nanoscale size. Their optical properties are size-dependent and have been reported to give different colors due to absorption in the visible range. Their reactivity, toughness, and other properties depend on their specific size, shape, and structure. These properties make them excellent candidates for various commercial and consumer applications, including catalysis, imaging, medical applications, energy-based research, and environmental applications. The heavy metal NPs of lead, mercury, and tin are reported to be very hard and stable, resistant to decomposition, and can cause many environmental toxicities. Nanotechnology refers to the production and use of materials whose constituents exist at the nanoscale. Conventionally down to 100 nm Nanotechnology investigates electrical, optical, magnetic activity, and structural behavior at the molecular and sub-molecular level. Nanoparticles are used in various fields of industrial production such as pharmaceuticals, solar cells, and oxide fuel cells for energy storage, and in a variety of everyday uses such as cosmetics and clothing, optics, catalysts, and disinfectants. used in the material.

Keywords- Nanoparticles, Types, Synthesis, Applications

Introduction-

Nanotechnology is the art of working with particles that have at least one dimension with a size of 1 100 nm. This means that we manipulate materials on a small scale, resulting in materials with new and surprising properties that differ from the same micro-sized materials, such as B. Stronger, smaller, lighter. Developing materials and using them in many applications, especially medicine, is a giveaway. This science should not be considered solely in terms of particle size. Many applications have started using science by doping in bulk materials to impart superior properties [1].

The assembly and fabrication of nanoparticles are based on two routes. The first, from the transformation of large materials and their smaller ones, is labeled top-down, and the second, from the assembly of nanoparticles from smaller particles, is labeled bottom-up. Nanoparticles can be classified as 1D, 2D, and 3D based on their dimensions. Dimensions include films used in solar cells, catalytic converters, and electronics applications. Two-dimensional containing carbon nanotubes consisting of a network of carbon atoms with a diameter of 1 nm and a length of 100 nm, the third dimension is a quantum dot, which is a device or particle with a diameter of 2–10 nm [2].

In recent years, nanotechnology has gained a personal interest in the fields of nanotechnology and nanoscience due to its large surface area, economy, low cost, and high efficiency. Nanotechnology has been a well-known area of research during the last century. Ever since Nobel laureate Richard P. Feynman introduced "nanotechnology" in his famous 1959 lecture "There's a lot of room at the bottom", nanoparticles have evolved not only in terms of their material but also in various dimensions. , also differed in shape and size. The surface can be irregular with surface variations, or it can be uniform. Some crystalline or amorphous nanoparticles contain aggregates or loose single- or polycrystalline solids. During the process of synthesizing new drugs, most drug candidates are insoluble or sparingly soluble in water, which is a major problem for the pharmaceutical industry [3].

One of the main reasons drugs are insoluble is their complex and large molecular structure. Over 65% of new active pharmaceutical ingredients (APIs) are reported to be poorly water-soluble or insoluble. Due to its low water solubility and high permeability, it is classified as Class II in the Biopharmaceutical Classification System (BCS), with the dissolution step being the rate-limiting factor for drug absorption [4].

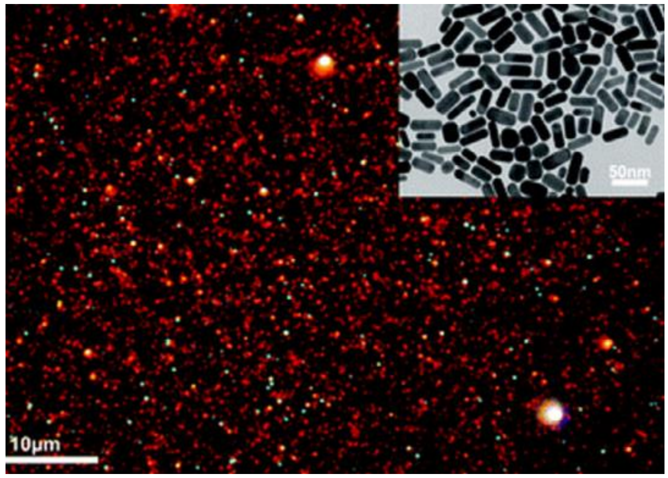

Fig no 01- The View of Nanoparticles

Classification of nanoparticles-

The nanoparticles are classified into different types based on morphology, size, and shape. some of the important classes of nanoparticles are mention in this review [7].

Organic nanoparticles-

Ferritin, micelles, dendrimers, and liposomes are among the organic nanoparticles depicted in Figure. The organic nanoparticles are non-toxic, biodegradable, and some of them, like micelles and liposomes, have hollow spheres. The term for heat- and light-sensitive nanocapsules is also well known. Due to these qualities, organic nanoparticles are the best option for medication delivery. Following that, target drug delivery employs nanoparticles extensively. Polymeric nanoparticles are another name for the organic nanoparticles. The nanosphere or nanocapsule is the most well-known shape of organic or polymeric nanoparticles. The outside boundary of the spherical surface of the matrix particles, whose former total mass is solid, adsorbs other molecules. In the latter scenario, the solid mass was encased by particles. [8].

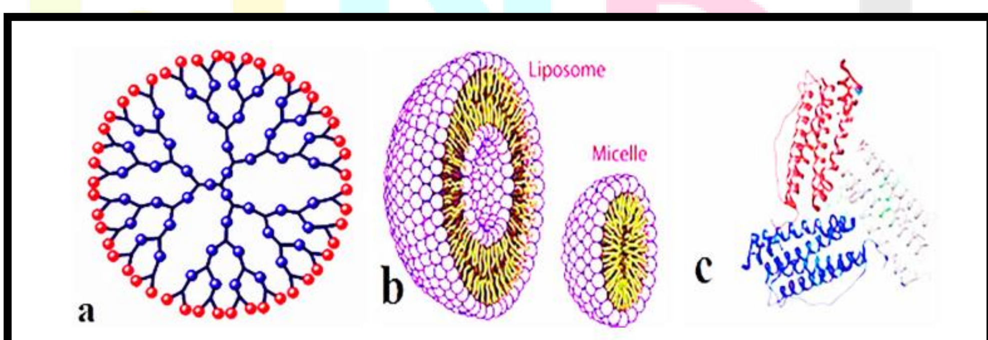

Fig no 02 - Organic nanoparticles (a) Dendrimers (b) Liposomes and Micelles (c) Ferritin

Inorganic nanoparticles-

Inorganic nanoparticles do not contain carbon. Non-toxic inorganic nanoparticles are present. The hydrophilic and biocompatible inorganic nanoparticles. Compared to organic nanoparticles, inorganic ones are much more stable. Metal and metal oxide nanoparticles are two categories of inorganic nanoparticles [9].

Metal nanoparticles-

Metals are utilised to create Metallica nanoparticles by employing destructive or constructive processes. The pure metal nanoparticles are produced using the metal precursors. Due to plasma on resonance characteristics, the metal nanoparticles have special optoelectrical capabilities. Shape, facet, and size all affect how metal nanoparticles are synthesised. All metals' nanoparticles can be created synthetically [10].

Well-known metal nanoparticles include those made of aluminium, gold, iron, lead, silver, cobalt, zinc, cadmium, and copper. Due to their small size (10–100 nm), surface characteristics like surface area to volume ratio, surface charge, pore size, and surface charge density, as well as their shapes (spherical, rod-shaped, hexagonal, tetragonal, cylindrical, and irregular), colours, and environmental factors (sunlight, moisture, air, and heat), nanoparticles have unique properties [11].

Metal oxide nanoparticles-

The goal of creating metal oxide nanoparticles is to alter the properties of the corresponding metal nanoparticles. For example, iron nanoparticles are converted to iron oxide nanoparticles through oxidation. Compared to iron nanoparticles, iron oxide nanoparticles have a higher level of reactivity.

Metal oxides are formed into nanoparticles due to an improvement in their reactivity and efficacy. Zinc oxide, silicon dioxide, iron oxide, aluminium oxide, cerium oxide, titanium oxide, and magnetite are examples of metal oxide nanoparticles. [12,13].

Ceramic nanoparticles-

Nonmetallic solids, or ceramic nanoparticles, are another name for them. By heating or subsequent cooling, ceramic nanoparticles are created. The nanoparticles of ceramic material might be polycrystalline, amorphous, porous, dense, or hollow. Due to their numerous applications in photocatalysis, catalysis, photodegradation of dye, and imaging, the researcher has focused on these nanoparticles. [14].

Carbon-based nanomaterial-

The carbon is the only component of the carbon-based nanomaterials. The classifications of carbon-based nanoparticles include fullerenes, carbon nanotubes (CNT), graphene, carbon black, and carbon nanofibers [15].

Fullerene-

C60 or C70 fullerenes are possible. Show that the fullerenes include hollow cage-shaped nanomaterial. Their notable commercial interest results from their electrical conductivity, electron affinity, structure, strength, and adaptability. Carbon molecules in the shape of pentagonal and hexagonal units make up fullerenes. Sp2 hybridization ties the carbon atoms of fullerenes to one another. The C60 or C70 fullerenes with diameters of 7.114 and 7.648 nm. A single layer or many layers of fullerene may exist. [16].

Carbon nanotubes (CNT)-

Carbon nanotubes are long, tubular structures with a diameter of 1-2 nm. Based on its diameter, the carbon nanotube can be classified as metallic or semiconducting. CNT's structure is similar to a graphite sheet rolling on top of itself. Rolling CNT are divided into single walled (SWNTs), double walled (DWNTs), and multiwalled categories (MWNTs) [17].

Multiwalled carbon nanotubes (MWNTs)-

Multiple rolled sheets make up multiwalled nanotubes (MWNTs). The smallest diameter of multi-walled nanotubes is 100 nm. Nanotubes are created by winding the graphene nanofoil, which has a honeycomb carbon lattice, into a hollow cylinder. Carbon tubes can be anywhere from a few micrometres and many millimetres in length. Strong CNT. CNT is easily bendable and returns to its original shape after being released without becoming brittle. CNT exhibits a variety of shapes, thicknesses, lengths, and numbers. [18, 19].

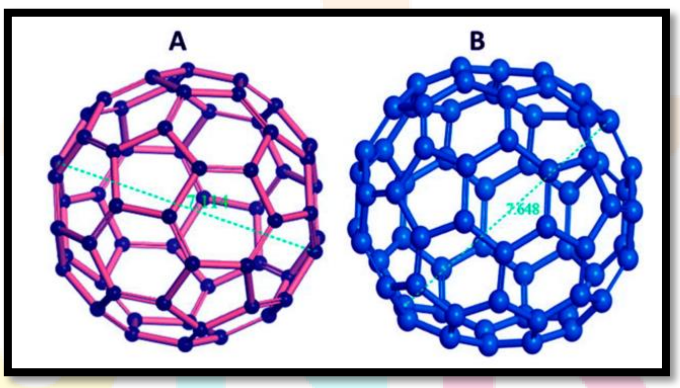

Fig no 03- Different form of Fullerenes (A) C60 and (B) C70.

Synthesis of Nanoparticles-

There are different methods for the synthesis of nanoparticles and these methods are divide into two main classes.

Top-down synthesis-

This synthesis uses a destructive method. Large molecules (bulk) break down into smaller molecules and these smaller molecules turn into nanoparticles. Grinding or milling, physical vapor deposition, and other destructive approaches are examples of top-down synthesis. Coconut shell nanoparticles are synthesized using this method.

Coconut shell nanoparticles are synthesized using a milling method, and raw coconut shells are finely ground for various time intervals using a planetary mill and ceramic balls [20].

They observed that the overall size of nanoparticles was affected by milling time using different characterization techniques. The crystallite size of the nanoparticles was observed to decrease with increasing milling time calculated from the Soheler equation. X-rays show that particle size decreases with time. The SEM results were also consistent with the X-ray pattern. A study showed the synthesis of spheroidal magnetite from iron oxide using a top-down method [21].

Using a top-down approach, we synthesized colloidal spherical carbon particles with sizes ranging from 20 to 50 nm. The synthetic procedure relied on the chemisorption of polyoxometallates onto the surface of interfacial carbon. Soot clumps into small spherical particles by adsorption. Micrographs showed that the carbon particle size decreased with sonication time [22].

A series of transition metal dichalcoenide nanodots (TMD ND,s) are fabricated from their substrates by a combination of grinding and sonication techniques. The overall size of transition metal dichalcoenide nanodots (TMD-ND,s) was found to be less than 10 nm. Transition metal dichalcoenide nanodots (TMD-ND,s) exhibit excellent dispersibility due to their narrow size distribution [23].

Table no Top-down synthetic techniques with merits, demerits

Top–down method	Merits	Demerits	Reference
Optical lithography	Long-standing, established micro/nanofabrication tool especially for chip production, sufficient level of resolution at high throughputs	Tradeoff between resist process sensitivity and resolution, involves state-of-the-art expensive clean room room-based complex operations	[24]
Soft and nanoimprint lithography	Pattern transfer based simple, effective nanofabrication tool for fabricating ultra-small features (<10 nm)	Difficult for large-scale production of densely packed nanostructures, also dependent on other lithography techniques to generate the template, and usually not cost-effective	[25]
Block copolymer lithography	A high-throughput, low-cost method, suitable for large scale densely packed nanostructures, diverse shapes of nanostructures, including spheres, cylinders, lamellae	Difficult to make self-assembled nanopatterns with variable periodicity required for many functional applications, usually high defect densities in block copolymer selfassembled patterns	[26]

	possible to fabricate including parallel assembly		
Scanning probe lithography	High resolution chemical, molecular and mechanical nanopatterning capabilities, accurately controlled nanopatterns in resists for transfer to silicon, ability to manipulate big molecules and individual atoms	Limited for high throughput applications and manufacturing, an expensive process, particularly in the case of ultra-high-vacuum based scanning probe lithography	[27]
E-beam lithography	Popular in research environments, an extremely accurate method and effective nanofabrication tool for	Expensive, low throughput and a slow process (serial writing process), difficult for	[28]

Thermal decomposition method-

Heat is employed in this endothermic process to break down chemicals. The chemical bond between two compounds is harmed by this heat. The decomposition temperature is the point at which an element begins to chemically break down. The nanoparticles are produced when meta decomposes at a specific temperature. Artificial gadolinium oxide nanoparticles with paramagnetic properties from Ahab, Atika, and others [29].

Table no 02- Bottom-up synthetic techniques with merits, demerits

Bottom-up	**Merits**	**Demerits**	**Refe rence**
Atomic layer deposition	Allows digital thickness control to the atomic level precision by depositing one atomic layer at a time, pin-hole free nanostructured films over large areas, good reproducibility and adhesion due to the formation of chemical bonds at the first atomic layer	Usually a slow process, also an expensive method due to the involvement of vacuum components, difficult to deposit certain metals, multicomponent oxides, certain technologically important semiconductors (Si, Ge, etc.) in a costeffective way	[30]

Sol gel nanofabrication	A low-cost chemical synthesis process based method, fabrication of a wide variety of nanomaterials including multicomponent materials (glass, ceramic, film, fiber, composite materials)	Not easily scalable, usually difficult to control synthesis and the subsequent drying steps	[31]
Molecular selfassembly	Allows self-assembly of deep molecular nanopatterns of width less than 20 nm and with the large pattern stretches, generates atomically precise nanosystems	Difficult to design and fabricate nanosystems unlike mechanically directed assembly	[32]
Physical and chemical vaporphase deposition	Versatile nanofabrication tools for fabrication of nanomaterials including complex multicomponent nanosystems (e.g. nanocomposites), controlled simultaneous deposition of several materials including metal, ceramics, semiconductors, insulators and polymers, high purity nanofilms, a scalable process, possibility to deposit porous nanofilms	Not cost-effective because of the expensive vacuum components, hightemperature process and toxic and corrosive gases particularly in the case of chemical vapor deposition	[33]

Characterization of Nanoparticles-

Zeta potential-

The zeta potential of nanoparticles is commonly used to characterize the surface charge properties of nanoparticles. It reflects the particle potential and is affected by particle composition and the medium in which the particles are dispersed. Nanoparticles with zeta potentials between -10 and +10 mV are considered to be nearly neutral, whereas nanoparticles with zeta potentials above +30 mV or below -30 mV are strongly cationic and anionic, respectively [35].

Zeta potential can also be used to determine whether the charged active material is encapsulated in the center of the nanocapsules or adsorbed on the surface. The magnitude of the zeta potential provides information on particle stability. The higher the potential, the greater the electrostatic repulsion and the better the stability.

It is important to consider that the magnitude of charge on the nanoparticle surface depends on the pH of the solution. Then use Henry's formula to calculate the zeta potential z. where Ue is the electrophoretic mobility, e is the dielectric constant, η is the absolute zero shear viscosity of the medium, f(ka) is the Henry function and ka is the measured value. ratio of particle radius to Debye length [36].

UV-visible absorption spectroscopy-

Absorption spectroscopy is used to determine the optical properties of solutions. A Send light into the sample solution and measure the amount of light absorbed. When changing the wavelength and measuring the absorbance at each wavelength. Absorbance can be used to measure the concentration of a solution using the Beer-Lamberts law. Optical measurements in UV-Vis spectrophotometers have different absorbance peaks such as 410nm [37, 38].

X-ray diffraction (XRD) analysis-

X-ray diffraction is a common technique for determining crystal structure and morphology. The strength increases or decreases depending on the amount of ingredients. This technique is used to determine the metallic properties of the particles, providing information about the translationally symmetric size and shape of the unit cell from the peak position, and the electron density within the unit cell from the peak intensity, i.e., where the atoms are arranged. Provide information about where you are. The XRD pattern is calculated using Cu-K radiation using an X per Rota-Flex diffractometer and the crystallite size = 1.5406 Å is calculated using the Scherrer equation [39, 40]:

$$CS= K / cos$$

Where

CS is the crystallite size, Constant

[K] = 0.94 is the full width at half maximum [FWHM] in radius

[β] = FWHM x π /180λ

Cos = Bragg angle.X-ray diffraction analysis with various nanoparticles has been studied by various research workers to find the high crystallinity of the prepared sample.

Fourier Transform Infrared [FTIR] spectroscopy-

It measures infrared intensity versus wavelength of light and is used to determine the nature of relevant functional groups and structural features of biological extracts, including nanoparticles. The calculated spectra clearly reflect the known dependencies of the nanoparticles' optical properties. Green synthetic silver nanoparticles analyzed using different leaf extracts were analyzed by Fourier transform infrared [FTIR] spectroscopy and exhibited characteristic peaks. [41, 42].

Microscopic techniques-

These techniques namely SEM and TEM mainly used for morphological studies of nanoparticles. Many researchers used these techniques to show that the synthesized nanoparticles were more or less uniform in size and shape [43].

Transmission electron microscopy (TEM)-

Transmission electron microscopy is a microscopy technique in which an electron beam passes through an extremely thin sample and interacts with the sample as it passes through. An image is formed from the interaction of electrons transferred through the sample. The image is magnified and focused on an imaging device such as a phosphor screen or layer of photographic film, or captured by a sensor such as a CCD camera. TEM forms an important analytical method in many scientific fields, both physical and biological. TEM has applications in cancer research, virology, materials science, pollution, nanotechnology, and semiconductors. [44].

Scanning electron microscope-

Scanning electron microscopy characterization is used to determine the size, shape, and morphology of the nanoparticles formed. SEM provides high-resolution images of the surface of the sample as required. Scanning electron microscopes work on the same principle as optical microscopes, but they measure electrons scattered by the sample rather than photons. Electrons can be accelerated by electric potentials, so they can have shorter wavelengths than photons. This allows the SEM to magnify images up to 200,000 times. Measure particle size and characterization. Sensitivity down to 1 nm on conductive or sputter coated samples [45]

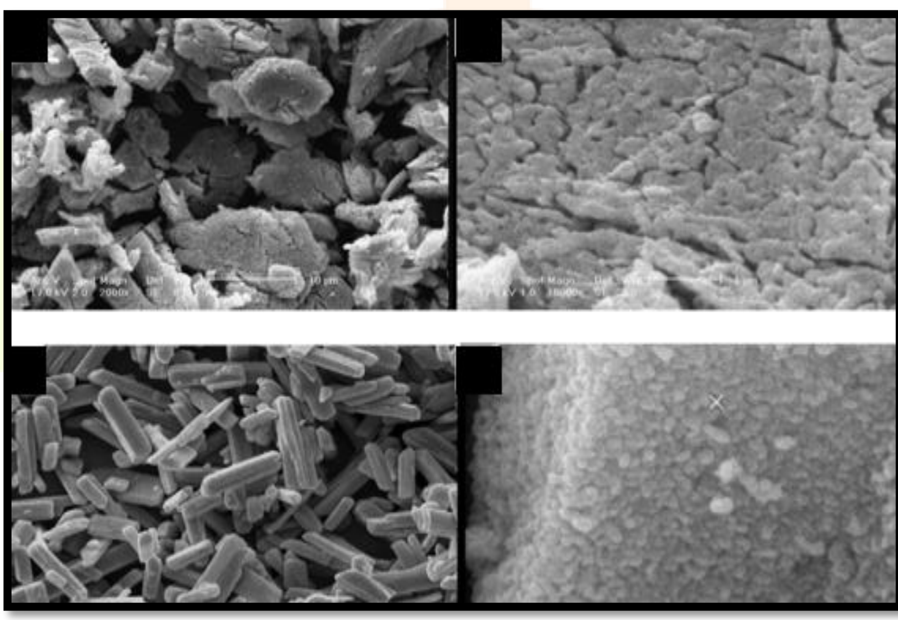

Fig no 04- SEM images of nano parities

General Applications of Inorganic Nanoparticles-

As anti-Infective Agents-

Metallic nanoparticles have been described as an HIV preventive treatment. Several studies have shown that silver acts directly on viruses as a virucidal agent by binding to the glycoprotein gp120. This binding in turn prevents CD4-dependent virion binding, effectively reducing HIV1 infectivity. Metal nanoparticles have also been reported to be effective antiviral agents against herpes simplex virus, influenza, and respiratory syncytial virus. [46].

As anti-Angiogenic-

Angiogenesis is the development of new blood vessels and occurs during normal development and in some disease states. It plays an important role in many diseases such as cancer and rheumatoid arthritis. Under normal conditions, angiogenesis is tightly regulated between various pro-angiogenic factors (VEGF, PDGF, TGF-B) and anti-angiogenic factors (platelet factor 4, TSP-1). In disease states, angiogenesis is turned on. Several reviews have reported that these agents have serious toxicities, including fatal bleeding, thrombosis, and hypertension. If only these nanoparticles were effective as anti-angiogenic agents, it could be overcome [47, 48].

In Tumour Therapy-

Bare gold nanoparticles were investigated to inhibit the activity of heparin-binding proteins such as VEGF165 and bFGF in vitro and VEGF-induced angiogenesis in vivo. Further studies in this area have reported that heparin-binding proteins are adsorbed to the surface of AuNPs and subsequently denatured. The researchers also showed that surface area played a large role in the therapeutic efficacy of her AuNPs. Mukherjee et al. also used a mouse ear model injected with an adrenoviral vector of VEGF to study the effect of gold nanoparticles on VEGF-mediated angiogenesis. , had less edema than similarly treated mice. Eom and his colleagues revealed in vitro and in vivo antitumor effects of 50 nm AgNps [49, 50].

In Leukaemia-

B-chronic Lymphocytic leukaemia (CLL) is a fatal condition that is primarily distinguished by apoptosis resistance. By co-culturing CLL B cells with an anti-VEGF antibody, it was discovered that more apoptosis was induced. Gold nanoparticles were employed in CLL therapy to boost the effectiveness of these drugs. The biocompatibility, extremely large surface area, surface functionalization, and simplicity of characterisation of gold nanoparticles were taken into consideration. VEGF antibodies were linked to the gold nanoparticles to test their capacity to destroy CLL B cells [51, 52].

In Rheumatoid Arthritis-

Scientists at the University of Wollongong (Australia) have developed a new class of anti-arthritic drugs that can be used with gold nanoparticles and have fewer side effects. Rheumatoid arthritis is an autoimmune disease that occurs when the immune system malfunctions and attacks the patient's joints. A new study shows that gold particles can penetrate macrophages and stop them from causing inflammation without killing them.Reducing the size of gold to smaller nanoparticles (50 nm) allows more Allowing gold to reach immune cells with less toxicity was published in the Journal of Inorganic Biochemistry [53, 54].

In Photo Thermal Therapy-

Gold nanoparticles strongly absorb light because they convert photon energy into heat quickly and efficiently. Photothermal therapy (PTT) is an invasive therapy that converts photon energy into heat to kill cancer. In radiotherapy, gold is a good absorber of X-rays, so the tumor takes up gold that absorbs more X-rays. As a result, more beam energy is deposited, producing an increasing local dose specific to tumor cells. Gold nanoparticles were more useful in treating cancer [55, 56].

Table no 03- Synthesis of different nanoparticles using different pants.

Type of NPs	Name of plant	Part of plant used	Size	Reference
Gold and silver	Aloe vera	Leaf	10–30 nm	[57]
Gold	Syzygium aromaticum (clove buds)	buds	5–10 nm	[58]
Silver	Citrus limon (lemon)	Lemon extract	<50	[59]
TiO2	Psidium guajava	leaf	32.58 nm	[60]
Cu	Ixoro coccinea	Leaves	80–110 nm	[61]
Fe	Plantain	Peel	Less than 50 nm	[62]

Conclusion-

This review describes the NPs, their types, synthesis, characterization, physicochemical properties and applications. Morphology can also be checked using various characterization techniques such as SEM. Due to their small size, NPs have a large surface area. A good candidate for a variety of uses. In addition to excellent optical properties even at this size, the importance of these materials in photocatalytic applications. Synthesis technology is the specific shape, size and magnetic properties of NPs. Although nanoparticles are useful in many applications, there are still concerns about health hazards due to their properties. Uncontrolled use and discharge into the natural environment. Nanoparticles should be considered to make the use of NPs more convenient and environmentally friendly due to their surprising properties. In recent years, it has attracted attention in many fields such as energy and health. Care, environment, agriculture, etc. Poorly soluble nanoparticle technology, poorly absorbed and labile bioactives likely Promising results.

Conflicts of interest-

There are no conflicts of interest and disclosures regarding the manuscript.

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