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Plant Mediated Green Synthesis, Characterization and Applications of Bimetallic Nanoparticles

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Abstract: Studies on Metal nanoparticles synthesized using plant extracts are drawing much attention in the research studies due to their distinctive physicochemical, electrical and magnetic properties. As these Plant Extracts contain polyphenols, flavonoids, ions, etc which help in the formation of the good nanoparticles with better yields. The nanoparticles thus synthesized are found to be stable with respect to their size, shape and have higher yields. Further, the nanoparticles thus formed are studied by interacting them with various biomolecules under various physical conditions to often improvise their application. Researchers are quite interested in this area as the product from this synthesis method is less hazardous when compared to the chemical methods and is cost effective too. It is thus becoming mandatory to exploit and process these nanoparticles considering their wide application in drug development, pharmaceutical formulation, pharmaceutical Engineering and Environment. The applications of bio-nanotechnology are greatly and widely appreciated in the modern technology in the fields covering drug delivery, gene-therapy, bio-imaging and tissue engineering. Green Synthesis Methods are quite eco-friendly and therefore serve as significant factors for vital raw products like enzymes, substrates and other materials for the formation of nanoparticles. The newly and appropriately coined Nano biotechnology thus has wide avenues of its applications in the Biochemical Science field of analysis of Biomolecules.

In the present summary an effort is made to review and disclose the contemporary updated information on the green synthesis of metals and their oxide nanoparticles, their advantages over the other physical and chemical methods. The review also focuses on the mechanism of the synthesis from the plant extracts, their compounds and their applications that would benefit the on-going and future researchers deeply and also it can serve as a manual to the beginners in this field.

Keywords: *Nanoparticles; Biomolecules; Metals; Plant Extracts; Synthesis; Nanobiotechnology*

1.0. Introduction

Over the past several decades Research scientists and Technologists have been investigating numerous precursor molecules using various approaches for the synthesis of the finest nanoparticles. The branch of Nanotechnology offers wide range of applications in every field possible like drug delivery, diagnostic, engineering, environment, etc. The evolving offshoot produces the particles with constant innovation and improvement that are of the size 1-100nm with enhanced physicochemical, biological, Electrical properties compared to their parent /precursor molecules. The synthesized nanoparticles display significant morphology, distribution. Active surface area to volume ratio of these particles is higher due to their nano size. Hence, they play an important role in the biological applications such as catalysis, therapeutics, as antimicrobial agents, biosensors, drug targeting and delivery (Morteza et al., 2018). Nanoparticles can be synthesized by physical, chemical and biological methods. Over the recent times synthesis by Green method/Biological method have gained curiosity, attention and thrust over the other two methods in the scientific community as these methods have minimized the negative or damaging effects.

Green synthesized metal nanoparticles have been acknowledged because of their more suitable physicochemical properties. Advantage of Green synthesis method are: 1) the synthesized material is less hazardous and safe for environment 2) The particles thus obtained are less toxic for humans 3) The method is cost effective 4) Plant extracts serve as natural reducing agents and stabilize the nanoparticles 5) Fabricating new clean eco-friendly technologies, Plants and processing equipment are possible (Li et al.,2016).

Among various types of nanomaterials such as metallic, Graphene, Quantum dots, Carbon nanotubes, Liposomes, Polymeric etc. the present study essentially deals with bimetallic nanoparticles and their application in brief. Bimetallic nanoparticles consist of two different metals and hence offer extra degree of interaction over the monometallic nanoparticles. Therefore due to their refined physico-chemical properties, bimetallic nanoparticles are gaining prominence owing to the fact that they have wide practical applicability in various fields such as imaging, biosensors, environmental, medicine etc (Jagpreet et al., 2018).

1.1. Criteria for the synthesis of nanoparticles

Synthesis of nanoparticles via Green Synthesis method involves the use of precursors that are bio in origin. The reaction conditions need monitoring of various operating parameter like temperature, pH, atmospheric pressure, Solvent, reducing agents etc. Several workers across the globe used plant extract as they are rich in numerous phytochemicals in various plant parts such as aldehydes, ketones, flavonoids, amides, terpenoids, carboxylic acids, phenols etc (Jagpreet et al., 2018).

a) Selection of plant sources: The first step in the synthesis of nanoparticles is the identification of the plant source for the good particle formation. The criteria for the selection of a good plant is that they should be locally available thus ensure easy harvest. The selection of the plant part is essentially important as it plays a major role in the particle formation. It is always advisable to choose the part is the nontoxic, disease free. The Selected part should be brought to research table as quickly as possible after harvest and should be sterilised before the procedure begins (Dhiman et al., 2023).

b) Morphology: Nanoparticle formed can be of various shapes such as sheets, spheres, flakes, fibres, mesh like network, etc. The shape of the particle is critical to its function. The shape and size is dependent on parameters such as temperature, pressure, pH, salt concentration, incubation period or reaction time etc. The smaller is the particle size, more is the surface area of interaction and thus can be studied for a variety of applications (Ngoan et al., 2023).

c) The Chemistry of the plant extract: The plant extracts are rich in several bioactive compounds such as phenols, antioxidants, flavonoids, alkaloids, terpenes, carboxylic acids, amino acids etc. The concentration of these compounds play a role in the morphology of the particle and time required for the reaction. These phytochemical compounds may vary in type and amount from species to species. Hence plant extract including its habitat should be carefully analysed before the synthesis of nanoparticle (Nguyen et al., 2023).

The compounds present in the plant extracts acts as a reducing agents and thus can reduce the metal salts employed in the synthesis to metal nanoparticles (Doble and Kruthiventi 2007). These formed particles have been put to use in a number of applications such as in medicine, catalysis, diagnosis, cosmetic industry, agriculture, and environment etc. in various fields for the welfare of people (Aguilar, 2013). In this review we tried to provide information on some of the most commonly used metals which are discussed below.

1.1.1 Gold nanoparticles (AuNP): The synthesis of gold nanoparticles has drawn attention worldwide due to their ability to acquire good morphology (shape and size) and other optical characteristics, their biocompatible nature (Harsh et al., 2020). Gold nanoparticles formed with different sizes, shapes have gained prominence in various sectors as drug carriers, catalysts, enhancers, in diagnosis for detecting the tumors, as antimicrobial agents *etc*. (Harsh et al., 2020). Studies suggest that a stable gold nanoparticles can be obtained when the pH of the reaction mixture was adjusted to acidic medium i.e. pH 2-5, while the temperature is maintained around 80^{o}C for 30 min during the synthesis of nanoparticles (Nazar et al., 2019).

1.1.2 Silver nanoparticles (AgNP): Silver has the history of being used as an antimicrobial agent since ages. Ag nanoparticles have got considerable attention from the scientific community because of the high electrical conductivity, stability of the particles, excellent catalytic activity, good biocompatibility etc (Nazar et al., 2019).Ag particles has got wider applications in the fields of medicine, therapeutics and also is employed as a anti-cancerous agent along with the chemotherapeutic agent during treatment (Morteza et al., 2018).The size of the nanoparticles increased with the increase in pH from 6 to 10.The Temperature for the reaction is 25^{o}C (Lukasz et al., 2020).

1.13 Oxides of Copper and Zinc Nanoparticles (CuONP, ZnONP): Copper Oxides nanoparticles are excellent catalysts due to their photocatalytic property; they are also used for the treatment of several diseases or in treatments of tumours. The synthesis of Copperoxide nanoparticles requires high temperature ranging from 400^{o}C to 700^{o}C depending on the plant source and the salt concentration and the time of incubation (Morteza et al., 2018).Zinc oxide nanoparticles have got an important role to play as semiconductors, Energy sector, also as sensors of gas, as catalyst, in resistors etc. The temperature required for ZnO particles is from 100°C to 400°C depending on the plant source used for the synthesis of these nanoparticles (Harsh et al., 2020).

1.1.4 Magnesium (Mg) and Cobalt (Co): these metals play a wider role in research and their applications in nanoparticle synthesis field. The synthesis of magnesium nanoparticles requires a temperature of 70°C for 4 hours while the synthesis of Cobalt nanoparticles require a temperature of 200°C for 25mins (Harsh et al., 2020, Srikala et al., 2009).

1.1.5 Titanium Dioxide nanoparticles (TiO_2): Experimental studies by Aswath et.al on synthesis of Titanium oxide nanoparticles from fruit peel suggest that the formed particles are cylindrical and crystalline in morphology. The temperature is regulated to around 100^{o}C.FTIR studies reveal that O-H, C=O, C-O, C-H groups in the extracts of fruit peel stimulated the particle Formation. The size of the particles formed are 5-10nm (Dhiman et al., 2023).

1.2 Mechanism Of Metal Nanoparticle Formation Using The Plant Extract

The synthesis of nanoparticles using plant extracts has gained wide popularity across the world, as this method is simple, well regulated, efficient, and flexible with respect to the parameter and the part of plant used for synthesis in comparison to other biological methods. The various parts of the plant such as stem, leaf, flower, and fruit can be utilised for the process of synthesis. The part of the plant utilised for the synthesis determines the type of phytochemical compound in the reaction. The concentration and the type of the phytochemical, pH, temperature, pressure, salt concentration, are some of the parametric factors that will regulate the rate of the reaction, nanoparticles formation and its stability (Dwivedi and Gopal, 2010). These phytochemicals that are found in the leaf extracts of plants act as stronger reducing agents and hence require less incubation period to get to the end result when compared to that of bacteria, fungi or algae (Jha et al., 2009). Some of the common phytochemical compounds found in the plant extracts are flavinoids, terpenoids, ketones, aldehydes, sugars, carboxylic acids, ascorbic acid, amides, phenols etc. which are responsible for the reduction of metals or their oxide to metal nanoparticles and also play a significant role in their stability (Prathna et al.,2010).

Studies carried out on basil (*Ocimum basilicum*)in the synthesis of Ag nanoparticles have briefed out that the plant extract used for the synthesis of particles contains various compounds of which the functional groups associated with the flavonoids, give them the ability to reduce the metal ion. The conversion of the enol to keto form results in the tautomeric transformations enabling the release of reactive hydogen atom in flavonoids causing the reduction of metal ion to metal nanoparticle (Naheed et al., 2010). Monosaccharide molecules like glucose can active reduce the metals to its nanoforms with various size and shapes. Whereas keto hexoses like fructose give nanoparticles that are monodisperse (Sudipa et al., 2004).Proteins found in the extracts of plants can give nascent particles. Studies reveal that the plant extracts is also rich in amino acids, among the 20 standard amino acids sulphur containing amino acids like cystiene, Methionine, and Di-amino monocarboxylic amino acids like arginine, lysine binds with the silver ions very efficiently, and it is found that the amino groups of the amino acids participate in the reduction mechanism actively (Y.N.Tan 2010). A study on the synthesis containing the compounds alkaloids, phenols, and anthracene by Huang et.al reported that functional groups like -C-O-C , -C-O-, C=C,C=O function in stabilizing the nanoparticles formed by capping them thus preventing the aggregation or agglomeration. The study was supported by FTIR analysis (Mude et al., 2009). The Experimental Evidence by Shankar et.al showed that Eugenol which is terpenoid is efficiently reducing the silver ions to silver nanoparticles, Au ions to Au nanoparticles. The -OH groups that are formed from the eugenol at the beginning of the reaction are found to be lost after the formation of nanoparticles. It is also observed that carbonyl, alkenes, chloride and few more groups like hydroxyl, RCH also appeared after the end of the reaction (Singh et al., 2010). It is thought that the synthesis of nanoparticles occurs in the following 3 phases: 1) activation phase during which the reduction of metal ions, and the reduced ions begin to nucleate, 2) The growth phase wherein we can observe the rise in nucleation process, 3) Termination phase: The formed nanoparticles acquire a final shape (Si and Mandal, 2007). The mechanism is depicted in the following Fig 2.

1.3 Advantages of Bimetallic Nanoparticles

Nanoparticles prepared using metals possess unique optical and electronic properties that are specifically related to the morphology. Some of the examples of metals used for the synthesis are silver, gold, platinum, copper, zinc etc. The use of single or monometallic nanoparticles use is confined as they possess limited properties as compared to bimetallic nanoparticles. Hence, Bimetallic nanoparticles exhibit an edge over the monometallic nanoparticles as they are formed by the combination of two different metals with different properties and the final product formed yields enhanced magnetic, plasmonic, electrical, optical ,structural and conduction properties (Gao et al., 2007, Toshima and Yonezawa, 1988, Sun et al., 2000). Regulating or monitoring the properties of these nanoparticles formed is very crucial as they play a major role in defining the properties of the synthesized nanoparticles and thereof their application (Naskar et al., 2017) Studies on Au and Ag demonstrated that Plasmon resonance property can be tuned (Vongsaval et al., 2011).While studies on Au and Cu have inferred that increased magnetic properties can be acquired by synthesizing the nanoparticles using chemical reduction method. Conferring the formed particles with good magnetic properties is essentially important for its use in magnetic resonance imaging (Cheng and Hight, 2007).

1.4 Plant Extracts in Nanoparticles Synthesis

The phytochemical compounds present in the plants have got the admirable ability to reduce the metal salts to metal nanoparticles. All the parts of the plants like stem, leaf, flower, and root have been used for the process of synthesis. Several researchers across the globe worked on several plants like Aloe vera (*Aloe barbadensis*) Basil (*Osimum santum*), Lemon (*Citrus limon*), Neem (*Azadirachta indica*), Drum Stick (Mongifera) *etc* (Table 1). Various metals like silver Gold, Copper, Iron, Zinc, Nickel, Cobalt, etc. and the oxides of these metals have been used to synthesize the nanoparticles (Iravani, 2011).

Study of Nanoparticles extracted from plants is called phyto-nanotechnology. Nanoparticles that are formed from such extracts are biocompatibility, nontoxic and scalable. The method of synthesis can be carried out with molecular grade water as it serves as better reducing agent than chemicals. Stems, roots, leaves, flowers etc. can also be used as extracts as these contain amino acids, terpenoids, phenolic compounds, *etc*. which helps in reducing salt concentration (Ramchander et al., 2021).

Table 1: Some of the examples of plants used for the synthesis of nanoparticles

S. No.	Name of the Plant	Common Name	Part of the Plant used	Reference
1	***Hibiscus rosa sinensis***	**Hibiscus**	**Flower**	**Harsh et al., 2020**
2	***Salix alba***	**White willow**	**Leaf**	**Nazar et al., 2019**
3	***Chenopodium album***	**White goosefoot**	**Leaf**	**Dwivedi and Gopal 2010**
4	***Ecliptia***	**False Daisy**	**Leaf**	**Jha et al., 2009**
5	***Ocimum basilicum***	**Basil**	**Leaf**	**Naheed et al., 2010**
6	***Caricature papaya***	**Papaya**	**Fruit**	**Mude et al., 2009**
7	***Syzygium aromaticum***	**Clove**	**Fruit**	**Singh et al., 2010**
8	***Majorana hortensis***	**Marjoram**	**Leaf**	**Ramchander et al., 2021(b)**
9	***Moringa olifera***	**Drum stick**	**Fruit**	**Ramchander et al., 2021(c)**
10	***Prunus yedoensis***	**Cherry Tree**	**Gum**	**Velmurgan et al., 2016**
11	***Tamarindus indica***	**Tamarind**	**Fruit**	**Sastry et.al., 2013**
12	***Citrus limon***	**Lemon**	**Fruit**	**Sastry et.al., 2013**
13	***Cucurbita pepo***	**Pumpkin**	**Seed**	**Abisharani et al., 2019**

1.5 Synthesis of Nanoparticles

While synthesizing good nanoparticles is the goal of every biotechnologist is to draw the formed material towards poly-dispersion phenomenon. Also maintaining the homogenous size and shape remains another challenge. Though Plant extract contain polyphenols, phytochemical agents, flavonoids , antioxidants which help in the nanoparticle formation, other physical parameters like pH, Temperature, pressure, time of incubation, Salt concentration , Aeration etc are some of the factors that also determine the morphology of the particles as well the quality and the quantity of the nanoparticles formed (Ramchander et al., 2021) . Studies have suggested that maintaining high pH and temperature results in small sized particles. Optimum concentration is required for the homogenous morphology of the formed molecules. Morphology i.e. size and shape depends on the time of the incubation. Studies suggested that varied sizes of the particles are formed by changing these factors (RaniPadmini et al., 2021). Synthesis of nanoparticles can be by two different methods.

1.5.1 Top-down approach: in this method the bulky material is chopped down to attain nano sized material (Numan et al., 2011). Under the top down approach the following methods are used (Figure 1):

a) Mechanical milling: This is one of the available simple and successful ways to obtain the nanocrystalline powders. This method is temperature independent. This method is again classified based on the technique used as conventional ball milling and high energy ball milling, where in a high energy magnet is used to apply the amplified magnetic field of which varied rates can be obtained by adjusting the position of the magnet from the cell. In the conventional method the bulky material is placed between the kinetic colliding balls and the material is broken down to reduce size (Laura et al., 2014).

b) Electro explosion and sputtering: Material is added to a reactor and high voltage is applied as microsecond pulse which results in the reduction of the bulky material to nanosize. Sputtering is a method in which the high energy atoms are ejected out from the solid target bombard with the bulky material to get chopped it to small size particle (Choet al., 2013).

c) Laser ablation: Laser is applied as pulse to break the precursor material to nanonmaterial. Varying the intensity and time of application of laser defines the morphology of the particles. This method yields small amounts of particles (Marc et al., 2002).

1.5.2 Bottom Up approach: As the name suggest small units are assembled to form the nano material. Some of the widely used techniques are described under this method.

a) Sol-gel method: it is also called as wet chemical method or chemical- solution deposition method. The technique is used for materials such as metal oxides. The precursor is a chemical solution (Rao et al., 2012).

b) Supercritical fluid technology: This technique is under wide use since last two decades. In this method supercritical CO_2 and H_2O are employed for preparation of nanomaterials. Supercritical CO_2 can act like both liquid and gas. Hence it can solubilise solutes that are low viscous liquids and highly diffuse gases. The Solubility capacity can be regulated by varying temperature and pressure. Separation of the unreacted material is quite easy which can be done by flushing the Carbon dioxide. Therefore purity of the material is maintained. Also it is inflammable and nontoxic, low liquid waste problems hence can be used frequently to synthesize nanomaterial from the metals (Ye et al., 2004).

c) Chemical vapour deposition: The molecules in the vapour phase act as precursor molecules that favour the nucleation enabling the deposition on a film resulting in the formation of nanoparticles. Providing the requisite conditions, solids, liquids and gases can act as precursors (Seravalli et al., 2021)

d) Pyrolysis: Mostly used to synthesize nanomaterials from organic matter. The starting molecules can be liquid and gas which are allowed to pass through an orifice at high pressure and high temperature. Oxide particles are recovered from the by product. This method often produces agglomerates and aggregates instead of single particles. Spray Pyrolysis is another method which utilises the nebuliser that ejects the small drops of initiator molecules (Srikala et al., 2009).

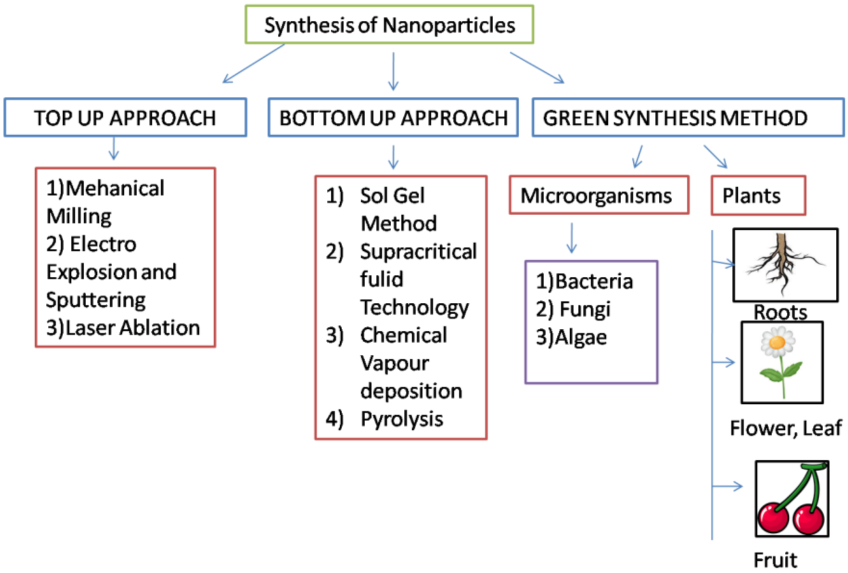

Figure 1. Methods used to synthesise Nanoparticles

1.6 Characterization Techniques

It is very important to make sure that the nanoparticles formed are within the nano scale. As stated by material science the term characterization is defined as a process under which the structural morphology and properties are explored. This step is very much important to understand the molecule. Some of the following techniques given in Table 2 can be used to study the nanoparticles (Deena et al., 2019).

1) **Microscopy based Techniques**: Some techniques that can be described here are Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM) (Joshi et al., 2008). Objects can be studied at micron size and even at sub-micron size at high resolution. The images produced can be magnified to several times to for better clarity. AFM also give us information about the roughness, height and depth of the peaks and valley found in the sample. Energy Dispersive X -Ray Analysis (EDAX) can be conjugated with SEM which also provides the information about the Elemental composition (Deena et al., 2019; Binning et al., 1986).

2) Spectroscopy based Techniques: Qualitative and quantitative studies can be done using spectroscopy studies. Ultraviolet Visible spectroscopy is one of the preliminary characterization techniques. UV spectrum is obtained by placing the sample in UV light. The samples can be studied from 100nm to 800nm. Using Raman Spectroscopy rational, vibrational and other modes of the samples or molecules can be studied (Deena et al., 2019). The spectrum obtained is called Raman spectrum. Advanced Raman spectroscopy techniques includes Stimulated Raman Spectroscopy, Surface enhanced Raman Spectroscopy, Resonance Raman Spectroscopy, Fourier Transform Infra-red Spectroscopy (FTIR) gives information about the detailed functional groups present in the sample. Organic, inorganic and polymer material can be studied using the infra-red light (Skoog et al., 2007).

3) X-Ray based Techniques: X-Ray photoelectron spectroscopy (XPS) is a spectroscopic method used for quantification as well as for determining the elemental composition. X-Ray diffraction (XRD) gives information about crystalline, elemental proportions, deviation of element structure from the parent or precursor molecule.

4) Dynamic Light scattering technique gives information about the particle size (Skoog et al., 2007).

Table 2: Characterization technique and their significance

S.NO	Name of the Characterization Technique	Significance of technique	References
1	SEM,TEM,STM	The morphology and size of the object is identified	(Joshi et al.,2019)
2	AFM	The roughness, height and depth of the peaks and valley is studied	(Binning et al.,1986)
3	EDAX	Elemental composition can be studied	(Deena et al.,2019)
4	UV Spectroscopy	Qualitative and Quantitative studies can be done	(Deena et al.,2019)
5	Raman Spectroscopy	Rational, vibrational and other modes can be studied	(Skoog et al.,2007)
6	FTIR	Functional Groups of the samples can be identified	(Skoog et al.,2007)
7	XPS	Quantification, for determining the elemental composition	(Skoog et al.,2007)
8	XRD	Crystalline, elemental proportions, deviation of element structure from the parent or precursor molecule.	(Skoog et al.,2007)
9	Dynamic Light Scattering	Particle size can be identified	(Skoog et al.,2007)

1.7 Applications of Bimetallic Nanoparticles

The detailed applications of Bimetallic Nanoparticles are mentioned below in the Figure 2. The applications are:

1) One of the important applications of Bimetallic Nanoparticles is its use as bio-sensing agents due to the magnetic property of the particles and in bio imaging as contrast agents for diagnosis of diseases. MRI is the widely known imaging technique routinely used for the identification of a number of medical conditions of the diseased patients (Mcnamara, Tofail 2017).

2) Bimetallic particles are extensively used for detection of the Biomolecules such as peptides, aptamers, Nucleic acids, antigens etc. These biomolecules when interacted with the nanoparticles cause aggregation of the nanoparticles which can be analysed and studied using various other techniques (Mcnamara, Tofail 2017).

3) Availability of the drug at the specific site is the biggest challenge the drug industry is encountering. Nanoparticles provide promising solution when attached to the drug molecule, they improve the uptake and also functions as excellent carriers in delivering the therapeutic agents to the target site. These nanoparticles are also potential carriers for gene transfer for specific protein expression (Mcnamara, Tofail 2015).

4) The Nanoparticles exhibit bactericidal effect and are good antimicrobial agents and antifungal agent (Mcnamara, Tofail 2015).

5) Nanoparticles have got the ability to function as excellent catalysts.eg: Gold nanoparticles are used in hydrogenation and oxidation reactions as catalysts (Irfain et al., 2020).

6) Nanoparticles can be used in the food industry for increasing the shelf life of the food. By employing nanotechnology the air tight packing of the food can be improved thus offer better preservation method (Irfain et al., 2020)

7) Bio nanoparticles with magnetic properties can be employed as water purifying agents thus give promising results in the removal of pollutants from water and in conserving environment (Arbab et al., 2021)

8) Bimetallic nanoparticles can be widely used for the improved agricultural practice like seed germination, to promote soil quality, and also as plant nutrients (Arbab et al., 2021)

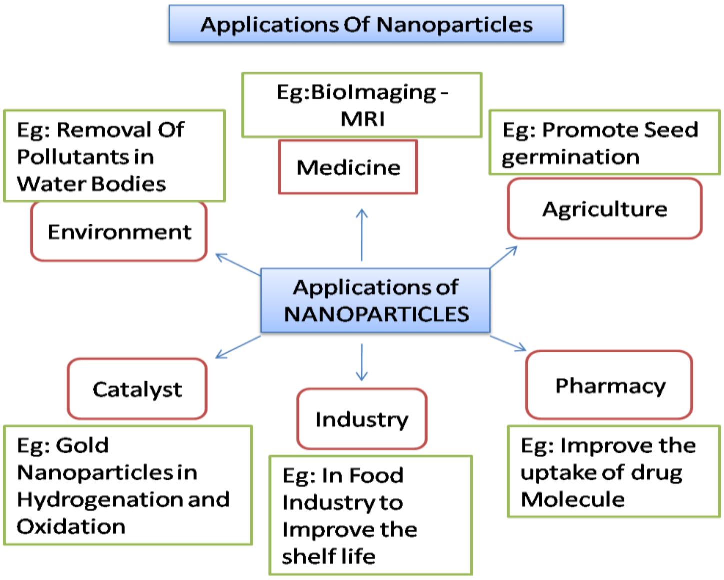

Figure 2. Some of the application of Nanoparticles with Examples

1.8 Future Prospects

Human growth and development is often restricted by a number of factors like pollution, cost of the compounds, effect on human health etc. Some of these can be answered by the potential applications of the nanoparticles in the fields of agriculture, Nano medicine, industry, environment etc. Bio nanoparticles have no toxic effects on human health and are safe to use for various applications some of which include therapeutics, Diagnosis and drug design and delivery. Green Synthesis of nanoparticles which is environmental friendly method reduces the cost of its production. One can say that when better advanced techniques are employed in the synthesis and characterization. The potential applications of this area will show promising results for the welfare of human habitat

Conclusion

Green mediated Synthesis of nanoparticles is an emerging branch with overlaying challenges. Its aim is to minimize harmful toxic effects that are posing danger to human health and environment. One of its objective is to provide excellent resources for biomedical field for use in therapeutics, treatment, drug delivery, gene therapy etc. hence it can be an alternate to Conventional biotechnology and thus this newly developing area can be called as Green Nanobiotechnology. Some of the problems encountered during the preparation are stability, aggregation, regulating the growth, polydispersity, homogenous distribution of particles etc. The synthesis shows significant impact on environment and on humans' well-being. To reach this goal, it is observed that regulating the quality and Quantity is very crucial during the synthesis. Developing strategies to scale up the production on a large scale is a priority. Green nano synthesis is a promising field in its early stage but further research will throw more light on its advancements and the implementation of its application.

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