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Green Synthesis of Silver Nanoparticles of *Morus Rubra* Leaves Extract

Mangilal Chouhan[1], Manoj Kumar Maurya[2], Abdul Hayum A[3], Nihar Ranjan Kar[4], Mukesh Kumar Meena[5], Dipansu Sahu[6], Sherry[7], Sonali Ravindra Pawar[8], Vedant *Kumar Prajapati***

1. Assistant Professor, Department of Pharmaceutical Sciences, Mahanlal Sukhadia University, Udaipur, Rajasthan

2. Assistant Professor, Nims Institute of Allied Medical Science & Technology, Nims University Rajasthan, Jaipur

3. Assistant Professor, Hindusthan Institute of Technology, Coimbatore-641032

4. Assistant Professor, Centurion University of Technology And Management, Gopalpur, Balasore, Odisha, India, Pin-756044

5. Assistant Professor, Department of Pharmaceutical Sciences, Mohanlal Sukhadia University, Udaipur, Rajasthan 313001

6. Associate Professor, Shree N.L. Patel College of Pharmacy Umrakh Gujarat 394601

7. Assistant Professor, Guru Nanak Institute of Technology Mullana Ambala Haryana 133203

8. Assistant Professor, Sinhgad College of Pharmacy Vadgaon Budruk Pune Maharashtra India

Corresponding: *Vedant Kumar Prajapati**

Affiliation: *Assistant Professor, Narayan institute of pharmacy Gopal Narayan Singh University Sasaram Bihar*

vedant.mpharn2012@gmail.com

Abstract: In this study, silver nanoparticles (AgNPs) were made quickly and safely without the use of harmful chemicals by combining silver nitrate in aqueous solution with Mulberry leaf extract. The extract from mulberry leaves works as a stabilising and reducing agent. A peak maximum is visible in the UV-Vis spectroscopy at 430 nm. The roughly spherical-shaped synthetic AgNPs seen in the transmission electron microscopy (TEM) image have a size range of 15 to 20 nm. The average particle size is assessed to be 10 nm in the TEM picture of the Nano Silver solution sample produced by the microwave aided approach. A distinct absorption band about 415 nm is visible in the UV-vis spectra of silver nanoparticles made with microwave assistance (AgNPs mw). Silver nanoparticle peak variations in the UV-Vis spectrum of AgNPsmw after two months of storage are minimal.

Keywords: *silver nanoparticles, AgNPs, Morus Rubra Leaves Extract*

Introduction

Small particles with a diameter between 1 and 100 nm are known as nanoparticles (NPs). Due to their tunable physicochemical properties, such as their melting point, wettability, electrical and thermal conductivity, catalytic activity, light absorption, better tunable optical properties, and higher reactivity, NPs have become more prominent in recent technological advancements

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compared to the material bulk states. Silver nanoparticles have been made using a variety of chemical and physical processes, including chemical reduction, electrochemical procedures, and photochemical reduction. Chemical reduction is the most widely utilised synthetic technique. However, some harmful compounds might be present as a result of the chemical creation of nanoparticles. Green synthesis techniques have been the subject of several investigations to reduce the usage of hazardous ingredients. Mulberry leaf extract is utilised as a reducing agent during the silver nanoparticle synthesis process. This method has several benefits and requires fewer chemicals than other methods, reducing environmental damage. Nanostructured materials have gotten a lot of practical applications in recent years. Due to their antibacterial qualities, silver nanoparticles (AgNPs) are employed in a variety of applications, such as medicines, cosmetics, medical devices, food and beverage, apparel, water purification, agriculture, and wastewater treatment [1–7]. Mulberry leaf extract was employed in this investigation as a stabilising and reducing agent. Mulberry leaf extract can be used as a reducing agent during the silver nanoparticle synthesis process, which not only has many benefits but also requires fewer chemicals. A very efficient and environmentally friendly process is created by combining green synthesis with microwave help.

Figure 1. Picture of Mulberry trees leaves.

Materials and Methods

Formulation of Mulberry Leaves Extract and Silver Nitrate Solution

Mulberry leaves were collected from a residential garden house in Hoi An, Quang Nam province, Vietnam. The leaves collected must be intact and at their prime (neither be too young or too old). Those fresh leaves were then cleaned with fresh water and let air dried by

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

laying them out evenly. 10 g of fresh leaves was obtained, cut into thin strips, then placed into a 200 mL heat-resistant glass flask. Then, they were boiled with distilled water in 5 min, cooled and the mixture was filtered with Whatman filter paper using a vacuum filter [4–7]. The mulberry leaves extract had a light yellow color. The extracted solution was stored in a fridge for further use. Dissolved silver nitrate ($AgNO_3$) from Sigma Aldrich was mixed with distilled water to get 4.10^{-3} M aqueous $AgNO_3$ solution.

Synthesis of Nano Silver Material

Mulberry leaves extract and Non-Microwave Assisted Synthesis of Nano Silver Visual Observation and UV-vis Spectral AgNO3 4.103 M solution were combined at various ratios, as shown in Table 1. These mixes were put on a shaker and swirled at room temperature for 30 minutes at 150 rpm. Except for mixtures M0 and M1, all of the mixtures had a 30-minute colour change from pale brown to dark red. Using different ratios of AgNO3 concentration and mulberry leaves extract results in different colours for each mixture (Figure 2). This finding suggested that nano-sized silver particles had generated.

Table 1. Synthesized samples.

$AgNO_3$ Solution (mL)	Mulberry Leaves Extract (mL)	Samples
0	10	M 0
50	0	M 1
50	1	M 2
50	4	M 3
50	6	M 4
50	7	M 5
50	8	M 6
50	9	M 7

Characterization Techniques:

Analyzed the UV-vis absorption spectra with a GE Ultrospec 7000 UV-vis spectrophotometer (GE Lifesciences, Freiburg, Germany) in order to look into the optical properties. The JEOL JEM 1010 (JEOL, Tokyo, Japan) was used to analyse silver nanoparticles under a transmission electron microscope (TEM). Fourier transform infrared (FTIR) Spectra were used to measure the X-ray diffraction spectra using the diffractometer Bruker D8-Advance (Bruker, Karlsruhe, Germany). With the IRAffinity-1S Shimadzu FTIR spectrophotometer (Shimadzu, Tokyo, Japan), extract for mulberry leaves was produced in the 400–4000 cm^1 range. Absorption is especially intense between the wavelengths of 200 and 250 nm. As a result, samples were 40 times diluted before being measured using UV-vis. The substance's UV-vis spectrum reveals a potent surface plasmonic resonance band with a centre wavelength of 430 nm. The absorbance

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intensity increased for samples M2, M3, and M4 when we raised the amount of mulberry leaf extract from 1 mL to 5 mL. The intensity decreased as the volume of mulberry leaves extract increased for samples with more than 5 mL of mulberry leaf extract. By combining spectral data with qualitative observation, we were able to determine that AgNPs were created when AgNO3 solution and mulberry leaf extract were combined. The sample M4 had the most AgNPs particles, as evidenced by the fact that it had the darkest red colour and the greatest peak intensity value of any of our samples. We may also deduce that the pace of AgNPs generation is so quick at high concentrations of mulberry leaf extract that it hinders the creation of a protective layer between particles. This was made possible by the occurrence of particle aggregation, which increased particle size. As the particle size rose, the peak's strength decreased and it moved to a longer wavelength (as in samples M5, M6, and M7). The olive-colored line in Figure 3 depicts the absorption spectrum of AgNO3 aqueous solution; there was no peak within the measuring range. Because of an organic compound present in the extract solution, the mulberry leaves extract's absorption spectra, shown in orange line in Figure 3, had a peak in the short wavelength region and no peak at wavelengths greater than 400 nm. According to the spectrum data, AgNPs particles could only be created when AgNO3 and mulberry extract were combined. Discrete lines could be seen when the absorption spectra was enlarged from 380 to 700 nm (Figure 3).

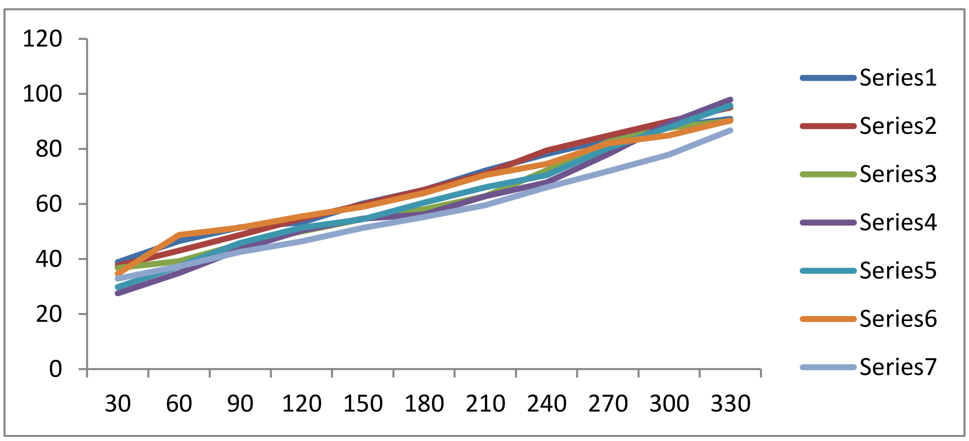

Figure 2. UV-Vis spectra of $AgNO_3$ solution (M1), Mulberry extract (M0) and AgNps prepared at different Mulberry leaves extract

Visual Observation and UV-Visible Spectral

AgNO3 solution in a 50 mL combination with 6 mL of mulberry leaf extract was divided into two equal portions. The first part (M8) was then put on a shaker machine and stirred for 30 minutes at room temperature at 150 rpm. The other component (M9) was microwave heated for one minute. M9's hues changed in the microwave in just one minute from light yellow to dark red, proving that the microwave-assisted approach was more efficient than the traditional method for synthesising (AgNPsmw). The example colours are shown in Figure 4.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

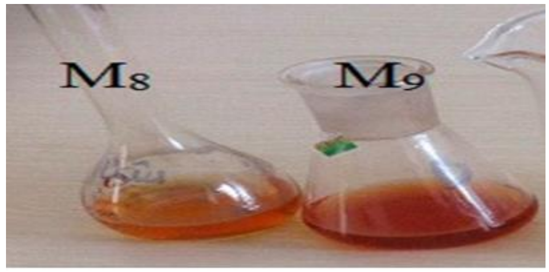

Figure 3: Photograph of silver nanoparticles (AgNPs) (M_8) and of AgNPsmw (M_9).

The UV-vis spectra (Figure 5) show that M9 has a higher absorption strength at roughly 415 nm than M8 and a shorter maximum wavelength than M8. The M9 sample was renamed M10 after being stored for two months. The peak intensity of the UV-vis spectra for M10 (the blue line in Figure 5) differs somewhat from that of M9 and shows a peak shift of 5 nm in favour of a longer wavelength. According to the aforementioned results, the synthetic colloid solution is incredibly stable. When compared to the work of other authors, our study led to smaller particles, a quick synthesis, and a higher absorption peak intensity.

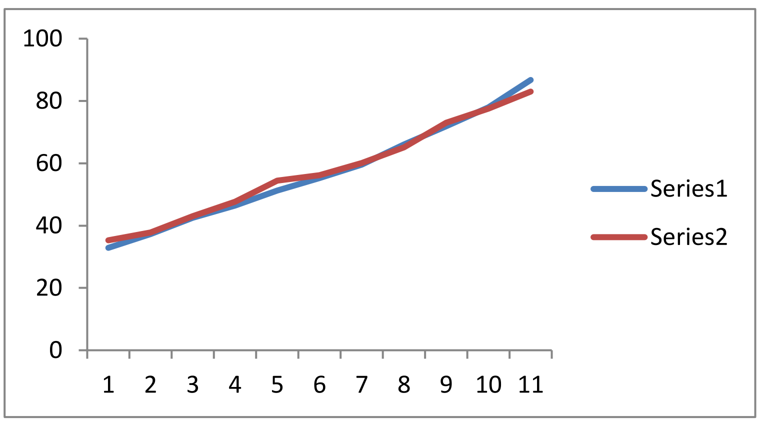

Figure 4: UV-Vis spectra of AgNPs (M8), of AgNPsmw (M9) and of AgNPsmw after two months of storage (M10).

X-ray Diffraction (XRD) Studies

One piece of cloth was divided into 25 cm2 pieces and submerged for 10 minutes in an AgNPs colloids solution, while the other piece was left out. Figure 6 displays the XRD patterns of the fabric dipped in a colloids solution of AgNPs and the cloth that was not dipped in a colloids solution of AgNPs. The undipped cloth's XRD pattern did not exhibit any peak silver features. On the other hand, the XRD pattern of the cloth that was coated with AgNP colloids revealed the peak silver feature. At 2 values of 38.2, 44.1, 64.5, and 77.6, which correspond to the (111), (200), (220), and (311) crystallographic planes of face-centered cubic (fcc) Ag crystals, respectively, four key characteristics of the diffraction peak for Ag were detected [14,15]. Few AgNPs particles were deposited onto the cloth surface due to the

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

low AgNps concentration and the large number of empty spaces inside the internal structure of the cloth, which resulted in a low peak intensity.

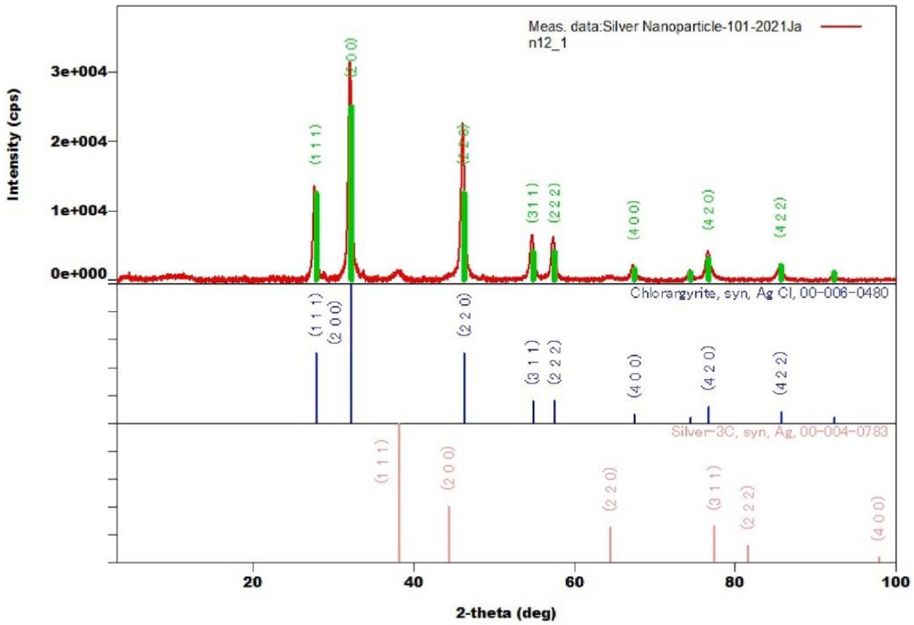

Figure 5: X-ray diffraction of a pieces of cloth dipped into a colloids solution AgNPs (blue line), and a pieces of cloth not dipped into a colloids solution AgNPs (black line).

Transmission Electron Microscope (TEM) Analysis

Figure 7 illustrates how TEM examination further confirmed the AgNPs' size and form. A relatively homogeneous range of spherical particle sizes, between 15 and 20 nm, could be seen in the TEM image of M8. The particle size in the TEM picture of M9 was around 10 nm. There was no evidence of nanoparticle clumping, and the particle sizes were more homogeneous.

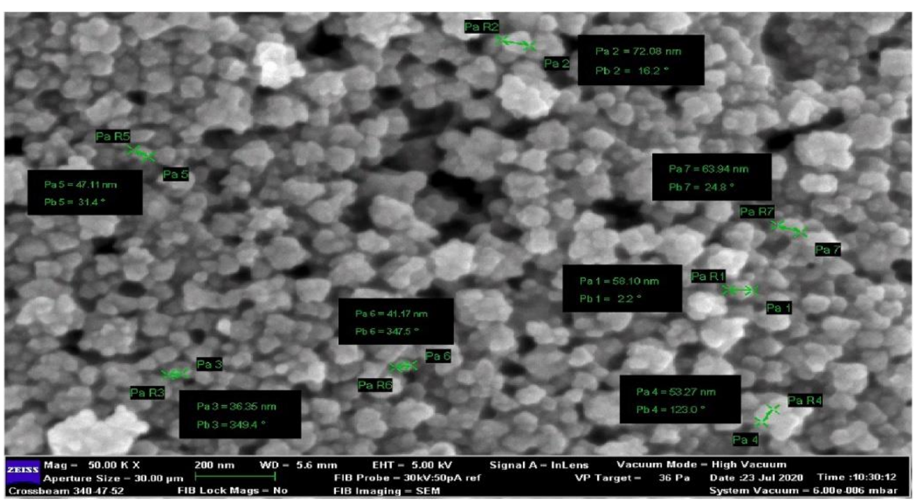

Figure 6: Shows the histogram of size distribution of silver nano particles. The average particle size measured from the TEM image is 10 nm. This large variation in particle size was due to the

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

presence of a few irregular shaped particles.

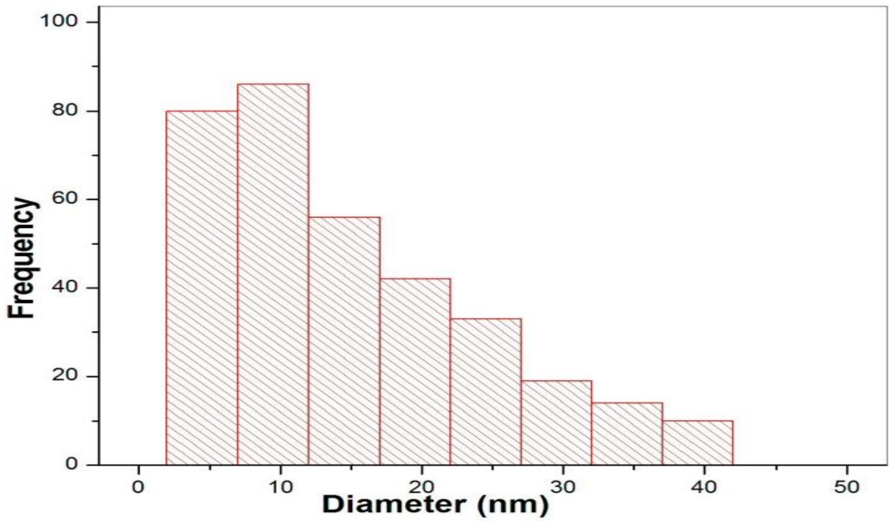

Figure 7: Histogram showing the particle sizes of AgNPs corresponding to TEM images M_9.

FT-IR Spectrum

To prevent the extracted solution from spoiling before collecting the mulberry leaf extract spectrum (from the sample synthesis to the FT-IR spectrum takes around 5 days), 0.5 mL of the AgNO3 solution was added to 50 mL of mulberry leaves extract. Figure 9 displays the FT-IR spectra of silver nanoparticles produced using this eco-friendly technique. Several absorption peaks can be found at 3261 cm1 and 1637 cm1. The biomaterial binds to the silver nanoparticles through amine and C=O of amide I and II of the protein, as shown by the peaks at 3261 cm-1, which correspond to O-H and N-H bonds, and the peak at 1637 cm-1, which corresponds to the C=O bond [1,6,7,16]. These findings show that the extract of mulberry leaves reduces and stabilises silver particles. Alkaloids, proteins, enzymes, amino acids, alcoholic compounds, and polysaccharides were claimed to be responsible for the reduction of the silver ions to nanoparticles, according to investigations by A.K. Mittal et al. The extract also contained the pigments quinol and chlorophyll, which helped to stabilise and reduce the nanoparticles [17]. Similar leaf extracts from Dhatura metel are also present in mulberry leaf extracts [18-32]. Mulberry leaf extract thus contributed to the stabilisation and decrease of the nanoparticles.

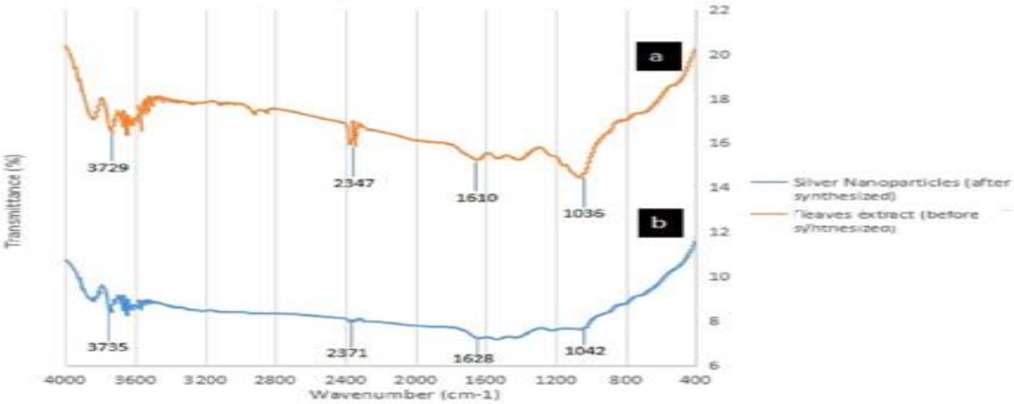

Figure 8: FTIR spectrum of mulberry leaves extract.

Conclusions

A green and environmentally friendly method has been used to successfully synthesise the colloid solution of silver nanoparticles (AgNPs). This technique uses less chemicals and is rapid and extremely effective. The method of green synthesis with microwave assistance is more efficient than the method without one. AgNPs exhibit an absorbance peak in the UV-Vis spectrum with a wavelength range of 425-435 nm. The size of nano-silver particles, which ranges from 15 to 20 nm, is spherical. AgNP smw exhibits a peak in its UV-vis spectrum at 415 nm, with an average particle size of 10 nm. The findings seen following two months of AgNP smw storage are quite stable.

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