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GREEN SYNTHESIS OF NANOPARTICLES: A REVIEW OF METHODS AND MECHANISMS

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ABSTRACT

Nanoparticles are the tiny particles and they are important because they have special properties that make them very useful. These was significantly proven by many researchers by applying there in various experiments. The main property among them is that they posseting the large surface to volume ratio which make every particle of the material to take part in reaction. These can be synthesizing by two main ways: by breaking down big pieces of material into tiny ones called as top-down method (like grinding a big rock into powder) or by bottom-up method where the particles are built up from tiny atoms and molecules. The nanoparticles having the special role in medical industry by showing their specific activity. The most significant and known property of nanoparticle is the antimicrobial property. The metal has itself having the same but its efficacy increases when their form will change into nano one. Usually, making nanoparticles involves using strong chemicals and high temperatures, can be harmful to the environment. A better way to make nanoparticles is by using natural substances from plants, called phytochemicals. These substances can help turn metal ions into nanoparticles in a process that is safe for the environment. This method, known as green synthesis. The method includes plant extracts to create nanoparticles without harmful chemicals. The various biomolecule plays crucial role in synthesizing nanoparticles. It is found that proteins and amino acids, which are the building blocks of bodies, can help to make and stabilize nanoparticles. For synthesizing the nanoparticle, it is important to select proper method, if the method will not harm the environment, then the approach will contribute to the sustainability. Green synthesis method is a safer way to make nanoparticles that helps and protect our planet while creating useful materials. This review article mainly focussing the green synthesis approach for synthesizing the nanomaterial.

Keywords: Biomolecules, Environment, Green Synthesis, Material, Nanoparticles, , Plant Extract.

I. INTRODUCTION

The substance having the size in between the range of 10-100 nm called as nanoparticles and the field of science continuously working on the development at the atomic, molecular or macromolecular scales known as nanotechnology [1]. The approach of nanoparticle is engrossing because the number of nanoparticles is not only small but also large enough portion of them are at, or closer to surface for suggestively improve the atomic, magnetic structure, physical and chemical properties and reactivity to the bulk materials [2].

The nanoparticles can be synthesized by mechanical or chemical method based on top down and bottom-up approach [3,4,5]. The mechanical method of synthesis of nanoparticles includes the grinding of bulk material which fallows the reduction of particles size in nanoscale [6,7]. But the disadvantages of the final particles of the product do not have an orderly shape, and again a process must be performed to make the particle shape desirable. The product formed by this method do not have orderly shape this is the major advantages of it [8]. For getting the particle in nanosized chemical method generally used. The method includes traditional synthesis of particle by using wet chemistry method where primely generating the particles in solution and cast the particles onto the substrate and eliminating the solvent and other impurities from particles [9].

Synthesis of nanoparticle by chemical process fallows bottom-up approach where atoms into new nuclei will grow into a nanoscale particle means there is a formation of large nanostructure from smaller atoms and molecule [10]. The material having good conductance of heat and electricity, shiny, malleable, ductile and fusible property called as metal. It has a crucial role in biological systems. As catalytic or structural cofactors, metal ions are critical to the function of estimated one-third of all enzymes. Additionally, metals play various roles in biological system [11]. Transition metals such as Fe^{2+}/Fe^{3+}, Zn^{2+} and Cu^{2+} generally serving as a

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component of proteins and enzymes or activator of enzymes, are considered to be the critical part in many vital biological processes including oxygen transport, energy production, neurotransmission, regulation of gene expression and synthesis of essential molecules [12,13]. The nanoparticles exhibit a unique physical, chemical and biological possessions at nanoscale compared to their respective particles at higher scales. This phenomenon is due to a relatively larger surface area to the volume ratio, increased reactivity or steadiness in a chemical process, enhanced mechanical strength [14]. This enormous property of nanoparticles is a hopeful tool for biomedical applications.

In the chemical synthesis method of nanoparticle, the precursor salt of any metal can be treated with any reducing agent so can the metal ion present in salt solution getting reduced by reducing agent and forming metal hydroxide. After dehydration of metal hydroxide, the product will be metal oxide nano particles. The precise selection of precursor salt, reducing agent, and conditions such as temperature and pH can impact on the outcome of the synthesis as well as properties of the resulting nanoparticles [15,16,17]. This method required high pressure, energy, temperature, or toxic chemicals. Therefore, many researchers are diverting themselves from using artificial methods [18]. In spite of this biomolecule like sugar, amino acid, protein can act as a reducing agent [19]. Synthesis of nanoparticle by using carbohydrates as a reducing agent successfully mentioned in the work done by the researcher and validated by proper characterization technique [20].

The chemical compound produced by plant called as phytochemical [21]. Generally, this phytochemical empowers the plant to fight against various infection by bacteria or viruses [22]. These are produced by either primary or secondary metabolism of plant [23]. Under the research phytochemical are broadly classified into two categories i.e. carotenoids [24] and polyphenols [25].The polyphenols includes phenolic acids, flavonoids, stilbenes or lignans. Based on similar chemical structure the flavonoids are again divide into groups such as anthocyanins, flavones, flavanones, isoflavones, and flavanols [26,27].

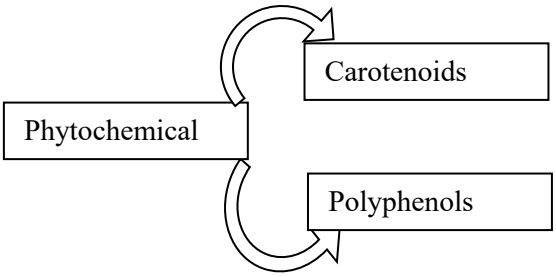

Figure 1: Classification of Phytochemical.

The Phenolic compounds present in the plant extract are the major ingredients of antioxidants in many plant species and their antioxidant action is primarily due to their redox properties. Hence, they can act as a reducing agent in neutralizing free radicals [28,29] and the reduction of metallic ions to metallic nanoparticles. The reduction of metal ion leads to the formation of metal nanoparticles fallowed by the phytochemical present in plant extract explains the Eco-friendly behaviour presenting a different way of thinking in chemistry projected to eradicate toxic waste, decrease energy consumption, and use of ecological solvents (alcohol, water, acetate) [30]. This plant mediated synthesis of nanoparticle method popularly known as green synthesis. The progress that meets the needs of the present without compromising the ability of future generations to meet their own needs called as sustainable development [31]. Green synthesis contributes to sustainable development by reducing environmental impact and maintaining biocompatibility.

It is observed in FTIR studies of nanoparticle synthesized by green synthesis method terpenoids are associated mostly with nanoparticle [32]. The dissociation of a proton of the eugenol (the major constituent about 70% to 90% in the aromatic oil extract) from cloves OH-group results in the formation of resonance structures capable of further oxidation. This method is accompanied by the active reduction of metal ions, followed by nanoparticle formation [33].

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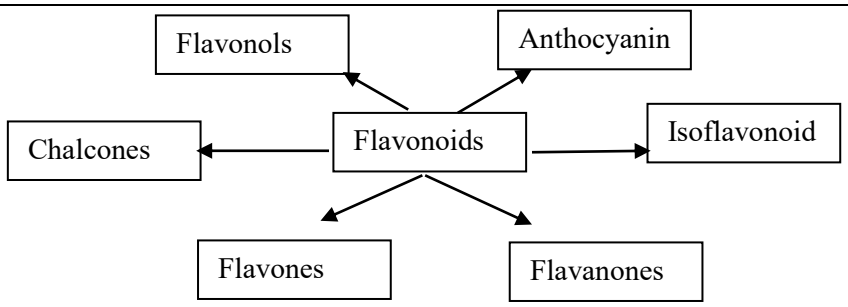

Fig. 2: Classes of Flavonoids

As mentioned above Flavonoids are a large group of polyphenolic compounds that comprise several classes: anthocyanins, isoflavonoids, flavonols, chalcones, flavones, and flavanones, which can actively chelate and reduce metal ions into nanoparticles. It contains many functional groups capable of nanoparticle formation. It has been suggested that the tautomeric transformations of flavonoids from the enol-form to the keto-form may release a reactive hydrogen atom that can reduce metal ions to form nanoparticles. Due to the specific chemical structure of flavonoids, it can easily chelate metal ion. These are benzopirone derivatives which are abundantly found in nature. The polyphenolic nature of flavonoids gives it the property of antioxidant behaviour. These properties depend on the number of hydroxyl groups present on its structure.

It is claimed that more the number of hydroxyl group present on the flavonoids there will be higher the antioxidant ability [34,35]. Quercetin is a flavonoid with very strong chelating action, because it can chelate at three positions concerning the carbonyl and hydroxyls at the C3 and C5 positions and the catechol group at the C3' and C4' site. These groups chelate various metal ions such as Fe^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}, Al^{3+}, Cr^{3+}, Pb^{2+}, and Co^{2+}.

The occurrence of such mechanisms may certainly clarify the capability of flavonoids to be adsorbed onto the surface of a nascent nanoparticle. This probably means that they are involved in the stages of initiation of nanoparticle formation [36]. This initiation stage is termed as nucleation the process by which atoms or molecules come together to form a new phase or structure [37]. This can be further aggregation, in addition to the bio reduction stage. It is mentioned that apigenin glycoside extracted from Lawsonia inermis (lawsonite thornless, henna) and used for the synthesis of anisotropic gold and quasi-spherical silver nanoparticles with an average size of 21–30 nm. It shows that isolated flavonoids and flavonoid glycosides have the ability to induce the formation of metal nanoparticles [38].

Nascent nanoparticles are very frequently found in association with proteins it is validated by FTIR studies [39]. Certain amino acid has the ability to bind with the metal ions and reduced it. Amino acids such as lysine, cysteine, arginine, and methionine are capable of binding silver ions [40]. It is recently analysed by Tan et al. that all of the 20 natural α-amino acids determine their potential for reduction or binding of metal ions. They also recognized that tryptophan is the strongest reducing agent for silver ions, whereas histidine is one of the strongest binding agents for it. Amino acids can bind to metal ions through the amino and carbonyl groups of the main chain or through side chains, such as the carboxyl groups of aspartic and glutamic acid or a nitrogen atom of the imidazole ring of histidine [41].

Although the nanoparticle shows their tremendous effect in the medical industry but their effect depends upon the doses. Otherwise, their effect may cause adverse effect on the body. The appropriate method for synthesizing nanoparticles is crucial for sustainable development. Plant is itself the unique pot of ingredient which possess different property hence the selection of right sample will give us the best result [42,43].

II. CONCLUSION

Many studies report the possibility of obtaining nanoparticles through a green synthesis process using a variety of plants, fungus, bacteria and algae. Besides, the studies mentioned here indicate that the active biological substances act as reducing, stabilizers or as chelating agent which are essential for converting the ionic metal in the metal form. The ionic form of metal in metal salt solution is reduced by reducing agent found in plant extract which will convert the metal ion in metallic form which may having the different functional group of specific ingredients present in plant extract. Further the reaction rate depends upon the phytochemical present in the plant.

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