Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 693 - 703
Received 16 February 2021; Accepted 08 March 2021.

Role of Silver Nanoparticles in Antioxidant Property

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Abstract:

The size of silver nanoparticles makes it available for a wide range of new applications in various fields of industry. The noble metal nanoparticles synthesis for applications such as catalysis , electronics, environment, biological, pharmacological and biotechnology is definitely an area for constant interest . The two main methods for extraction of silver nanoparticles are the physical method and the chemical method. Green synthesis helps in overcoming this limitation , the size of Silver nanoparticles makes it available for a wide range of new applications in various fields of the industry especially in medicine.

Biological methods are being used as a major alternative because this approach is very environment friendly and is less toxic and that also includes plant extracts,microorganism, fungi, etc . The major applications for silver nanoparticles in the field of medicine mainly include diagnostic applications and therapeutic applications apart from its antimicrobial and antioxidant activity . Due to the nanotoxicity, these silver nanoparticles have few drawbacks too. In many contexts, biological approaches using biological molecules derived from plant sources in the form of extracts displayed superiority. These plant based biological molecules undergo highly controlled assemblage to maintain the suitable and the appropriate size for the nanoparticle.

Keywords: Metal nanoparticles, AgNPs, greener approach, antioxidant property, review study.

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Introduction:

Nanotechnology is definitely an emerging tool in the drug delivery system among various serious types of disorders. Nanoparticles are mainly materials with an overall size of almost 100 nm (Nagaich.U et al.,2006) . Metal nanoparticles using plant extract is much more of a greener and sustainable approach for application for a delivery system of drugs. Silver nanoparticles have proved to show good antibacterial properties. They are widely used as a healing method also and have been used as an antibacterial agent for many years (Ghosh S et al.,2012) Silver nanoparticles also possess various antifungal, anti- inflammatory, antiviral, antioxidant and antiplatelet activity (L.Ge et al.,2014). Silver nanoparticles can be extracted from many methods like physical methods , chemical methods that involve thermal reduction , polyol process, microemulsion technique and photochemical reduction that involves microwave reduction, photo reduction and X-ray radiolysis. Antioxidants play an important role in our body . Antioxidants are substances that can prevent or slow damage to cells that are caused by free radicals. They are unstable molecules, and when this instability occurs , the body produces antioxidants as a reaction to environmental pressures (Salari S et al 2011). The antioxidant activity of these particles are mostly characterised by using 2, 2 - diphenyl - 2 - picrylhydrazyl hydrate (DPPH) assay and ferric reducing antioxidant power (FRAP) . A major advantage of silver nanoparticles medicine is that it is a cheaper and a better alternative due to extraction of indigenous plants . And they also do not exhibit many side effects. Silver is usually known for its antimicrobial and antioxidant property and is gaining popularity due to its many beneficial advantages.

Our team has rich experience in research and we have collaborated with numerous authors over various topics in the past decade (Duraisamy et al. 2019; Ariga et al. 2018; Kannan and Venugopalan 2018; Basha, Ganapathy, and Venugopalan 2018; Rajakeerthiand Ms 2019; Teja, Ramesh, and Priya 2018; Menon et al. 2018; Siddique et al. 2019; Nandakumar and Nasim 2018; Manohar and Sharma 2018; Hema Shree et al. 2019; Rajendran et al. 2019; Gheena and Ezhilarasan 2019; Hussainy et al. 2018; Hannah et al. 2018; Sharma et al. 2019; Ravinthar and Jayalakshmi 2018; Jose, Ajitha, and Subbaiyan 2020; Sekar et al. 2019; Kumar and Antony 2018; Johnson et al. 2020; Janani, Palanivelu, and Sandhya 2020; Seppan et al. 2018; Jeevanandan and Govindaraju 2018; Nandhini, Babu, and Mohanraj 2018).

Aim and objectives:

The aim of this current study is about the use of plant extracts for biosynthesis of silver nanoparticles and to evaluate their antioxidant activity from a collection of articles and do a review study. Also to see if the antioxidant activity of Silver nanoparticles is better than other drugs in the market.

Materials and methods :

For this review , the articles were selected from pubmed, google scholar, chem RXIV, BiORXIV . The articles are all referred to metal (silver) nanoparticles it's role is antioxidant activity . All of these articles were involved with transversal studies, metaanalysis, clinical assays. An extensive literature review was done
from the articles collected.

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Discussion : -

Nanotechnology in medicine:

Nanotechnology is actually the synthesis, characterization, fabrication, and manipulation of structures, devices, or even materials that have at least one dimension (or contain components with at least one dimension) that is approximately 1–100 nm in length. Particle size with below this threshold results in materials with physical and chemical properties and are significantly different from the properties of macroscale materials composed of the same substance. Nanotechnology is mostly expected to open up some new aspects to fight and prevent diseases using atomic scale of tailoring materials (Curtis A et al.,2001). The ability to uncover the structure and function of these biblestems at the nanoscale, stimulates research leading to improvement and stabilisation in biology, biotechnology , medicine and even health care(Wwaren C et al.,1998). The size of these nanomaterials can be useful for both in vivo and in vitro biomedical research and applications. The integration of these nanomaterials along with biology has led to the development of various diagnostic devices, contrast agents, analytical tools, physical therapy applications and drug delivery vehicles (Vaseahshta A et al.,2005). Most of the natural processes also take place in the nanometer scale. Hence, there is a confluence of nanotechnology and biology that can address several biochemical and biomedical problems and can revolutionize the field of health and medicine (Farokhzad C et al.,2005) Nanotechnology is currently being employed as a tool to explore the darkest fields of medicinal services and sciences in several ways such as sensing, targeted drug delivery, imaging , gene delivery systems and also artificial implants (Fahy CIM et al.,1991). The new age drugs are mainly nanoparticles of polymers, metals or ceramics that can combat conditions like cancer (Frutas R A et al.,2000) and also even fight various human pathogens (Frutas R A et al.,2005) Applying nanotechnology for treatment, diagnosis, monitoring and control of diseases has been referred to as “nano medicine " . In the past decade, the nanoparticles biosynthesis has received an increasing attention due to its growing need to develop environmental friendly technologies in synthesis of materials. The biosynthetic method employing plant extracts has received some attention as a simple and viable alternative to chemical procedures and physical methods synthesizing metal nanoparticles only in recent years. Nanotechnology is becoming important for the food and health sectors. Very promising results and applications are being developed in the areas of nutrient and drug delivery systems through bioactive nanoencapsulation, biosensors to detect and quantify pathogens, as well as novel resources for the evaluation and development of newer, safer, and effective drug formulations.

Recently, biological molecules are used as templates for “green nanotechnology” which is increasing and plants, plant wastes, bacteria, and fungi are have been used for the nanoparticles synthesis.According to one of the articles, plants are better options for nanoparticle synthesis because they are mostly not toxic, provide natural capping agents, and reduce the cost of microorganism isolation and culture media.

Although the use of nanoparticles in medicine appears to be a relatively recent trend, the basic nanotechnology approaches for medical application date back to several decades.

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Nanoparticles (metal):

The introduction of nanoparticles has revolutionized in various fields including medicine, nutrition and energy . Nanoparticles are mostly in the size of about 100 nm . The use of nanotechnology in fields of medicine in particular, specifically drug delivery is shown to have various benefits (Rajeshkumar S et al.,2019). In the past decade, noble metal nanoparticles have attracted much attention of scientific researchers due to their applications in medicine , biology optoelectronics, material size (BarbintaPatrascu et al.,2011).Among many of the noble metals, silver is the most extensively used and studied because of their unique properties and its use in bio medical field especially (SendovaVassiliva et al.,2007). A lot of strategies are employed for the synthesis of silver nanoparticles but the greener methods have gained considerable interest because of the use of environmentally benign materials(Hristov H et al.,2009). So the synthesis and design of nano materials through biological routes (called biosynthesis) have attracted great interest . The nanoparticles are mostly being used to reduce toxicity and side effects that drugs may impose to patients . Over the past few years, noble metal nanoparticles have expanded rapidly owing to their superior characteristics (Rajesh Kumar S et al.,2017). Silver nanoparticles are the most coveted nanomaterial due to their high exceptional physiochemical properties such as high ratio of surface area to mass , electric , Optical , catalytic etc. synthesis of nanosized particles of metals and metal oxides has progressed rapidly in the medical field due to the astounding characteristics acquired by these nanoparticles (Menon S et al.,2018). Metallic nanoparticles may be synthesized by physical, Chemical and Organic methods . Silver nanoparticles are widely used in the pharmaceutical industry in the manufacturing of ointments and creams to inhibit burns and wounds related infections (Satyavani et al., 2011). The silver ion has a very strong inhibitory effect against microorganisms (Mohanta and Behera, 2014). Biological synthesis of nanoparticles is an alternative and eco-friendly method for production of nanoparticles (Firdhouse and Lalitha, 2015; Chung et al., 2016; Nayak et al., 2016). The use of silver nanoparticles both as an antimicrobial agent (Majeed et al., 2016) and as a potential drug carrier in treatment of cancer has recently gained attention (Nayak et al., 2016).

Silver nanoparticles can be synthesized from a variety of chemicals and physical methods, involving chemical reduction, photochemical reduction, electrochemical reduction and heat vaporization. These processes involve various toxic chemicals as reducing agents. Because of using these noble metal nanoparticles in areas of human contact, there is a need to develop eco-friendly biosynthesis process that lessens the use of toxic chemicals.The biological method is preferred among the others as physical as it is found to be highly expensive and the chemical method is extremely toxic to the environment (Kumar J S et al.,2017).Thus, plant mediated biological synthesis of nanoparticles has been gaining importance and attention due to its simplicity as well as its sustainablity and eco friendliness.

Antioxidant pronity of silver nanoparticles:-

Our institution is passionate about high quality evidence based research and has excelled in various fields ((JayaseelanVijayashreePriyadharsini 2019; Pc, Marimuthu, and Devadoss 2018; Ramesh et al. 2018; Ramadurai et al. 2019; Sridharan et al. 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Mathew et al. 2020; Samuel 2021; R et al. 2020; Chandrasekar et al. 2020; J. VijayashreePriyadharsini, SmilineGirija, and Paramasivam 2018)

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In order to conquer the complication of toxicity in the synthesis and biological applications, plants or plant extracts have been found to have a leading role in the process of AgNPs bio synthesis. Different chemical constituents and phyto-molecules play both roles of protective and reductive agents which are very important for the reduction of silver ions using natural compounds and reductive enzyme complexes. In recent studies, extracellular AgNPs were synthesized using different plant extracts and that can be used as a potential reducing agent.
Plant extracts are mostly preferred over biological sources due to their decreased availability and a huge spectrum of reducing metabolites. Plant secondary products provide rich resources as nutraceuticals, potential drugs, and food additives. Plant Polyphenols are huge groups of natural antioxidant secondary metabolites.[6] The reduction properties of these metabolites have been linked with the high potential of plant extracts to synthesize nanoparticles with new and improved characteristics.
Most of the articles used mainly two assays to test the antioxidant activity. DPPH and FRAP. Upendra Nagaich(Upendra Nagaich et al.,2016) used DPPH assay to test the antioxidant activity of silver nanoparticles extracted from Apple extract . He used a stock solution of DPPH and a mixture of methanol, hydrogen solution and distilled water and Calculated the DPPH scavenging effect by using the formula:

$$\text{DPPH scavenging effect (\%)} = \frac{(\text{control absorbance} - \text{sample absorbance})}{\text{control absorbance}} \times 100.$$

And hence he proved that the AgNPS hydrogels were highly stable and were effective antioxidants, Gitishree Das (Gitishree Das et al.,2019) also used a similar DPPH assay using silver nanoparticles of Ananas comosus and explained about its moderate antioxidant activity. A similar formula was also used here. Mohamed S Abdel Aziz et al (Bunghez I R et al.,2012) also explained about the antioxidant property of silver nanoparticles using chenopodiummurale leaf extract by using the DPPH assay . Nagarajan keerthiga(Nagarajan keerthiga et al.,2019) explained about the antioxidant property of silver nanoparticles extracted from Cumin til using DPPH assay . I.R Bunghez(Bunghez I R etal.,2012)explained the antioxidant activity of silver nanoparticles extracted from ornamental plants . But here, the chemiluminescence assay was used . The reducing activity of these flowers were proved and they can also be used as capping agents for photosynthesized AgNPS.

Recent advances:

Recent studies show that the new targeted nanoparticle contrast agents can be used for early diagnosis and characterization of atherosclerosis and cardiovascular pathologies at even cellular and molecular levels that might act as the next frontier for combining imaging and rational drug delivery can help in personalized medicine (Wickline G et al.,2002). Nanotechnology that are based on highly efficient markers and precision, quantitative detection devices used for early diagnosis and therapy monitoring will have a huge impact on management of patients and in improving quality of life and in lowering mortality rates, in

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diseases like cancer, tumours etc. This evolution in science and opens various opportunities for it's application assures that nanotechnology will become one of the most dominant technologies of the 21st century (Vairavel M et al.,2020, Santhoshkumar J et al.,2017, Menon S et al.,2017, Rajeshkumar S et al.,2017, Rajeshkumar S et al.,2019)

Conclusion:

From the articles discussed, this paper describes about the biosynthesized silver nanoparticles mediated from various plant extracts and it's antioxidant activity Plant synthesized silver nanoparticles have a strong antioxidant activity due to the presence of bioactive molecules on the surface of silver nanoparticles. The main advantage us that they are a cheaper alternative due to extraction of indigenous plants and exhibit no side effects.

Previously our team had conducted numerous experimental analyses [Ashwini S et al.,2017,Ashwini et al.,2017,Lakshmi et al.,2015,Sharma P et al.,2019,Perumalsamy, H et al.,2019, Mehta M et al.,2019, Lakshmi T et al.,2017] such as in vivo studies [Ezhilarasan D et al.,2017,Ezhilarasan D et al.,2017, Gheena S et al.,2017, Menon S et al.,2018] and in vitro studies [Rajeshkumar S et al.,2018,Karthiga P et al.,2018,Rajeshkumar S et al.,2018] over the past 5 years. The idea for this review stemmed from the current interest in the community.

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