**Silver Nanoparticles Extracted from Plant Extracts and Its Bioapplications: A Modern Review**

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**ABSTRACT**

Emergence of eco-friendly technology for the biosynthesis of nanoparticles has resulted out as a notable step in the field of nanotechnology and additionally branch of science that deals with the framing of materials at atomic level to realize distinctive properties and bio applications. Of all the metal nanoparticles, silver nanoparticles steal attention due to its remarkable physical, chemical and biological properties. Green chemistry has emerged as an alternative to the range of conventional strategies used for synthesis of nanoparticles. Employment of plants in the synthesis of nanoparticles is considered to be the foremost appropriate technique attributable to the broad variation of the bio-molecules in them which not solely cut back however conjointly act as helpful capping agents, thereby increasing the rate of reaction. Unlike microbial culture they can be easily handled, broadly distributed and also easily available. The present review examines the different types of plants that should be employed for the speedy recovery of silver nanoparticles and also focus on its antibacterial, antifungal, antioxidant, antiviral, anticancer and anti-diabetic agent.

**Keywords: silver nanoparticles, antimicrobial, antioxidant, antiviral, diabetic, anticancer, aloevera**

**Introduction**

Nanotechnology is one of the growing field due to its potential applications in diverse fields including catalysis, energy, chemistry and medicine. Nanotechnology primarily deals with the synthesis, characterization and exploration of various kinds of nanoparticles. The term nanoparticle is used to describe a particle having size less than 100 nm. The word “nano” is derivative of a Greek word meaning dwarf or extremely small [1]. They tend to react differently than larger particles of the same composition because of their large surface area, thus allowing them to be used in novel applications [2]. They can be considered as the fundamental building block of nanotechnology [3]. The concept of nanotechnology was given by physicist Professor Richard Feynman in his historic talk “there’s plenty of room at the bottom” [4], however the term nanotechnology was introduced by Professor Norio Taniguchi of Tokyo Science University [5].

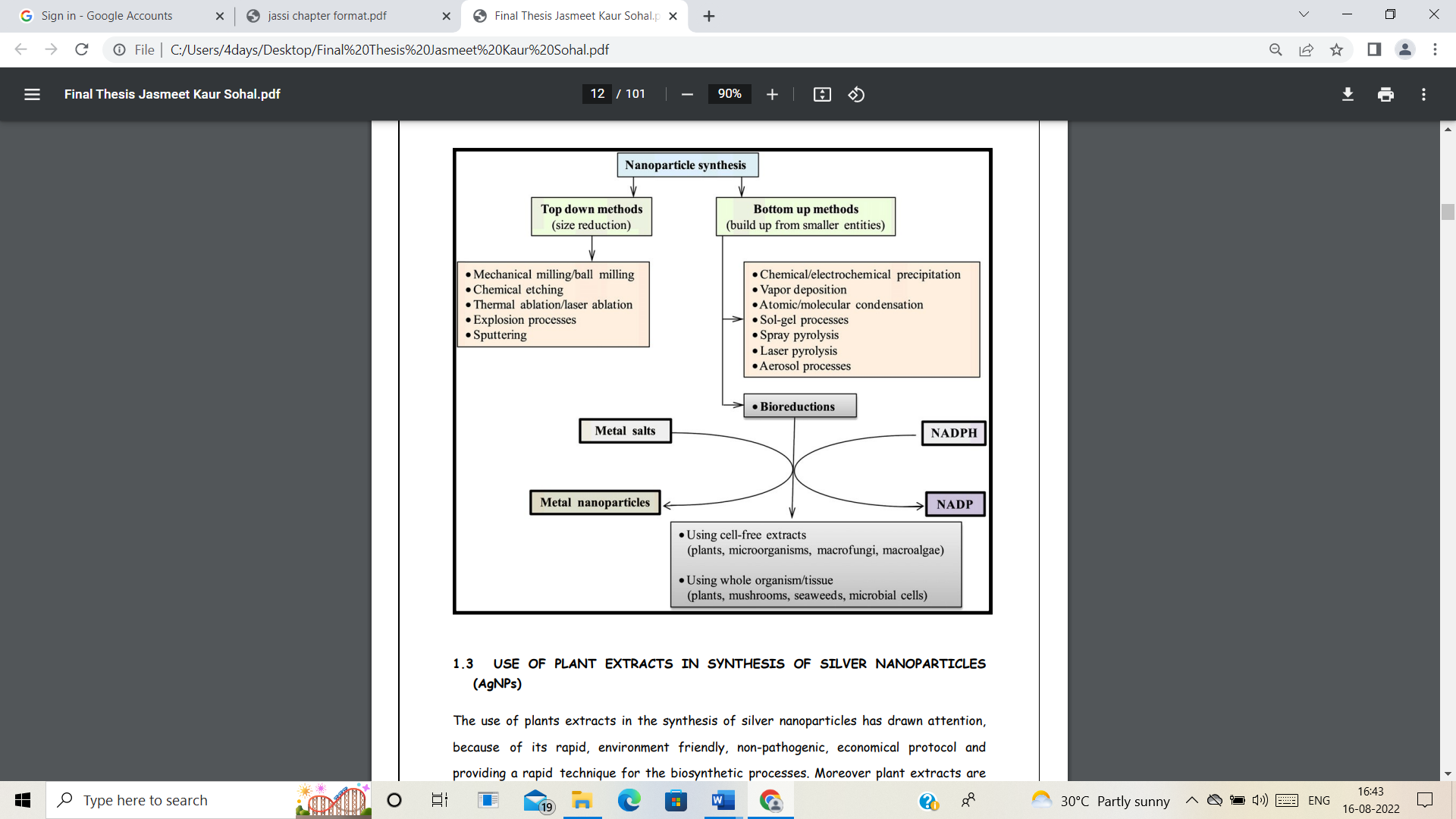
The field of nanotechnology have grown rapidly especially from the last two decade, due to the ease of use of advanced characterization techniques as well as large number of synthesis methods for nanomaterials. Nanoparticles can be generally classified as: Organic nanoparticles and Inorganic nanoparticles. Organic nanoparticle incudes carbon nanoparticle (fullerenes) and inorganic nanoparticles include magnetic nanoparticle, noble nanoparticle (Au and Ag), semiconductor nanoparticle (TiO2 and ZnO). Especially inorganic nanoparticles have grabbed attention 3 towards itself because of its superior material properties with versatile functions. Due to nano size feature, it is easily used for chemical imaging drugs agents and drug. Versatile function of inorganic nanoparticles is used for the cellular delivery because of their wide availability, rich functionality and good biocompatibility. They are also a good carrier in targeted drug delivery and controlled drug release [6]. Hence, completely advantageous material for medical science (eg: mesoporous silica combined with molecular medicines shows an excellent image on drug releasing). Gold nanoparticle is good carrier in thermo therapy of biological target. Synthesis of nanoparticle gets concern in nanotechnology due to the variable size, shapes, chemical composition and controlled dispersity and their potential use in the medical science for the better treatment of human beings.

In all the metallic nanoparticles, silver nanoparticles grab more attention because of its unique physical, chemical and biological properties. They are one of the promising products in the nanotechnology industry. Current research in nanotechnology focuses on the development of consistent processes for the synthesis of silver nanoparticles. Various literatures depict many ways to synthesize silver nanoparticles which include physical, chemical, and biological methods. The physical and chemical methods used for the synthesis of nanoparticles are not only energy consuming but also non-eco-friendly due to the use of toxic solvents and stringent techniques [7]. Therefore, in the past few years, green synthesis methods have replaced various physical and chemical methods for nanoparticle synthesis, to avoid toxicity of the process and increase quality.

To induce antimicrobial effect silver is mostly used in its nitrate form, but when nanoparticles of silver are made there is a huge increment in surface to volume ratio which makes it an excellent antimicrobial agent. Various literatures depict many ways to synthesize silver nanoparticles which include 2 physical, chemical, and biological methods. Efforts has been made for the development of eco-friendly and cost-effective technique for synthesizing nanoparticles. So, use of plant extracts is the most adopted green and rapid method for nanoparticle synthesis because they are widely distributed, easy and safe to handle and contain several metabolites required for reduction and stabilization of nanoparticles.

**2. Biological Approach for Synthesis of Nanoparticles**

In present scenario the major focus of researchers is the development of efficient green chemistry methods employing natural reducing, capping, and stabilizing agents to prepare nanoparticles with desired morphology and size have. Biological methods used to synthesize nanoparticles comes under the principles of green chemistry, these methods do not use any harsh, toxic and expensive chemical substances. In recent years the biological methods based on microorganisms, whole plant or plant extracts have been demonstrated to be cost-effective and environmentally benign and yet produce highly stable nanoparticles. Out of all the biological methods used for the synthesis of nanoparticles, the methods based on microorganisms have been frequently reported [8,9]. But production of microorganisms is often more expensive than the production of plant extracts. So, use of plant extracts is the most adopted green and rapid method for nanoparticle synthesis because they are widely distributed, easy and safe to handle and contain several metabolites required for reduction and stabilization of nanoparticles. Synthesis of nanoparticles using plant extract or by whole living plants has been also reported in literature [10, 11]. Different methods for synthesis of metallic nanoparticles were depicted in Figure 1



**Figure1: Different approaches for nanoparticle Synthesis [12].**

**3. Green syntheses of silver nanoparticles using plant extract**

The use of plants extracts in the synthesis of silver nanoparticles has drawn attention, because of its rapid, environment friendly, non-pathogenic, economical protocol and providing a rapid technique for the biosynthetic processes. Moreover, plant extracts are easy and safe to handle unlike microbial cultures. The reduction and stabilization of silver ions is achieved by a combination of variety of biomolecules such as amino acids, proteins, enzymes, polysaccharides, alkaloids, phenolics, tannins, saponins, terpenoids and vitamins which are already present in the plant extracts having medicinal values and are environment friendly, yet chemically complicated structures [13]. A large number of plants and plant extracts are reported to facilitate silver nanoparticles synthesis. The general protocol for silver nanoparticle synthesis using plant extracts involves the following steps:

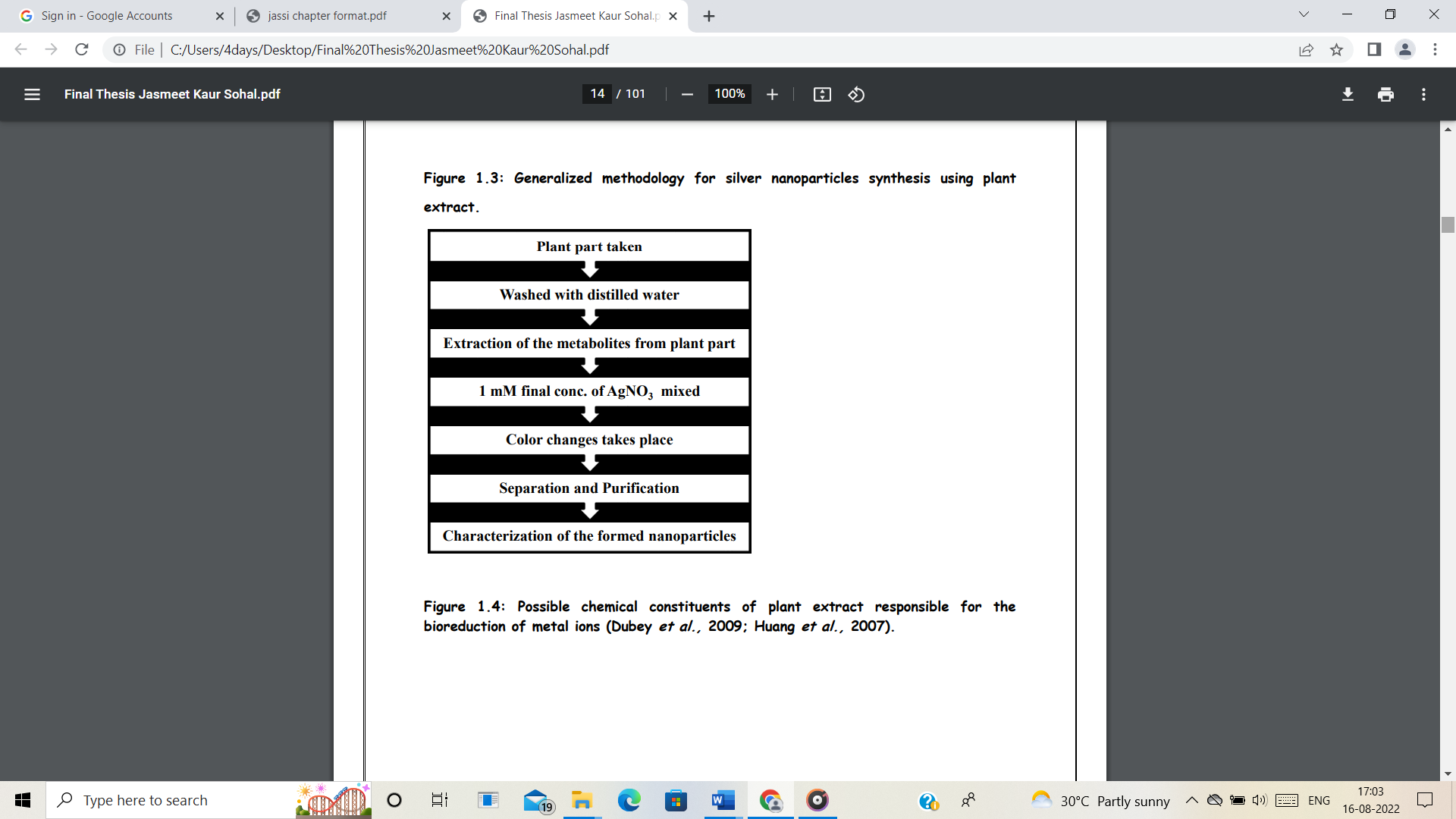
**A. Collection of the plant material:** Plant part of interest is collected and washed thoroughly with tap water to remove necrotic parts, dirt and epiphytes, followed by sterile distilled water to remove debris if any. The fresh and clean plant part is then shed dried for 10-15 days and powdered with the help of blender.

**B. Plant extract preparation:** The dried powdered is mixed with desired solvent in 1:10 ratio and boiled for few minutes. The infusion is then filtered through Whatman filter paper to remove the insoluble material from the extract.

**C. Precursor preparation:** Precursor for silver nanoparticle synthesis is prepared as 1 mM AgNO3 solution.

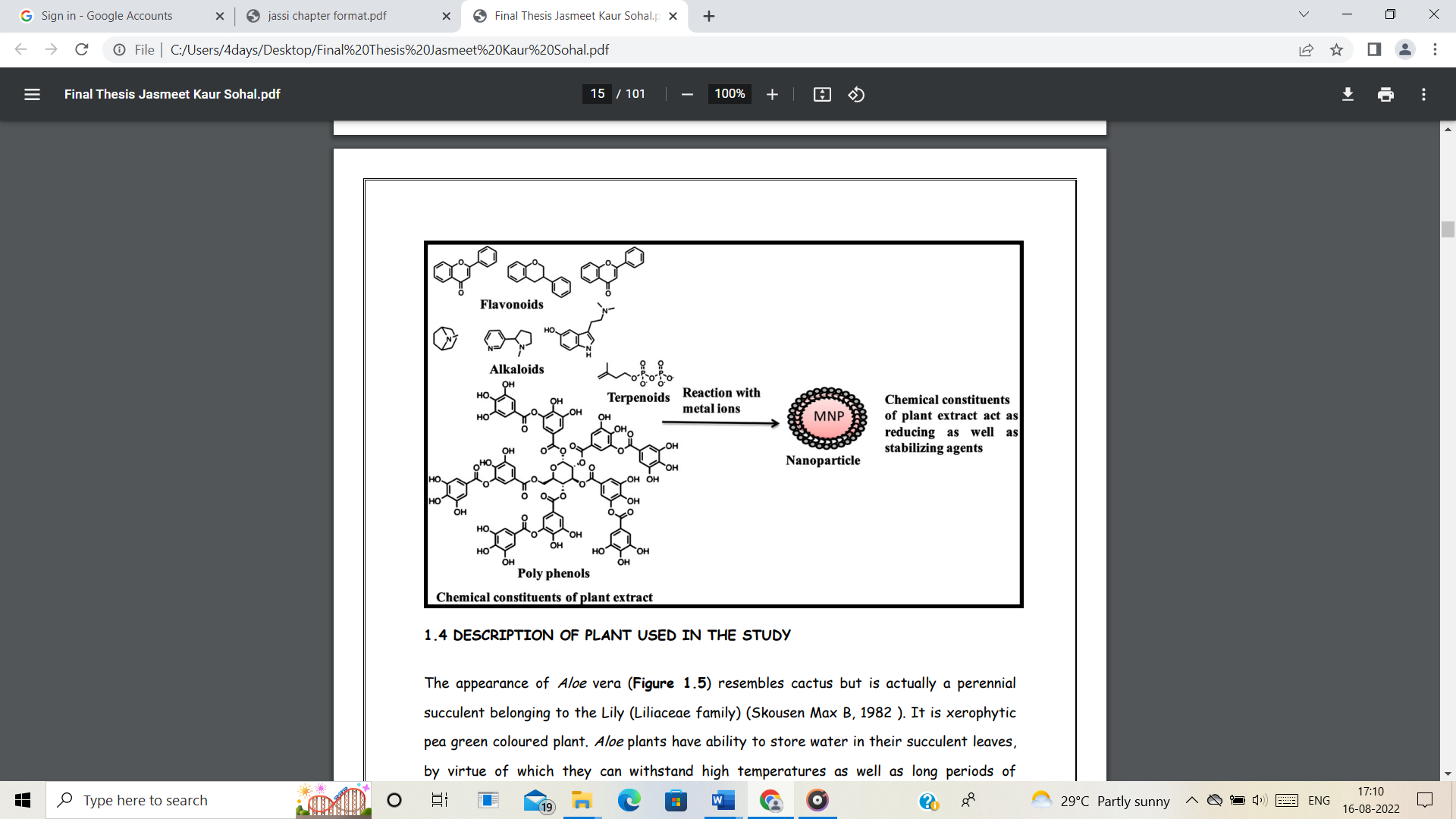
**D. Synthesis of AgNPs:** 1 mM AgNO3 solution is added to few ml of the plant extract which leads to the reduction of Ag(I) ions to Ag (0).

**E. Confirmation**: Synthesis of AgNPs can be confirmed by measuring the UV–visible spectra of the solution at uniform intervals [14]. The absorption maxima of AgNPs ranges between wavelength of 400–450 nm [15]. After synthesis the nanoparticles are characterized by using various techniques. Finally, after confirmation of formation of nanoparticles for its application it needs to be separated and purified from the plant extract (Figure 2).



**Figure 2: Generalized methodology for silver nanoparticles synthesis using plant extract**.

Factors affecting the rate of production of the nanoparticles, their quantity and other characteristics includes nature of the plant extract and its concentration, the pH, the concentration of the metal salt temperature and contact time [16]. Figure 3 shows the probable chemical constituents present in the plant extract responsible for the bioreduction of metal ions, their growth and stabilization.



**4. Biological applications**

**A. Antibacterial and Antifungal Activity**

Currently, struggle to heaps of well-known antibiotics of bacteria of the genera Escherichia, Streptococcus, Salmonella, Pseudomonas etc. is a very important medical problem that mandatory to be resolved furthermore as doable. AGNPs are found to be the foremost promising half in the fight against pathogens within the seek for novel bio medicine. The capability of silver nanoparticles to inhibit growth and to induce the death of unhealthful microorganisms that cause a different kinds of worldwide human diseases square measure united by the enormous majority of the analysis. As indicated on top of, the ability of AgNPs to bind to completely different biomolecules in microorganisms provides their continuous medicine effect. Nowadays, plant extracts are major source of AgNP production. Having their own therapeutic properties and forming AgNPs in particular capping, plants are the primary object of research in this area. Table 1 displays only a minor fraction of the established anti-bacterial result of silver nanoparticles from completely different plant extracts, sometimes superior to antibiotics. Consequently, an inhibitory effect has been exhibit against *C. kefyr* [17], *Vibrio parahaemolyticus* [18], *F. oxysporum, Alternaria brassicicola* [19], *E. aerogenes, B. bronchiseptia* [20], *Fusarium* sp., *Rhizopus* sp. [21], *A. niger, A. flavus* [22], *S. typhimurium, S. enteritidis* [23], *K. pneumoniae, Acinetobacter baumannii* [24], *Str. aureus, E. coli* [25], *St. aureus, Str. Pyrogenes* [26], *Aeromonas hydrophila, Pseudomonas fluorescens* [27], *E. coli* [28], *M. tuberculosis* [29].

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| --- | --- | --- |
| *C. albicans, C. kefyr* | *Euphorbia hirta leaf extract* | 17 |
| *V. parahaemolyticus* | *Adathoda vasica leaf extract* | 18 |
| *F. oxysporum, Alt. brassicicola* | *Citrus limon leaf extract* | 19 |
| *A. fumigatus, F. solani, A. niger, A. flavus, S. aureus, E. aerogenes, B. bronchiseptia* | *Bergenia ciliate leaf extract* | 20 |
| *Fusarium, Rhizopus, Proteus, A. flavus, A. niger* | *Svensonia hyderobadensis leaf extract* | 21 |
| *St. aureus, B. subtilis, Ps. aeruginosa, E. coli, K. pneumonia, A. niger, A. flavus* | *Rhinacanthus nasutus leaf extract* | 22 |
| *E. coli, K. pneumoniae, S. typhimurium, S. enteritidis* | *pu-erh tea leaves* | 23 |
| *K. pneumoniae, Acinetobacter baumannii* | *Neurada procumbens leaf extract* | 24 |
| *S. aureus, Escherichia coli* | *Melissa officinalis leaf extract* | 25 |
| *St. aureus, Str. Pyrogenes, Str. Viridans, Corynebacterium xerosis* | *Usnea longissima extracts* | 26 |
| *Aeromonas hydrophila, Pseudomonas fluorescens and Flavobacterium branchiophilum* | *Boerhaavia diffusa* | 27 |
| *E. coli* | *Aloe vera* | 28 |
| *M. tuberculosis* | *Cucumis sativus plant extract* | 29 |

**B. Antioxidant Activity**

Many scientists studied the radical scavenging activity of plant extract mediate synthesized silver nanoparticles at various time. Nanoparticles fashioned exploitation plant extracts have increased inhibitor activity and it’s is also due to the excellent absorption of inhibitor from plant extracts on the surface of nanoparticles. The inhibitor properties of a silver phyto-nanosystem build them helpful within the cure of illness. Hence, silver Phyto-nanoparticles noninheritable from extracts of plants extracts were found to own high antioxidant activity [30]. Salari *et al* (2019)explained the AgNPs synthesized victimization AN binary compound *Prosopis farcta* fruit extract were wonderful radical cleaners [31], the similar result was shown *in vitro* for AN binary compound extract of apple extract [32], genus *Indigofera hirsuta* [33], leaf extracts of *Elephantopus scaber* [34]. Therefore, high indicators of the activity of inhibitor phyto-nanoparticles could also be associated with the specific capping of AGNPs, particularly for medicative plants, whose extracts contain a range of antioxidants (polyphenols, flavonoids, etc.).

**C. Antiviral Activity**

In current human history, viruses are known as one of the foremost deadly human pathogens. The morbific

nature of viruses involves attachment and penetration into the host cell. during this case, the virus binds to the ligands and proteins on the plasma membrane surface exploitation its own macromolecule components. Preventing such binding seems is that the best route to avoid cell infection. Silver nanoparticles were found

to stimulate the apoptotic pathway by making free atomic number 8 radicals that showed anticancer, antiproliferative and antiangiogenic effects in vitro [35]. Silver nanoparticles disrturb traditional cellular operate and affect the influence of membranes by persuade varied apoptotic communication genes in class cells, leading to planned necrobiosis [36]. As in the antioxidant activity, the foremost common bio factory plants for the production of AGNPs, in the main the anti-cancer properties are already acknowledged. Therefore, different organisms also are used for the synthesis of nanoparticles, for instance, the fungus, bacteria, *A. Fumicatus* [37]. With vigour anti-cancer properties and very low toxicity, AgNPs are the foremost promising malignant tumour drugs. additional analysis into the antiviral activity of AgNPs may open up new potentialities within the fight against varied virus-induced diseases.

**D. Anti-Diabetic Activity**

Since alpha-amylase and glucosidase are necessary enzymes in sugar metabolism, their bar is one among the most key ways within the treatment of polygenic disease. *Amylase* and *glucocidase* inhibitors forestall the breakdown of carbohydrates into monosaccharides, that is that the main reason for the rise in glucose levels. An amylase inhibitor, together with starchy foods, reduces the regular rise in blood glucose. AgNPs are spoken as *alpha amylase* inhibitors in many studies in vitro and in vivo [38}.

**5.Conclusion**

Green biogenesis of silver nanoparticles mediates plant extracts have various benefits over different ways

because they're surroundings friendly, price effective. It is highly appropriate for the assembly of nanoparticles freed from toxic contaminants needed in bio applications. Green biosynthesized silver nanoparticles have vital options of engineering science through unequalled applications and the synthesis of nanoparticles exploitation plants is a lot of helpful than different biological ways as a result of plant materials area unit easy to handle, safe, cosmopolitan and promptly available. This review by conferring totally different literatures according freshly has showed the numerous of plant extract mediate biogenesis of silver nanoparticles and describe them as a decent medicament, antifungal, antioxidant, antiviral, antitumor and anti-diabetic agent.

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