GREEN CHEMISTRY: AN ENVIRONMENTAL FRIENDLY WAY TO NANOMATERIALS SYNTHESIS

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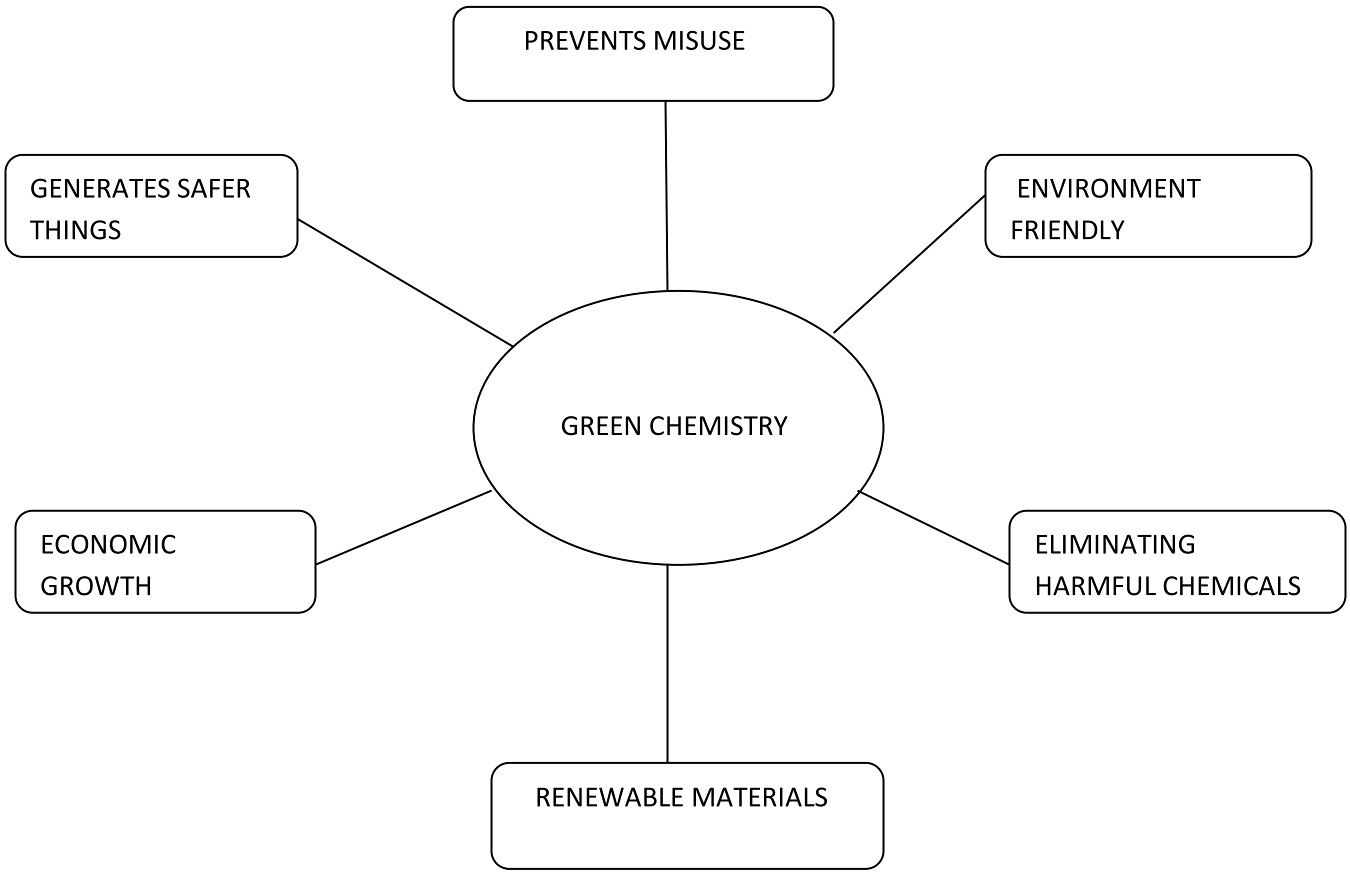
1. INTRODUCTION

Nanotechnology is seen as a crucial 21st century technology and has created a lot of excitement around the world, but it has slowed down due to a lack of understanding of the risks involved with it and a lack of policies to control new concerns. However, researchers keep working to overcome obstacles in the areas of managing, producing, funding, regulatory, and technical concerns[1]. The use of synthetic mixtures and physical tactics had fallen out of favor over the last several years, but the researchers' serious worldview was changed by the realization of their destructive effects on human health and condition. The term "green synthesis" is now used to describe the process of plants or their metabolites combining nanoparticles (NPs)[2]. In order to achieve sustainability, green nanotechnology involves the biosynthesis of nanomaterials from natural bioactive agents such as plant materials, microbes, and various bio-waste like agricultural residues, eggshells, vegetable waste, fruit peels, and others. It is a strategy that is inexpensive, straightforward, safe, low-risk, nontoxic, and ecologically friendly. Green nanotechnology is a key component of clean technologies intended to improve the environment and transform extra bio-active goods into more profitable and sustainable green nanomaterials[3].

Unsurprisingly, the usage of nanostructured materials has led to increased concerns about human health and environmental safety, which has favored the growth of a sub-field devoted to environmentally friendly and safe-by-design solutions. Innovative approaches could reduce the hazards that nanomaterials pose to the environment and to human health throughout the course of their lifespan, for instance by substituting acceptable eco-friendly processes or products for harmful ones . Green nanotechnology uses the tenets of green chemistry to create nanomaterials that are sustainable in their creation, usage, and disposal[4].

2. GREEN CHEMISTRY

While talking about green chemistry at first what's important is what is green chemistry??



ASPECTS OF GREEN CHEMISTRY [5]

GREEN CHEMISTRY can be elucidated as "Generating chemical products and processes to decrease or get rid of the usage and creation of insecure chemicals." This elucidation came in light for the first time at the start of the 1990s[6] .The idea of design is the key component of green chemistry. Design cannot be done by accident since it is an expression of human intention. It comprises innovation, preparation, and methodical conceptualization. ''Design guidelines'' are the Twelve Principles of Green Chemistry[7].And the Twelve Foundations of Green Chemistry[8] are discussed below:

1. Protection Avoiding waste altogether is preferable to treating or cleaning up garbage that has already been produced.

2. Atom Economy Maximizing the assimilation of all components utilized throughout the process into the finished product should be a goal of synthetic approaches.

3. Chemical Synthesis that are not as dangerous Wherever possible, synthetic ways should be created to utilize and produce chemicals that are safe for both the environment and humans.

4 .Making safer chemical designs Chemical goods should be made with the least amount of toxicity possible in mind.

5. More secure solvents and accessories Wherever feasible, auxiliary compounds (such solvents, separating agents, etc.) should be avoided, and when they are utilized, they should be harmless.

6. Energy-efficient design Chemical processes' energy requirements should be recognized for their negative economic and environmental effects and ought to be reduced. If feasible, use artificial means should be carried out at the surrounding pressure and temperature.

7. Use of Renewably Sourced Feed-stocks A feedstock or raw resource should be renewable whenever it is technically and economically feasible, rather than depleting.

8. Cut back on derivatives Derivatization that isn't essential (using blocking groups ,Protection/ deprotection, temporary alteration of physical/chemical processes) must to be minimized or avoided, if at all feasible, trash and can produce reagents.

9. Catalysis Stoichiometric reagents are inferior to catalytic reagents, which should be as selective as feasible.

10. Creating a Degradable Design Chemical goods should be made to degrade into harmless degradation products at the end of their useful life and not linger in the environment.

11. Real-time evaluation to prevent pollutionFurther development of analytical techniques is required to provide real-time, in-process monitoring and control before potentially dangerous compounds emerge.

12. Chemistry that is inherently safer for preventing accidentsSubstances and their forms that were used in to reduce the likelihood of chemical mishaps, such as releases, explosions, and fires, a chemical method should be used.

For the simplicity of 12 principles of green chemistry a acronym 'PRODUCTIVELY' was revised which binds up the soul of all principles in just two or three words.

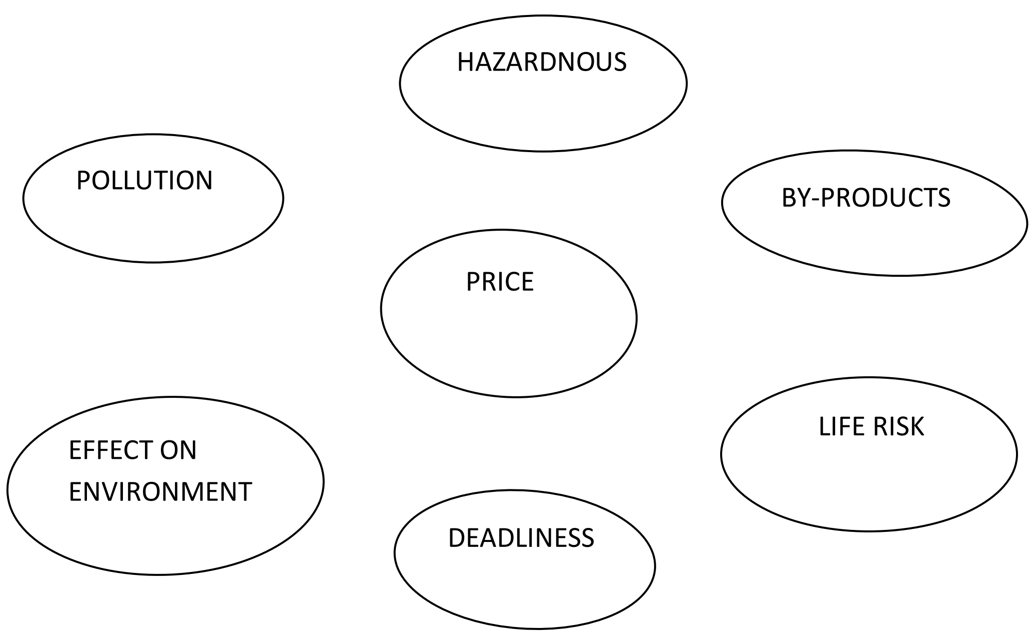
P- Prevents misuse
R- Renewable materials
O- Omit by-products steps
D- Degradable synthetic products
U-Use safe chemical methods
C- Catalytic reagents
T- Temperature, Pressure ambient
I- In-process monitoring
V- Very few additional substances
E- E-factor, increase feed in product
L- Low pathogenicity of chemical products
Y- Yes, it is safe/protected from harm

These are the 12 condensed principles of green chemistry[9].

3. GREENCHEMISTRY-SCOPE AND APPLICATIONS

Green ideas promote safe, eco-friendly, and clean methods for creating, processing, and using any physical thing. The application of this idea goes beyond industry to include research institutions, governmental agencies, environmental protection organizations, etc., which has prompted the creation of novel or modified processes for the sustainable synthesis, processing, as well as controlling of chemical substances to lessen risks to human health and the environment[8].

Following the principles of green chemistry, several cutting-edge ideas were created for companies to discover data for the evaluation and prediction of green chemicals. One of them, the green chemistry expert system (GCES), offers recommendations on how firms might apply green chemistry sustainably. It contains data on chemicals, the quantity of reactions, and the yield of those reactions. In order to estimate the amounts of the products and their waste, it also recognizes the characteristics of the reaction process. It offers guidance on safer chemical synthesis techniques. Additionally, this source offers details on the physical-chemical characteristics and the circumstances of various alternative, less dangerous compounds' reactions[10]. The main goal of green chemistry is to build a sustainable future; it is not only a lab curiosity. Companies are now able to market these concepts because to the growing number of green approaches created by academic and corporate experts. By implementing the green chemistry principles, industry, from small firms to huge organizations, has already taken significant steps towards sustainability. The creation of less dangerous commercial products and processes, the transition from inefficient chemical synthesis to bio-based synthesis, and the substitution of oil-based feed-stocks with renewable starting materials are just a few examples of the significant decisions that have been made and will ultimately have significant effects on the global chemical markets[11].



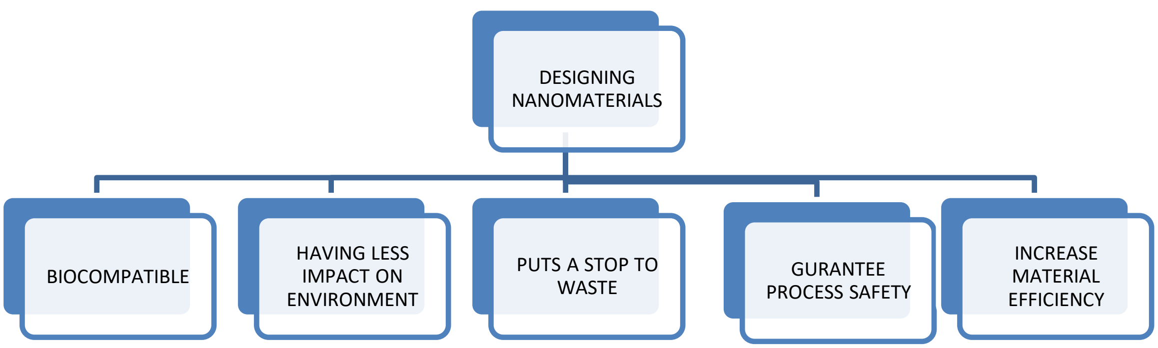
WHAT GREEN CHEMISTRY REDUCES?[5]

4. GREEN NANOTECHNOLOGY

Green chemistry cum the skeleton of the Principles of Green Chemistry have been incorporated into green nanotechnology[12]. In green nanotechnology, new design rules have been established for engineering non dangerous nanomaterials, which aren't only safer during the product phase but also during the material's life cycle. To achieve this ideal, design rules grounded on green chemistry must be followed. This new approach facilitates the development of safer, indispensable accoutrements for the conflation of nonhazardous, marketable grade nanomaterials. Along with safety, this approach focuses on the desirable parcels of accoutrements and efficacy of product. Eventually, the green nanotechnology approach seeks the development of competent indispensable strategies for reliably creating nanomaterials, with well- defined chemical and physical characteristics. Similar to green chemistry, in this approach the safety of mortal health and the environment is put foremost through applicable product design and process control[13][14].

5. DESIGNING GREEN NANOMATERIALS

The principles of green chemistry can be utilized in the design of green nanomaterials in the following ways:



Designing aspects of green chemistry

•Designing friendly nanomaterials: examining the required characteristics of nanomaterials (size, structure and structure functionality) biological properties while utilizing safe raw materials.

•Designing to lessen the impact on environment: Analyzing the toxicity of damaged subunits, nanomaterial degradation features, and the employment of biosynthetic methods.

•Designing to put a stop to waste: Limiting the production of undesirable derivatives or by-products, eliminating the usage of solvents for purification, and creating alternative purification techniques.

•Designing to guarantee process safety: replace harmful reagents and solvents with benign reagents and renewable feed-stocks.

•Designing to increase material efficiency: new safe raw ingredients and solvents are optimized together with real-time monitoring of the synthesis of nanomaterials.

By building in former discussed design techniques in nanofabrication could rise to the creation of justifiable green nanomaterials.

5.1 METHODOLOGIES OF NANOPARTICLES SYNTHESIS

Numerous techniques are used to manufacture nanoparticles, which may be divided into two categories: bottom-up techniques and top-down techniques.. The primary distinction between the two approaches is the raw material used to create the nanoparticles. While atoms or molecules are the starting material in bottom-up approaches, top-down methods start with bulk material and employ various physical, chemical, and mechanical processes to reduce particle size to nanoparticles.

5.1.1 TOP-DOWN METHODS: With this technique, large bulk materials are broken down into tiny nanoparticles. The size reduction of the initial material through various physical and chemical processes is the foundation for the creation of nanoparticles. It covers techniques including thermal, laser, and mechanical milling. Despite being simple to use, top-down approaches are not ideal for creating irregularly shaped and very tiny particles[15].

5.1.1.1 MECHANOSYNTHETIC METHODS: The cheapest methods for manufacturing nanomaterials in large quantities are mechanical ones. Perhaps the simplest of them all is ***ball milling***. Through mechanical attrition, in which kinetic energy from a grinding media is transmitted to a material undergoing reduction, ball milling creates nanoparticles. Nanomaterials are "put back together" in an industrial-scale processes called consolidation and compaction to create materials with improved characteristics. This is one approach to create metallic alloys.

5.1.1.2 THERMAL METHODS

that provide heat to a manufacturing process because they make up a broad category. Of them, electrospinning is a technique for creating materials for nano-threads. When it comes to energy input, high energy techniques are those that demand an excessive amount of heat, electricity, or solar energy. The first regulated method of creating carbon nano-tubes was using arc discharge. Solar flux and laser ablation are also effective. Control over quality and possible upgrade is the issue. Top-down chemical fabrication styles are always easy to upmarket and numerous, similar as anodizing, are wide artificial processes. Lithographic styles, as we all know relatively well, although energy ferocious and taking precious outfit and installations, are top-down styles able of producing for the utmost part micron-sized features. Lithography is the means of making published circuits and computer boards for several decades now. The drive to miniaturize in the future is a expensive adventure as more important sources(high energy electron shafts and shorter wavelength sources), support outfit and installations are needed. Nanoimprint lithography(o) is lithography but not according to typical norms. It is more like template conflation. A template material is made first and also stamped into a soft polymeric material to form a pattern. The template stamp is formed by top-down system as is the stamped material. Nanosphere lithography utilizes latex spheres that form a templated matric. So, we can call these ways template process as well[16].

5.1.2 BOTTOM-UP METHODS : Although easily available, inexpensive, and effective, bottom-up methods lack precise control over particle form, size, and dispersion[17].

5.1.2.1SOLID STATE METHODS

PHYSICAL VAPOR DEPOSITION METHOD

Material is placed on a surface using the physical deposition method as either a thin film or as nanoparticles. Material is vaporized by highly controlled vacuum techniques including thermal evaporation and sputtering deposition before being further condensed on a substrate. The fabrication of a thin layer of lanthanum strontium cobalt typically uses physical vapor deposition methods, such as pulsed vapor deposition.

For pulsed laser deposition, a solid target is subjected to laser ablation, which results in the generation of plasma of ablated species. These ablated species are then deposited on a substrate to create a film. Carbon nanotubes are frequently coated using this technique with thin films and metal nanoparticles[15].

CHEMICAL VAPOR DEPOSITION METHOD

In the late 19th century, chemical vapor deposition was first documented and patented, and technique was used to create carbon fiber filaments and carbon powder color pigments for electric lamps. This method of deposition involves the chemical interaction of gaseous molecules containing atoms necessary for film formation to deposit a thin film of the target material on a surface .A thin film is created by a sequence of chemical interactions involving the precursor fragment, the substrate surface, and the target material, which is released as a volatile molecule and functions as a precursor. In this approach, the surface chemical reaction often produces atomic layer deposition (ALD) thin films[15].

5.1.2.2LIQUID STATE SYNTHESIS METHOD

SOL GELMETHOD

Livage etal.(1988) first time review this fashion on sol gel chemistry of transition essence oxides. The sol gel system of nanoparticles conflation involves either; a) Mixing of preformed colloids essence(oxide) with a sol containing the matrix forming species followed by gel conformation, b) Direct mixing of essence and essence oxide or nanoparticles within a pre hydrolysed silica sol. c) Complexation of essence with silone and reduction of essence before hydrolysis. In this system, a network conformation is introduced using colloidal suspense(sol) and gelatin to form a network in nonstop liquid phase(gel). The ions of essence alkoxides and aloxysilanes are used as a precursor for conflation of colloids. The tetramethoxysilane(TMS) and tetraethoxysilane are most generally employed which forms silica gel.

Essence alkoxides are organo- metallic precursor for colorful essence similar as silica, aluminium, titanium and numerous other and are immiscible in water. Alcohol is used as collective detergent. originally in this system, homogeneous result of one or further named alkoxides is set and a catalyst is added to initiate a response at controlled pH*. The sol- gel conformation involves four main way; hydrolysis, condensation, flyspeck growth and agglomeration of flyspeck*.

In direct rush of essence or essence oxide fashion, the essence oxide patches are rained from silica sol [15] generally by heat treatment at low temperature. Thin flicks are substantially prepared by using this method.

In general, the "bottom-up" strategy, also known as wet chemistry, is focused mostly on solution phase chemistry and differs from the "top-down" strategy in that it employs physical means to minimize crystal size[18]

However,environmentally friendly green technologies means green methods are affordable, widespread, and produce stable information[19]**.**

5.2 GREEN SYNTHESIS OF NANOMATERIALS

Green synthesis ofnanomaterials, includes synthesis using microbes,plant extracts or using plant based phytochemicals. Biosynthesis or Green synthesis strategies have been developed as a new method to improve or to get rid of the physical and chemical approaches challenges. Amongst these plant-mediated green synthesis of NPs is considered a very high rated accepted technology in the fast pace era. Green Chemistry has an upper hand over the chemical techniques as a facile, economical, environment-soothing, readily scaled up, without high temperature, pressure and energy, biocompatible, without using hazardous chemicals and safe for human therapeutic uses[20].

5.2.1 MICROBIAL SYNTHESISOF NANOPARTICLES One of the strategy of green nanomaterial conflation is biosynthesis, which is a complex multistep conflation approach regulated by catalytic enzymes, where natural products are used to produce the material. Green biosynthesis incorporates different methodologies,as nanomaterials are created using *fungi*, actinomycetes, algae. Bacteriaare well known for the intracellular and extracellular synthesis of inorganic materials; also they have demonstrated the ability to produce essence nanoparticles through biosynthesis. Geobacterferrireducens, Bacillus subtilis were set up to be effective in creating iron and gold nano- patches, independently[21]. The natural conflation of tableware and gold nanoparticles was also observed by a fungal mediated green process utilizing Aspergillus flavus and Fusarium oxysporum[22]. Actinomycetes are also effective biogenic microorganisms, enjoying the concerted characteristics of both prokaryotic bacteria and fungi. Actinomycete species like Thermomonospora and Rhodococcus have been observed to be able of producing gold nanoparticles in the presence of alkaline conditions also, algae grounded biosynthesis of nanomaterials has also been success-fully accomplished. For example, a brown algae called Sargassummuticumis able of preparing iron oxide nanomaterials through biogenetic synthesis[23]. also, the intracellular conflation of gold and some other nanomaterials wasalsoexploredinplants suchasBrassicjuncea, Festucarubra, and Medicago etc.

MICROBIAL SYNTHESIS OF NANOPARTICLES

NANOMATERIALS	**BIOSYNTHETIC AGENT**	**APPLICATIONS**	**REFRENCES**
GOLD NANOSPHERES	Pseudomonas denitrificans- bacteria	Stable GNP, comtrol over the size an shape	[24]
GOLD NANOPARTICLE	Prasiolacrispa- fresh water green algae	Nearly spherical shape and average crystallite size 9.8nm	[25]
GOLD NANOPARTICLE	Sargassumswartzii- marine algae	Induced cytotoxicity, mitochondrial damage	[26]
SILVER NANOPARTICLE	Bacillus lichen infirmis- soil bacteria	Antibacterial and antibiofilm activity	[27]
PALLADIUM NANOPARTICLE	Chlorellavulgaris- single cell green algae	Rapid synthesis , stabilized particles	[28]
SILVER NANOPARTICLE	Bacillus methylotrophicus – methanol-utilizing bacterium	Remarkable antimicrobial activity	[29]

5.2.2 Green Synthesis Using Plants

Almost every part of the plant has been used for nanoparticle synthesis like Leaves, roots, fruits, seeds etc. Plant extracts are rich in polyphenols, flavonoids, tannic acid, terpenoids, ascorbic acids, carboxylic acids, aldehydes, amides, and other compounds besides reducing polysaccharides, which produces the ideal redox conditions for the production of nanomaterials from their precursors. These natural reagents work as potent reducing agents without endangering the produced nanostructures since phytochemicals are present in plant extracts. Furthermore, thanks to the capping effects of phytochemicals, which do not alter the desirable qualities[30][31]. Leaves extracts such as Mangifera Indica, SyzygiumCumini ,Carica Papaya ,tea leaves ,aloe-vera and many more been utilized for the biosynthesis of nanoparticles[32][33].

Nanomaterials can be synthesized using root, seed and fruit extracts. The biological technique is always appealing and environmentally beneficial when producing ZnO nanoparticles. Zingiber officinale(ginger) aqueous root extracts may be used to make ZnO nanoparticles. The flavonoid test indicated that the root extracts were abundant in flavonoids, which improved the biogenic production of ZnO nanoparticles[34].Silver nanoparticles can be synthesized using dried roasted Coffea Arabica seed extract[35] and silver nanoparticles also can be synthesized using papaya fruit extract[36].

5.2.3 Synthesis of nanoparticles using natural plant based products:

Plant based natural products have been used by many researchers for synthesis of nanoparticles. Clove oil is one such product. Clove oil contains 81-95% of Phenols (Eugenol with about 3% of Acetyleugenol), Sesquiterpenes(α- and β-Caryophyllenes) and small quantities of esters, alcohols and ketones. It has been used for synthesis of Silver nanoparticles.The probable mechanism of reduction of Ag+ via clove oil is given by the proton donation of eugenol structure reducing the Ag+ to Ag0 , thus forming AgNPs. In addition , the phytochemicals present in the essential oil also interact on the surface of NPs , resulting in stabilisation and preservation[37].

Ascorbic Acid is another such natural product used for nanoparticle synthesis.The ascorbic acid was used as reducing agent to synthesize silver nanoparticles due to its low toxicity and high biodegradability The ascorbate ion is the predominant species at typical biological pH values. It is a mild reducing agent and antioxidant. It is oxidized with loss of one electron to form a radical cation and then with loss of a second electron to form dehydroascorbic acid[38].

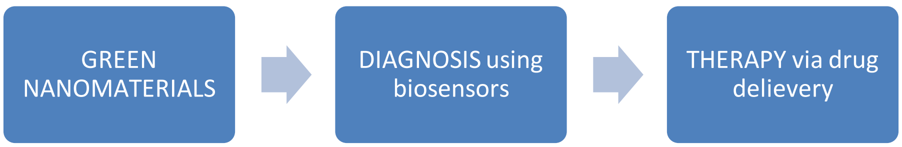
Even the Green Coffee (G-Coffee) extracts has also been used to make iron nanoparticles. G- Coffee bean excerpt(GCBE) has high contents of composites, similar as polyphenols, that ameliorate the protective agents against habitual conditions performing from oxidative stress. GCBE is rich in phenolic composites, antioxidants, and a family of esters formed by chlorogenic acids (CGA)(several hydroxyl cinnamic and quinic acids)[39].

5.3 APPLICATIONS OF GREEN NANOMATERIALS

In the fast pace era, nanomaterials are used in many fields. Medicines, cosmetics, detergents, electronics, energy storage devices, water filtration systems, etc. are examples of commercially produced goods. This chapter will concentrate more on the biological applications of green nanoparticles due to the enormous interest in biocompatible materials in the healthcare industry

BIO-MEDICAL APPLICATIONS OF GREEN NANOMATERIALS

Due to their enhanced biocompatibility, green nanoparticles are often employed in the biomedical industry. The most significant biological uses of greener nanomaterials include diagnosis and treatment. Another application that includes cell isolation and cellular proteomics is cell separation. Green nanomaterials are used for bio-sensing, bio-imaging (MRI, CT), and stem cell tracking in nanomaterial-mediated diagnostics. Green materials' medicinal potential in drug transport, hyperthermia, and antimicrobial-anticancer action has all been studied[7].



Biomedical applications of nanomaterials

DIAGNOSIS APPLICATIONS OF GREEN NANOMATERIALS

Using MRI computed tomography, the metal nanoparticle-mediated diagnostic procedure is established for biological imaging. Excellent superparamagnetic characteristics were produced utilizing a green method that included microwave production of duplex-coated iron oxide nanoparticles, making them ideal for MRI imaging[40]. A green manufactured iron oxide-gold nanohybrid system for contrast agents in MRI and CT imaging has been created by Narayanan et al.[41].Biosensors created using nanomaterials are utilized for diagnostics in addition to bioimaging. For the creation of biosensors to electrochemically reduce glucose oxidase and monitor glucose levels, reduced graphene oxide-gold nanocomposites were created using rose water[42]. Another study by Zang et al. used a one-pot green synthesis technique to create a self-assembling membrane made of reduced graphene oxide and gold nanoparticles. The amperometric detection of hydrogen peroxide, a cancer biomarker, is carried out using this nanohybrid[43].By using gold and silver nanoparticles in a quercetin-based green synthesis method, Bollella et al. created a new third generation lactose biosensor based on cellobiose dehydrogenase. The created electrochemical sensor demonstrated excellent lactose detection sensitivity and stability[44].

NANOMATERIALS	PLANT SAMPLE	PRECURSOR	APPLICATIONS	REFERE-NCES
IRON NANOPARTICLES	Sesamum indicum	Ferric chloride	Signficantant typhoid activity	[45]
IRON NANOPARTICLES	Mangifera-Indica	Ferric Chloride		[32]
IRON NANOPARTICLES	Syzygium Cumini	Ferric Chloride	Antibacterial and Antifungal	[46]
IRON NANOPARTICLES	Carica Papaya	Ferric chloride	Photocatalytic and Cytotoxicity	[47]
IRON NANOPARTICLES	Tea extract	Ferric sulphate		[48]
IRON NANOPARTICLES	Camellia sinensis (green tea)	Ferric chloride	Degradation of dyes, removal of heavy metals, antibacterial activity	[20]
SiILVER NANOPARTICLES	Aloevera	Silver nitrate	Antibacterial activity	[49]
SILVER NANOPARTICLES	Camellia sinensis	Silver nitrate	Sensing of Cu^{2+} and Pb^{2+} ions in aqueous solutions	[50]
SILVER NANOPARTICLES	Impatiens balsamina	Silver nitrate	Antibacterial activity	[51]
SILVER NANOPARTICLES	H.isora	Silver nitrate	Antibacterial and antioxidant activity	[38]
SILVER NANOPARTICLES	Green tea	Silver nitrate	Antimicrobial, cytotoxicity	[52]

SILVER NANOPARTICLE	Nicotianatobaccum	Silver nitrate	Antibacterial activity	[53]
SILVER NANOPARTICLE	Crotalaria verrucosa		Economical way to reduce dengue vector larval population	[54]
COBALT NANOPARTICLE	Catharanthusroseus	Cobalt chloride	Antioxidant, antibacterial, hemolytic and dye degradation	[55]
COBALT NANOPARTICLE	Psidiumguajava	Cobalt nitrate	Photocatalytic, antibacterial and antioxidant activity	[56]
COBALT NANOPARTICLE	Populus ciliate	Cobalt nitrate	Antibacterial activity	[57]
COBALT NANOPARTICLE	Raphanussativus var. longipinnatus	Cobalt acetate	Antibacterial, Cytotoxicity	[58]
COBALT NANOPARTICLE	Eucalyptus	Cobalt chloride	Removal of lead from polluted water	[59]
GOLD NANOPARTICLE	Couroupitaguianensis	Chloroauric acid	Anticancer activity	[60]
NICKEL NANOPARICLES	Fumaria officinalis	Nickel sulfate	Antioxidant and anti human ovarian cancer activity	[61]
NICKEL NANOPARTICLES	Desmodiumgangeticum	Nickel chloride	Atibacterial, antioxidant and cytotoxicity	[62]

6. LIMITATIONS OF GREEN NANOTECHNOLOGY

The practical implementation of green chemistry's concepts is a hurdle[8].A systemic risk assessment methodology, a clear waste categorization process, industrially driven and legislative initiatives, and the use of suitable technology to control cum serve nanowaste streams are additional important difficulties facing current nanowaste management[63]. The absence of precise design standards for the creation of green nanomaterials, however, may cause significant issues in the future. The demand for particular guidelines in the development of green products is another issue. Moreover, the production of green nanomaterials is hampered by the relatively frequent updating of toxicity regulations. The wide concept of acceptability, which tension the economic viability of the method, is another problem with green nanotechnology. Another concern is the effectiveness of reprocessing and reusing the green goods utilized in synthesis methods[14]. Energy consumption reduction and energy waste minimization are additional obstacles in the use of green technology. When using green nanoproduction approaches, creating a plant design with lesser energy needs, for instance, might be quite difficult. The industry adoption of cutting-edge green benign technology is one of the obstacles to implementation. Execution may be restricted as a result of process design, legal difficulties, or financial limitations[64].

7. FUTURE PRESPECTIVE

Because plant extracts include phytochemicals, they function as potent reducing agents without endangering the safety of the nanomaterials that are produced.In addition to reducing polysaccharides, plant extracts are rich in polyphenols, flavonoids, tannic acid, terpenoids, ascorbic acids, carboxylic acids, aldehydes, amides, and other compounds that produce the ideal redox conditions for the production of nanomaterials from their precursors. Additionally, phytochemicals serve as capping agents to prolong the stability of developed nanomaterials without changing their desirable qualities[64][13]**.**

8. CONCLUSION

The desire to create green nanotechnology, which combines green chemical principles with nanotechnology, has been spurred by safety concerns of nanomaterials for human health and ecosystem. Numerous grave issues relating to nanotoxicology might be successfully addressed by green nanotechnology. Design modifications of material synthesis and careful handling might greatly increase safety levels.Safer goods have been created while lowering production costs, raw material usage, harsh chemical use, and energy requirements by adopting green chemical techniques. Implementing the Atom economy allowed for the efficient use of resources and the recycling and reuse of inputs. Process efficiency was achieved by waste minimization and prevention of wasteful intermediates. Adopting biogenic synthesis methodologies has boosted product quality to safer levels instead of using hazardous, chemically synthesized or modified nanoparticles .More biocompatible goods that may be safely supplied to the body for diagnostic and therapeutic purposes are made available by using green nanotechnology. Additionally, green nanotechnology provides abright future for thecommercialpharmaceutical, cosmetic, electrical, and other sectors without endangering the environment.

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