Green Synthesis and Characterization of Silver Nanoparticles using aqueous extracts of three Tunisian plant species, *Basil*, *Eucalyptus* and *Geranium*

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***Abstract*— Green synthesis of silver nanoparticles (AgNPs) has been produced by mixing silver nitrate solution with leaf aqueous extracts of three Tunisian plants namely *Basil*, *Eucalypltus* and *Geranium* as a reducing and stabilizing agent for AgNPs. After only 10 min of reaction, the light yellow color of the *plant* leaf extract was changed to brown due to the reduction of silver ions to AgNPs, under ambient conditions. The formation of biosynthesized AgNPs was monitored by UV-Visible spectroscopy which revealed an absorption peak at 400 nm. X-Ray Diffraction (XRD) was used to confirm the average particle size of AgNPs which were found to be 40, 50 and 30 nm using *Basil*, *Eucalypltus* and *Geranium* leaves aqueous extracts, respectively. Fourier transform infrared (FTIR) spectrum confirmed the possible interaction between silver nanoparticles and capping agents.**

Keywords*— Green synthesis, silver nanoparticles, Basil, Geranium, Eucalyplus, FTIR.

I. Introduction

In today's world, nanotechnology is a diverse field, ranging from extensions of the conventional device to completely new approaches based upon molecular self-assembly. It is also an amalgamating technology which has fascinating multi-disciplinary application in various sections of biological, medicine, cosmetics, renewable energies, environmental remediation and biomedical devices [1, 2]. In recent years, several methods have been used to synthesis AgNPs, including chemical and physical methods [3-6]. However, they are expensive, time-consuming, and environmentally toxic. The biological synthesis of NPs uses different biomaterials such as bacteria [5], yeast [6], algae [7], and plants [8-10]. In biosynthesis methods, the use of plants for the synthesis of nanoparticles attracts the attention of scientists for having a quick, environmentally-friendly, low-cost and simple biosynthesis process compared to other conventional methods [11]. Recently, it has been reported that plants rich in tannic acid have a great potential to synthesize AgNPs and give more stability to the nanoparticles [12].

Besides, investigation on the different plant sources which provide several extract compositions as the reagents for silver reduction could be interested. In this study, we report the synthesis of AgNPs from *Basil*, *Eucalyptus* and *Geranium* plants (Fig.1).

Basil plant is native throughout the old world tropics and widespread as a cultivated plant and an escaped weed. It is cultivated for religious and medicinal purposes, and its essential oil.

Eucalyptus plant has a worldwide distribution, which includes more than 700 species. Also, this plant formerly was used to treat diarrhea, bronchitis, asthma, and respiratory tract infections. Hence, its extracts could be used as a natural antioxidant additive in pharmaceutical and food.

Geranium plant is widely distributed around the world due to its adaptability to different climates. The choice of these plants was motivated by the presence of aromatic compounds.

This paper describes the synthesis and characterization of AgNPs using the aqueous leaf extract of three different plants.

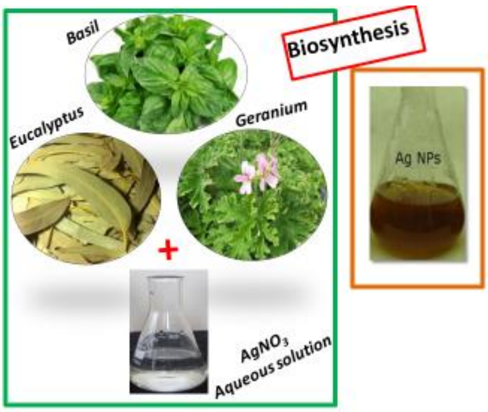

Fig.1. Green synthesis of AgNPs using *Basil*, *Eucalyptus* and *Geranium* plants.

II. MATERIALS AND METHODS

A. *Materials*

We purchased silver nitrate ($AgNO_3$) from Sigma-Aldrich with a purity of 99.999%, distilled water (GFL Gesellschaftfür). In reacting materials; all solutions were prepared using distilled water. *Basil*, *Eucalyptus* and *Geranium l*eaves were collected from the Higher Institute of Agronomy, Chott Mariem, Tunisia (35.915196N, 10.560222E).

B. *Preparation of leaf extract and biosynthesis of silver nanoparticles*

Silver nanoparticles (AgNPs) were synthesized using the same protocol as previously described in the literature [13].

III. RESULTS AND DISCUSSION

A. *Biosynthesis of silver nanoparticles*

The addition of aqueous leaf extract of the different plants to the $AgNO_3$ solution produces a change in the color of the reaction mixture from yellow to brown (Fig.2). Such change in color occurred because the active molecules present in the aqueous leaf extract reduce the Ag^+ ion into Ag^0. The maximum absorbance at 400 nm, which is observed in the extract's UV-visible spectral analysis is the characteristic surface plasmon resonance (SPR) peak of AgNPs. Factors such as size, shape and particles formed influence the SPR peak formation. Similarly, many other reports confirm that the resonance peak of AgNPs appears in this region [14, 15].

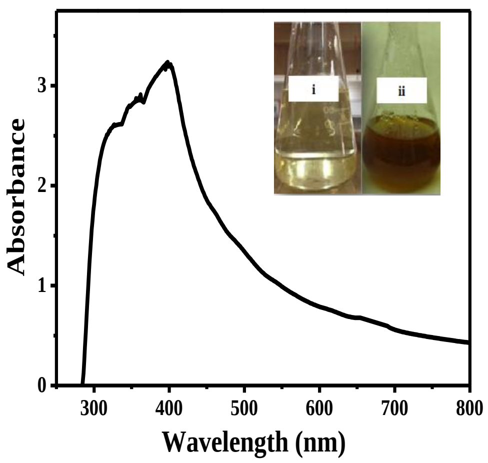

Fig.2. UV–Visible spectra of biosynthesized AgNPs.

B. *X-Ray Diffraction Analysis*

In the XRD pattern, five prominent diffraction peaks were observed which corresponds to (110), (111), (200), (220), (311) and (222) Bragg reflection, this confirms that the AgNPs have a face centered cubic (fcc) crystalline structure [14, 16]. The size of AgNPs was obtained from the X-Ray Diffraction pattern, according to the line width of the maximum intensity reflection peak. The size of the AgNPs was calculated using the Scherrer equation:

$$D = (0.9\ \lambda)/(\beta \cos \theta)$$

Where D is the average crystal size, λ is the X-ray wavelength, °2θ is Bragg's angle and β is the corrected full width at half maximum (FWHM) in radians. The mean value sizes of AgNPs obtained is 40, 50 and 30 nm respectively using *Basil*, *Eucalyptus* and *Geranium* leaves extracts.

C. *Fourier-Transform Infrared spectroscopy (FTIR) Analysis*

The FTIR spectrums confirmed the possible interaction between silver nanoparticles and the bioactive molecules implicated in the nanoparticles. The FTIR spectrum of AgNPs and *Basil*, *Eucalyptus* and *Geranium* aqueous leaves extract reflected intensive peaks corresponds to hydrolyzable tannic acid involved in *plant* leaf extract responsible for the bioreduction and stabilization of AgNPs. The proposed mechanism for biosynthesis AgNPs using *plant* leaf extract was shown in Fig.3.

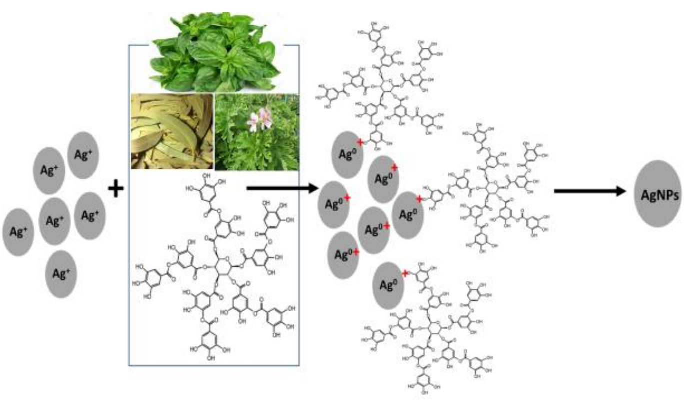

Fig.3. Proposed mechanism for the biosynthesis of AgNPs using *plant* leaf extract

IV. CONCLUSIONS

In this paper, a biological method was reported for the green synthesis of silver nanoparticles using aqueous leaves extract of three Tunisian plants namely *Basil*, *Eucalyptus* and *Geranium*. The development of AgNPs was confirmed by the observed surface Plasmon resonance (λ_{max} at 400 nm) in UV-Vis spectra. FTIR analysis revealed that the synthesized particles were adhered by the functional groups of metabolites from the plant extract. The X-Ray Diffraction results confirm that the AgNPs have a fcc crystalline structure with different size which were found to be 40, 50 and 30 nm, respectively, using *Basil*, *Eucalyptus* and *Geranium* aqueous leaves extract.

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