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Silver Nanoparticle for the Development of Latent Fingerprint

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ABSTRACT

The initiation of the development of latent fingerprints among the porous surfaces is first approached through the method of ($AgNO_3$) silver nitrate due to the significant enhancement in the cost of the chemical; it created the situation for forensic experts to search for a substitute for the chemical. Silver nitrate, the specific component for synthesizing the nanoparticles of metal called (AgNP) nanoparticles, has unique properties for adhering to the residue of fingerprints. Silver nanoparticles also attracted the expert's attention to the domain of nano-forensic fingerprinting. This entire study is also concentrated on utilizing the lower concentration of ($AgNO_3$) by a new silver nanoparticle development method.

This method is also synthesized with the method of wet chemical along with the various types of molar concentrations of (0.1, 000.1, 0.01) of AgNO3, which gets characterized through the visible spectrophotometer of ultraviolet as well as having the electron microscopic transmission of high resolution (HR-TEM). The diameter of the silver nanoparticle is also calculated through the HR-TEM, which was around 0.01M at 12.50 $\pm$ 2.64 approximately. The analysis measures the stability and quality of the fingerprints produced on the blank sheet or the porous substrate while utilizing the Silver Nitrate and silver nanoparticles.

Within this entire study, the Silver Nitrate can develop the details of distinct ridges and is also found to be stable for more than 30 days. Comparatively, silver nitrate is used to develop the agents in the latent fingerprints; only the faint patterns of the ridge were observed and analyzed, which may further represent the degradation of the fingerprint's stability around 20 days. The silver nanoparticles method also represents a good amount of stability and visibility through the utilization of the lower concentration of AgNO3, which can also be utilized by replacing the conventional method of silver nitrate.

The size of the particle also depends on the SPR surface plasmon resonance. If the particle size is smaller, the wavelength will also get shorter, but when there is an increase in the size of the particle, the wavelength curve also shifts towards the red coloration. The spectra absorbance of the AgNPs prepared with the three various types of molar concentrations (0.1- 0.001M) of the Silver Nitrate were observed with the wavelength of (400-newton meters for 0.1M) and (402-newton meters for 0.001M). Due to these SPR phenomena in the AgNPs, a slight increase or decrease in the size of the particle is related to the change in wavelength of the colloidal solution. 10 ml of $AgNO_3$ and one percent of the solution of polyvinyl alcohol are added to prepare the Silver Nitric solution, which has constant stirring while utilizing the magnetic stirrer for an hour. In the same way, the solution of 10ml of sodium Borohydride is also prepared with constant stirring after this complete dissolution of the $AgNO_3$ and sodium hydride. The aqueous solution is added to it drop by drop. The yellow colloidal solution is generated under this high-speed stirring of around 100 rounds per minute at atmospheric pressure and room temperature.

Keywords: Latent fingerprint**,** HR-TEM**,** Silver nitrate**,** silver nanoparticles**,** Ridge**,** Porous surface

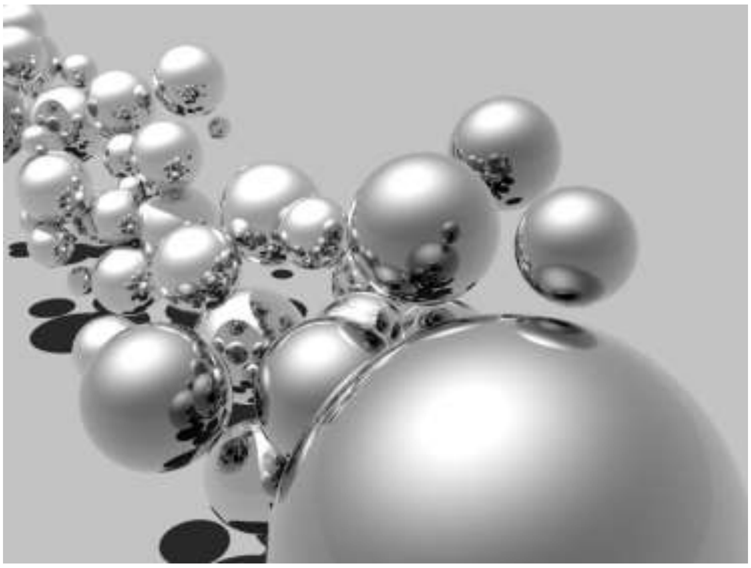


Image of silver nanoparticles

(Source: www.elgalabwater.com, 2023)

1. INTRODUCTION

The factual proof always identified in the Crime Scene is the fingerprint, as it is the most unnoticed path of establishing an individual's identity. In this modern era of DNA analysis, fingerprints are still important and considered the main tool in investigating crime. The hand is also furnished with capillaries that may aid in holding objects. When the portion of the palm or the fingers comes in touch with any surface, it leaves the deposition of sweat, probably similar to the ridge design. This type of deposition is also unrevealed due to its colourless sweat composition. Moreover, this kind of deposition of fingerprints is also named latent fingerprints. Several types of conventional methods are also utilized to detect and develop these types of latent fingerprints.

UV-Vis adsorption can be stated as the technique that is utilized to determine the functionality of nanoparticles optically. In this type of experiment, the analysis of UV-Vis is carried out on the HACH Dr 5000, which is the UV-visible spectrophotometer. This meter is equipped with facilities like wavelength scanning in a full range from 190- 1100 Newton meters, spectral meter band having a width of around 2 Newton meters, and a scanning speed of around one scan per minute in the steps of one Newton meter.

Typically, these types of fingerprints also suffer some limitations, such as the shortage of visibility, contrast, and stability. It can also be noted that the certainty of such a method in detecting the latent fingerprint is also not so much a functional method. Therefore, a requirement is present for the selective and advanced method for detecting latent fingerprints. From the past years, this vintage method of the AgNO3 has been utilized for development of the latent fingerprints which is also becoming the best suitable for plain surfaces like blank sheets of paper. The method of developing silver physically combines with the oxidation-reduction couple in which the ions of iron get reduced with the ions of AG in the metallic silver which also creates the silvery image of the fingerprints on the blank sheet of paper (Aggarwal & Chitkara, 2022).

Fingerprint residue is visible as a dark grey or black silver picture on the paper surface thanks to the interaction between the silver nanoparticles (1-200 nm) created during the reaction and the organic components of the fingerprint residue. The electrostatic force of attraction between the negatively charged silver colloids and the positively charged fingerprint remnants is what causes the fingerprint to develop. A latent fingerprint can be stated as the latent which means the unseen or hidden fingerprint which can be seen by applying various types of methods on it so that it can be visible to the human eye. The latent fingerprints are also undetectable until they are brought out by applying any kind of physical or chemical process which is always designed for the enhancement of the Residue of a latent fingerprint. It may also be affected by gender, stimuli, age, occupation, diseases, and any kind of substance.

Figure1. Latent fingerprint

(Source: www.slideshare.net, 2023)

Based on the survey of the literature, the complete mechanism for analyzing the visualization of latent fingerprints through the AgNO3 involves the chemical reaction among the ions of chloride as well as the AgNO3 which may lead to the reaction of the insoluble particles of the silver chloride creating the image of fingerprint in a brown shade. This kind of net reaction of the AgNO3 with the sodium chloride particles in the fingerprints is also presented in the form of an equation below.

$$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$$

Similar to this method, the novel solution of the (AgNPs) also represented a glimpse of a better future in the conducting of the identification of latent fingerprints. This mechanism of the development of fingerprints through the (AgNPs) or silver nanoparticles was initiated in the year 2001 by scientists in the method of developing silver physical (Ag-PD). This method of developing silver physically combines with the oxidation-reduction couple in which the ions of iron get reduced with the ions of AG in the metallic silver which also creates the silvery image of the fingerprints on the blank sheet of paper. Fingerprint residue is visible as a dark grey or black silver picture on the paper surface thanks to the interaction between the silver nanoparticles (1-200 nm) created during the reaction and the organic components of the fingerprint residue (Zhang *et. al*., 2017). The Silver nanoparticles were prepared at various types of molar concentrations of $AgNO_3$ and were applied as the spraying solution for developing the fingerprints on the white porous surface of the paper. It also represents the clear visibility of the patterns of fingerprints with the distinguishable ridge types like the ridge ending, bifurcation, bridge, and core as well as Delta at the 0.01 moles similar with that the characteristics of the ridge like the enclosure Delta, short ridge also observed at the 0.01 moles concentration of the AgNPs solution at the concentration of 0.1 moles of the AgNPs.

The electrostatic force of attraction between the negatively charged silver colloids and the positively charged fingerprint remnants is what causes the fingerprint to develop. Particle size also depends on the SPR surface plasmon resonance, if the particle size is smaller the wavelength will also get shorter but when there is an increase in the size of the particle, the wavelength curve also shifts towards the red coloration. The spectra absorbance of the AgNPs prepared with the three various types of molar concentrations (0.1- 0.001M) of the Silver Nitrate were observed with the wavelength of (400-newton meters for 0.1M) and (402-newton meters for 0.001M). Due to these SPR phenomena in the AgNPs, a slight increase or decrease in the size of the particle is related to the change in wavelength of the colloidal solution.

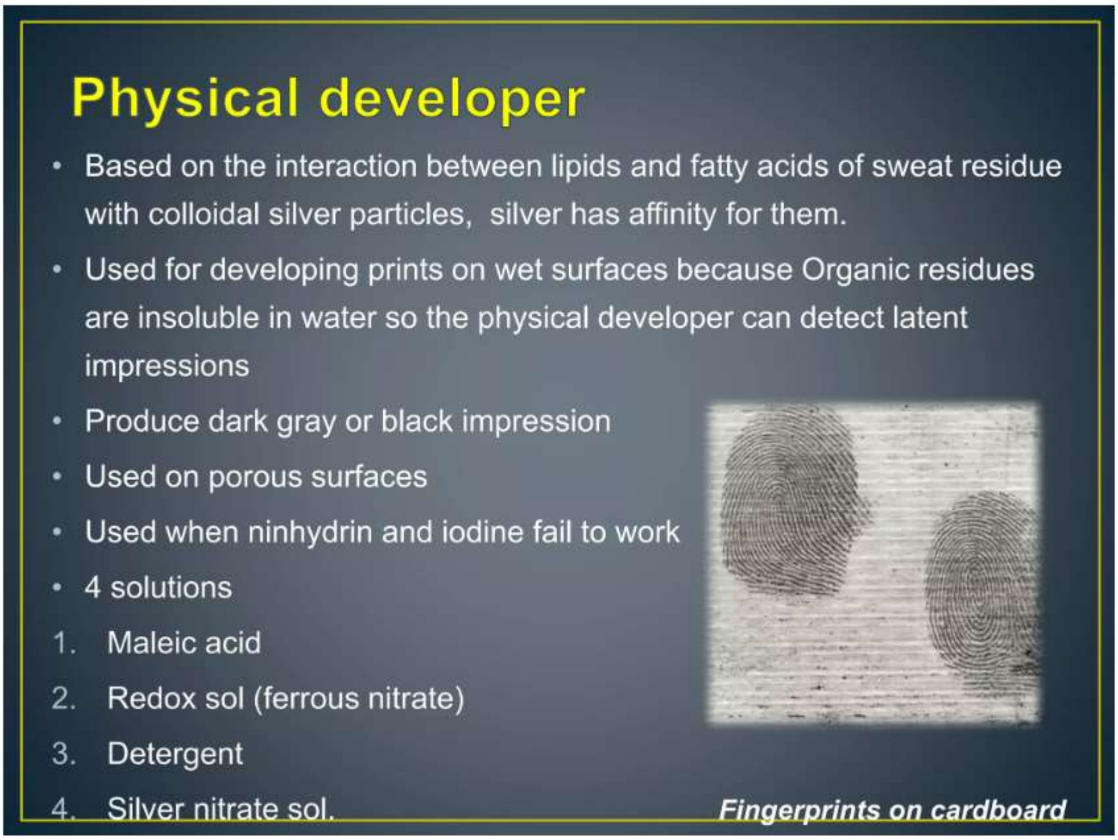


Figure 2. Physical developer

(Source: www.slideshare.net, 2023)

They also noticed that the complete changes of the fingerprints on the blank sheet of paper through this method were because of the physical interaction among the fat-soluble fingerprints as well as the silver nanoparticle's Residue. This mechanism of latent fingerprint development approach through the use of silver nanoparticles comprises of the basic physical interaction which is also mentioned in the literature previously in which the Residue of fingerprints gets charged positively as well as the (AgNPs) also acquire the electron from its surrounding environment.

The process of acquiring the positive charge on the fingerprints as well as the negative charge on the (AgNPs). Moreover, this method also comprises major drawbacks like the size of the silver nanoparticles that are created because this process is around 1 to 200 Newton meters and this process is also time-consuming as well a large amount of silver Nitrate solution is also utilized in this process (Yun *et. al*., 2020).

Eventually, compared with the present study of the method of silver nanoparticles created to the one to hundred Newton meters the dimension also provided a large amount of surface area for the development of the latent fingerprint in the short duration and having a small amount of silver nitrate solution. Moreover, this method of silver nanoparticles is also simple and easy to utilize as compared to the silver physical developer method. The complete mechanism for visualizing the fingerprints of the silver nanoparticles is also represented in the heading below.

2. Latent fingerprint development mechanism by the silver nanoparticles

The organic components of the fingerprint residue have an affinity for metallic silver, according to published research. Based on this idea, silver nanoparticles have been employed since 1970 as a reagent in the silver physical developer (Ag-PD) approach to reveal latent fingerprints on porous paper surfaces. The Ag-PD method uses an oxidation-reduction pair in which an iron salt converts a silver nitrate aqueous solution into metallic silver. The fingerprint residue is visible as a dark grey or black silver picture on the paper surface thanks to the interaction between the silver nanoparticles (1-200 nm) created during the reaction and the organic components of the fingerprint residue.

The electrostatic force of attraction between the negatively charged silver colloids and the positively charged fingerprint remnants is what causes the fingerprint to develop. According to other researchers, the Ag-PD approach is effective for identifying latent fingerprints on porous objects, especially when visualization is done on objects that have been accidentally or purposefully moistened. However, the technique has one flaw, which is that using just the Ag-PD solution results in low visibility of the fingerprints. The issue was solved by applying gold nanoparticles stabilized with a citrate ion to the fingerprint before treating it with an Ag-PD solution.

2.1 The Development of Nanoparticles for Forensic Fingerprinting

Information regarding the identification of latent fingerprints using nanoparticles was accessible in the early 1970s. To see latent fingerprints on porous paper surfaces throughout the 1980s, the standard silver physical developer process employed nanoparticles like gold and silver. However, the use of nanoparticles for the identification of latent fingerprints was rather limited over these 20 years. To detect latent fingerprints on porous and nonporous surfaces, nanoparticles such as aluminium oxide, silicon dioxide, amphiphilic silicon, fluorescent starch-based carbon, and Eu+3-doped Al_2O_3 gained popularity between 2006 and 2016 (Madhavan & Sharma, 2019).

This mechanism of latent fingerprint development approach through the use of silver nanoparticles comprises of the basic physical interaction, which is also mentioned in the literature previously in which the Residue of fingerprints gets charged positively as well, and the (AgNPs) also acquire the electron from its surrounding environment. The process of acquiring the positive charge on the fingerprints as well as the negative charge on the (AgNPs) This is also described in the steps below (Malik *et al.*, 2020).

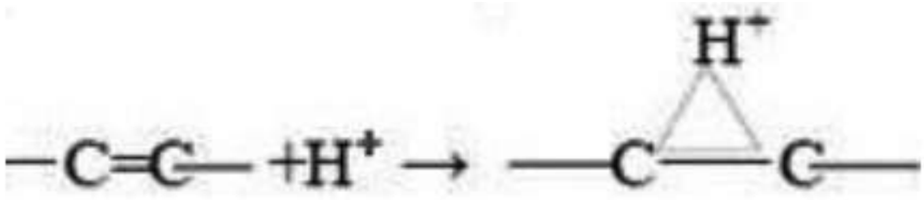
Figure 3. Steps of Developing Fingerprint

(Source: www.slideshare.net, 2023)

Fingerprint Residue gets positively charged based on the survey of previous literature. The latent fingerprint development on the blank sheet of paper through the silver salt or the Silver Nitrate is also challenging as the $CaCO_3$ coating of paper turns the paper black colour because of the presence of silver oxide with the silver ions. Moreover, to solve this issue, the latent fingerprint gets the pre-treatment with the acidic acid which was used for the neutralization of the blank sheet of paper. This reaction is also presented in the form of an equation below.

$$CaCO_3 + 2H+ \rightarrow Ca_2 + + H2O + CO_2$$

The researchers also suggested that under the reaction of the acidic surroundings. The bonds of double carbon also get positively charged. Apart from all other components of the residue of fingerprints which contains the double bonds of carbon which single one is the unsaturated fatty acid. Moreover, this acidic environment also gets a positive charge in the fatty acid's components of the residue fingerprints. These type of fatty acid reactions is also presented below in the form of an image (Luthra & Kumar, 2018).



2.2 Silver nanoparticles get negatively charged

In the present study (AgNPs) are utilised for analyzing the latent fingerprints on a blank sheet of paper. This silver nanoparticle was also prepared based on utilizing the AgNO3 as the precursor through its chemical reduction method within the presence of strong and responsive reducing agents such as sodium borohydrides. Having the small reduction centre borohydrides, the (AgNPs) are also created at the time of reaction, which gets circled spontaneously with the electrons of the irons of Borohydride, which is also represented in the form of an image in Figure 4 (Yang et al., 2019). The size of a particle also depends on the SPR surface plasmon resonance; if the particle size is smaller, the wavelength will also get shorter, but when there is an increase in the size of the particle, the wavelength curve also shifts towards the red colouration. The spectra absorbance of the AgNPs prepared with the three various types of molar concentrations (0.1- 0.001M) of the Silver Nitrate were observed with the wavelength of (400-newton meters for 0.1M) and (402-newton meters for 0.001M). Due to these SPR phenomena in the AgNPs, a slight increase or decrease in the size of the particle is related to the change in wavelength of the colloidal solution (Lavanya *et al.*, 2022).

Due to such a type of adsorption of electrons from the ions of borohydride, the AgNPs also carry the electrons which are previously mentioned in the literature itself (Zhao *et. al*., 2016). Such mechanism of latent fingerprint development approach through the use of silver nanoparticles comprises of the basic physical interaction, which is also mentioned in the literature previously in which the Residue of fingerprints gets charged positively as well as the (AgNPs) also acquire the electron from its surrounding environment. The process of acquiring the positive charge on the fingerprints as well as the negative charge on the (AgNPs) (Naik et al., 2021).

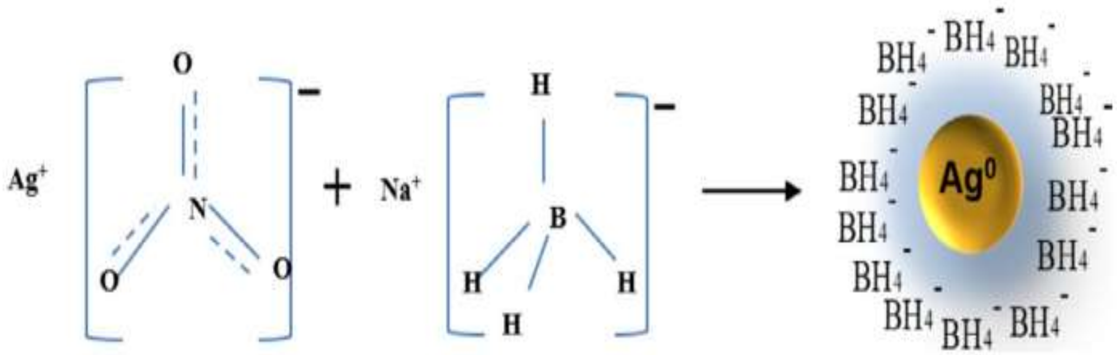


Figure 4. Chemical reduction of Silver with the sodium borohydride reductant.

(Source: www.onlinelibrary.wiley.com, 2023)

Terms of fingerprint Residue come in contact with the electrons of (AgNPs) due to the absorption of borohydride ions; they get attached by the electrostatic force. The physical interaction of the (AgNPs) with the sebaceous secretion of the residue of fingerprints also leads to the visualisation of the latent fingerprint on the blank sheet of paper, which is represented in Figure 5 (Wei & Cui, 2021).

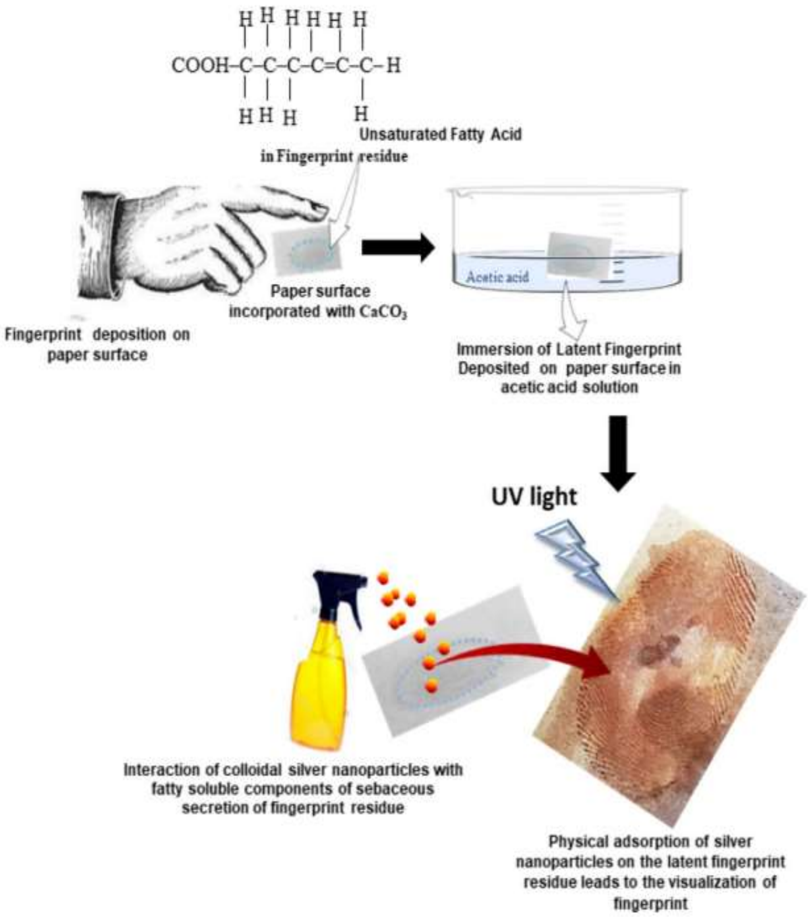


Figure 5. Represents the producer of the development of latent fingerprint through (AgNPs) on the blank sheet of paper

(Source: www.onlinelibrary.wiley.com, 2023)

In the previous study of the data, the development of the fingerprints while using the $AgNO_3$ is also represented that it provides the highest degree of stability related to the surface of the paper where the aqueous solution of about 1 to 3% of the Silver Nitrate is used. Eventually, this aqueous solution of 1 to 3% of the $AgNO_3$ is also created from 10 to 30 grams of the AgNO3 as well as the cost of 1 gram of AgNO3 is almost 1.66 in Indian currency (Rajan *et al.*, 2019). Moreover, the significant enhancement in the cost of $AgNO_3$ from the past years has also created a situation for forensic experts to think about to find a more suitable way that can be less expensive as compared to using the silver nitrate solution (Singh *et al.*, 2022). Discussing this aspect, the present study concentrates on the minimal utilization of $AgNO_3$ through its lowering concentration as we also decrease the concentration of around 0.1 to 0.01 moles, which can ultimately decrease the cost. Eventually, the detailed study of the stability-developed latent fingerprints with the $AgNO_3$ as well as the AgNPs is also illustrated here (Du *et al.*, 2017).

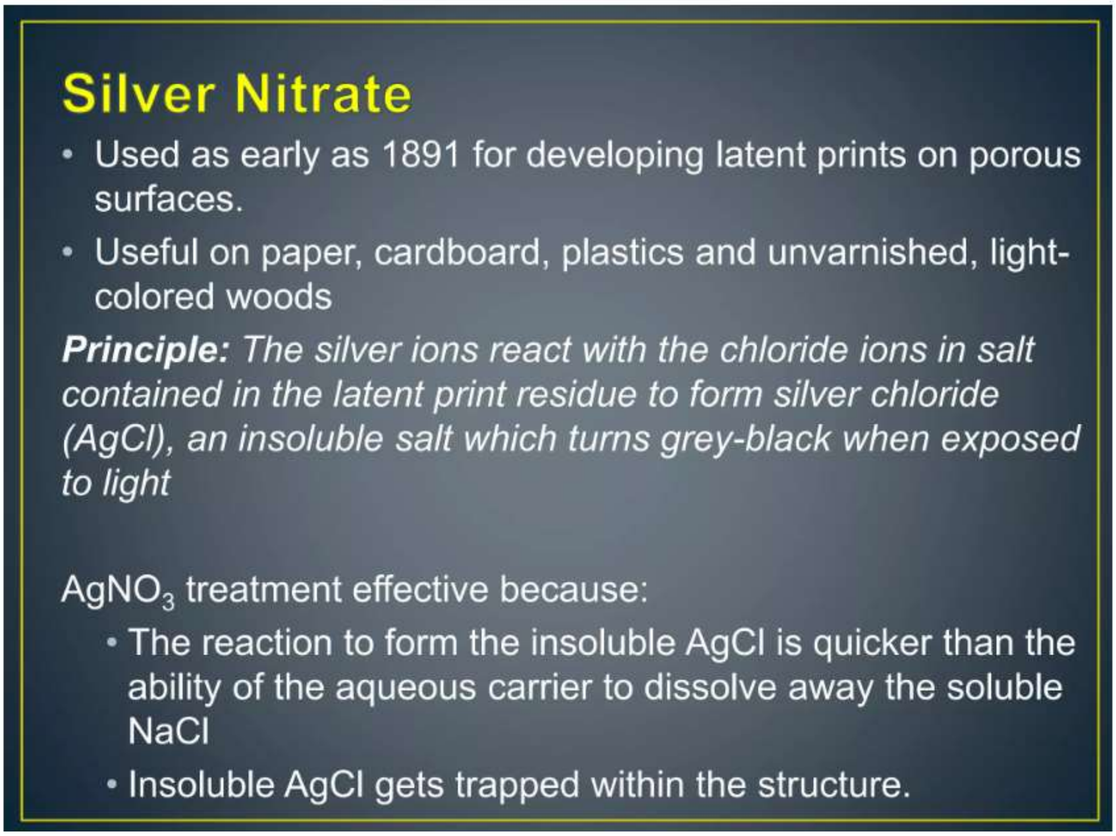


Figure 6. Silver nitrate specifications

(Source: www.slideshare.net, 2023)

2.3 Chemicals required

Silver nitrate of analytical grade, polyvinyl alcohol, sodium borohydride. All these chemicals were utilized without any kind of further purification. The samples of the Chemicals were also categorized through the ultraviolet visibilities Spectroscopy on the bench top. The size of the particle was also determined by the utilization of the electron transmission microscopy of high resolution with an incident energy of around 200 KV. The images of fingerprints were also taken by the utilization of a camera of 1080x 2350 pixels of resolution. If the particle size is smaller the wavelength will also get shorter but when there is an increase in the size of the particle, the wavelength curve also shifts towards the red coloration. The spectra absorbance of the AgNPs prepared with the three various types of molar concentrations (0.1- 0.001M) of the Silver Nitrate were observed with the wavelength of (400-newton meters for 0.1M) and (402-newton meters for 0.001M). Due to these SPR phenomena in the AgNPs, a slight increase or decrease in the size of the particle is related to the change in wavelength of the colloidal solution (Evangelista, 2022).

2.4 Preparation of the solution of $AgNO_3$ and AgNPs

10 ml of the solution of $AgNO_3$ is prepared and one percent of the solution of polyvinyl alcohol is added for preparing the Silver nitric solution having constant stirring while utilizing the magnetic stirrer for an hour. In the same way, the solution of 10ml of sodium Borohydride is also prepared with a constant amount of stirring. After this complete dissolution of the $AgNO_3$ as well as sodium hydride (Zhu *et. al*., 2022). The aqueous solution is added to it drop by drop. Under this high-speed stirring of around 100 rounds per minute at atmospheric pressure and room temperature, the yellow colloidal solution is generated. This complete reaction also allows it to proceed for at least 2 hours. The solution which is obtained from the reactions also allowed for settling time for a night. The solution of 10 ml of silver nitrate is also prepared in Milli-Q water (Sigdel, 2019).

2.5 Characterization of AgNPs

2.5.1 UV-Vis

This UV-Vis adsorption can be stated as the technique that is utilized for determining the functionality of nanoparticles optically. In this type of experiment, the analysis of UV-Vis is carried out on the HACH Dr 5000, which is the UV-visible spectrophotometer. This meter is equipped with facilities like wavelength scanning in a full range from 190- 1100 Newton meters, spectral meter band having a width of around 2 Newton meters as well and a speed of scanning is around 1 scan per minute in the steps of one Newton meter (Cheng et al., 2016).

2.5.2 HR-TEM

The size of the particle was also ascertained through the transmission of electron microscopy of high-resolution images as well and the specified area of the electrons in the diffraction pattern was also acquired while utilizing the JEOL 2100F. An analysis of TEM samples was also prepared by putting a single drop of the silver nanoparticles solution in the copper grid which is carbon coated while operated with the incident energy of around 200 KV. This solution of the point lattice is around 0.23- 0.1 Newton meters, as well as the magnification on the range is around x50- x1.5 M. Images of HRM as well as the histogram of the distribution of sizes of the AgNPs synthesized with the various types of concentrations of the silver nitrate solution represented in Figure 7. The image of TEM of the AgNPs at the value of 0.01 moles represented the irregular shape and morphology of particles with its overall average diameter of the particles around 10.66 to 1.22 high low in which the images of TEM of the silver nanoparticles at 0.01 moles demonstrated the good amount of distribution of the particles which follows the spherical shape having the average diameter of the particle size of around 12.50 to 2.64 high low (González *et al.*, 2020).

2.5.3 Condition and Method for Latent Fingerprint Development

The blank sheet of paper is also incorporated through the alkaline filler such as calcium carbonate and in the situation when it gets reacted with the particles of silver nanoparticles, it also leads to the alteration of the concentration of silver nanoparticles. Moreover, it is suitable for neutralizing the alkaline solution of the paper before starting the development of the fingerprint by providing the acid pre-wash to the sample of the paper. Acidic acid is also commonly utilized for such types of purposes. The solution comprises 25 grams of acetic acid and 1 l of the water is created. This sample of the paper is dipped in this solution for around 5 to 10 minutes (Bumbrah *et al.*, 2022).

2.5.4 Latent Fingerprints Development

Latent fingerprints were analyzed based on collecting the Impressions of the fingerprints on the blank sheet of paper. The two methods split this process of recognition for the latent fingerprints. The first method involves the treatment of the surface of the paper containing the latent fingerprints with the Acetic Acid for around 5 to 10 minutes. The solution of silver nanoparticles is also sprayed on the blank sheet of paper and it was placed in the ultraviolet chamber for around 10 minutes (Li *et. al*., 2017).

This process is repeated two times for the complete development of the latent fingerprints on the sample of paper. In the second method, a solution of silver nitrate was sprayed on top of the blank sheet of paper. The concentration of the Silver Nitrate also gets reduced from 0.1- 0.0001, and the characteristics of the Ridge also get diminished because of the lower concentration of the $AgNO_3$ which ultimately also lowers the production of the ions of silver for the complete creation of the AgCl with the components of salt in the residue fingerprint. Figure 7 also represents that the complete visibility of the developed latent fingerprint with the $AgNO_3$ at the 0.1- 0.0001 moles also gets reduced due to the course of this duration.

The fades fingerprint because of the diffusion of the chloride ions present in the residue fingerprint over this period. The system of latent fingerprint development approach through the use of silver nanoparticles comprises of the basic physical interaction which is also mentioned in the literature previously in which the Residue of fingerprints gets charged positively as well as the (AgNPs) also acquire the electron from its surrounding environment. process of acquiring the positive charge on the fingerprints as well as the negative charge on the (AgNPs). The method of developing silver physically combines with the oxidation-reduction couple in which the ions of iron get reduced with the ions of AG in the metallic silver which also creates the silvery image of the fingerprints on the blank sheet of paper (Ahmad *et.al*.,2019).

Fingerprint residue is visible as a dark grey or black silver picture on the paper surface thanks to the interaction between the silver nanoparticles (1-200 nm) created during the reaction and the organic components of the fingerprint residue. The electrostatic force of attraction between the negatively charged silver colloids and the positively charged fingerprint remnants is what causes the fingerprint to develop (Lin *et al.*, 2022).

2.5.5 Optical Analysis of AgNPs

The review represents that the particle size also depends on the SPR surface plasmon resonance; if the particle size is smaller, the wavelength will also get shorter, but when there is an increase in the size of the particle, the wavelength curve also shifts towards the red colouration. The spectra absorbance of the AgNPs prepared with the three various types of molar concentrations (0.1- 0.001M) of the Silver Nitrate were observed with the wavelength of (400-newton meters for 0.1M) and (402-newton meters for 0.001M). Due to these SPR phenomena in the AgNPs, a slight increase or decrease in the size of the particle is related to the change in wavelength of the colloidal solution (Leśniewski, 2016).

2.5.6 Morphological Analysis of AgNPs

The images of HRM as well as the histogram of the distribution of sizes of the AgNPs synthesized with the various types of concentrations of the silver nitrate solution represented in Figure 7. The image of TEM of the AgNPs at the value of 0.01 moles represented the irregular shape and morphology of particles with its overall average diameter of the particles around 10.66 to 1.22 high low in which the images of TEM of the silver nanoparticles at 0.01 moles demonstrated the good amount of distribution of the particles which follows the spherical shape having the average diameter of the particle size of around 12.50 to 2.64 high low (Sharma *et. al*., 2021). The concentration of the Silver Nitrate also gets reduced from 0.1- 0.0001, and the characteristics of the Ridge also get diminished because of the lower concentration of the $AgNO_3$ which ultimately also lowers the production of the ions of silver for the complete creation of the AgCl with the components of salt in the residue fingerprint. Figure 7 also represents that the complete visibility of the developed latent fingerprint with the $AgNO_3$ at the 0.1- 0.0001 moles also gets reduced due to the course of this duration. The fades fingerprint because of the diffusion of the chloride ions present in the residue fingerprint over this period (Brandão *et. al*., 2020).

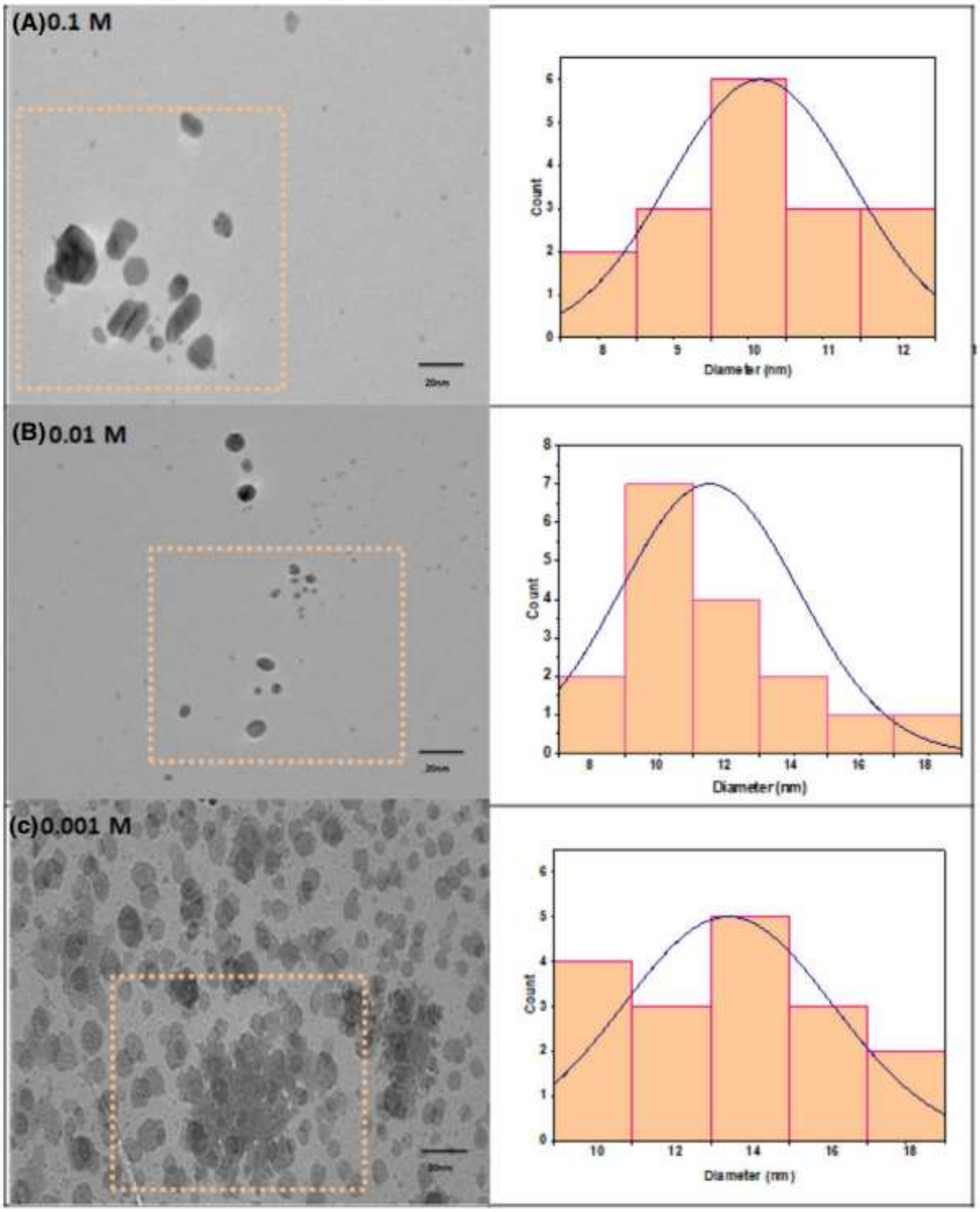


Figure 7. HR-TEM images and distribution of the particle size of the silver nanoparticles prepared through various concentrations of $AgNO_3$

(Source: www.onlinelibrary.wiley.com, 2023)

Moreover, the image TEM of the Silver nanoparticles is almost 0.1 M representing the agglomeration of the particles having an average diameter of size of a particle is around 14.4 to 2.68 high low. Due to the reduction in the molar concentration of the NABH reducing agent, the linear increment as well as the differences in the size of nanoparticle is also observed for around 0.01 as well as 0.1 M, having the average size of the particle is around 12.50 to 2.64 high low (Prabakaran & Pillay, 2020). Moreover, the molar concentration of the sodium hydride represented the crucial differences in the spherical shape of AgNPs representing various types of size distribution among the histogram as represented (Bhati & Tripathy, 2020).

The distribution of particle size of the AgNPs is also determined through the utilization of the image software. This complete analysis was also performed by converting the pixels into nanometres while setting the scale bar as well as the part of the TEM image was also selected. The selected portion of every particle measured individually, as well as the measurement of the data, was plotted utilizing a histogram. Using its software Origin pro-8. This detailed description of the common size of the particle of AgNPs which is prepared at various types of molar concentrations of the Silver Nitrate.

2.5.7 Latent fingerprint development through $AgNO_3$

This silver nitrate prepared at various types of molar concentration is also applied as the spraying solution for developing the fingerprints, which are deposited on the Porous blank sheet of paper. The poor visibility of the fingerprints was also developed through the $AgNO_3$ solution, which also represented the same type of ridge patterns; only a few of the characters, like the bifurcation, ridge ending, and the eye, were visible at 0.1 moles. Types of fingerprints also suffer some limitations which are the shortage of visibility, contrast, and stability. It can also be noted that the certainty of such type of method in detecting the latent fingerprint is also quite not so much a functional method (Prasad *et. al*., 2019).

The $AgNO_3$ method is utilized for the development of the latent fingerprints which is also becoming the best suitable for plain surfaces like the blank sheet of paper. The method of developing silver physically combines with the oxidation-reduction couple in which the ions of iron get reduced with the ions of AG in the metallic silver, which also creates the silvery image of the fingerprints on the blank sheet of paper. Therefore, a requirement is present for the selective and advanced method for detecting latent fingerprints. From the past years, this vintage method of AgNO3 has been utilized for the development of latent fingerprints, which is also becoming the best suitable for plain surfaces like blank sheets of paper. The method of developing silver physically combines with the oxidation-reduction couple in which the ions of iron get reduced with the ions of AG in the metallic silver, which also creates the silvery image of the fingerprints on the blank sheet of paper (Khadri *et al.,* 2017).

The Delta at the 0.01 moles, as well as the short ridges, are visible at 0.001 Mole as depicted in the histogram figure 7. It is also observed that the concentration of the Silver Nitrate also gets reduced from 0.1- 0.0001, and the characteristics of the Ridge also get diminished because of the lower concentration of the $AgNO_{3,}$ which ultimately also lowers the production of the ions of silver for the complete creation of the AgCl with the components of salt in the residue fingerprint. Figure 7 also represents that the complete visibility of the developed latent fingerprint with the $AgNO_3$ at the 0.1- 0.0001 moles also gets reduced due to the course of this duration. The fades fingerprint because of the diffusion of the chloride ions present in the residue fingerprint over this period (Nagar *et. al*., 2022).

2.5.8 Latent Fingerprints Pre-treatment

Latent fingerprint pre-treatment in the neutralization of acidic acid on the paper. This step is prepared on the paper for latent fingerprint development through the utilization of silver nanoparticles.

Concentration	Mean ±SD	Total number	Sum	Median
0.001 M	10.66 ± 1.22	17	181.22	10.54
0.01 M	12.50 ± 2.64	17	212.53	11.89
0.1 M	14.44 ± 2.68	17	245.62	14.43

Figure 8. Avg. particle size distribution of AgNPs through various molar concentration

(Source: www.onlinelibrary.wiley.com, 2023)

2.5.9 Latent Fingerprint Development through AgNPs

After completing the process of the pre-treatment of the blank sheet of paper. The Silver nanoparticles are prepared at various types of molar concentrations of $AgNO_3$ and were applied as the spraying solution for developing the fingerprints on the white porous surface of the paper represented in the above figure 7. It also represents the clear visibility of the patterns of fingerprints with the distinguishable ridge types like the ridge ending, bifurcation, bridge, and core as well as Delta at the 0.01 moles similar with that the characteristics of the ridge like the enclosure Delta, short ridge also observed at the 0.01 moles concentration of the AgNPs solution at the concentration of 0.1 moles of the AgNPs (Bhagat *et. al*., 2021).

Moreover, the fingerprints were analyzed but with less amount of clarity represented by the characteristics of namely the bridge, and core represented in Figure 7. Eventually, it is also evident that the 0.1 to 0.0001 moles of concentration of the AgNPs solution method also did a good number of results on the plane sheet of paper because of the size of the particle which is around 10 to 14 Newton meters as measured with the HRM as well as comparatively having the large amount of surface area that also provides the sample area in the development phase of the fingerprint latent within the faster rate (Suryawanshi & Nalage, 2023).

This AgNPs solution method is the best and most effective method for the complete development of the Latent fingerprints on the blank sheet of paper having the interactions among the fatty acid components as well as the Silver colloidal of the fingerprint mentioned in the previous sections of the literature. Process of acquiring the positive charge on the fingerprints as well as the negative charge on the (AgNPs). Moreover, this method also comprises major drawbacks like the size of the silver nanoparticles that are created because this process is around 1 to 200 Newton meters and this process is also time-consuming as well a large amount of silver Nitrate solution is also utilized in this process. Compared with the present study of the method of silver nanoparticles created to one to hundred Newton meters the dimension also provided a large amount of surface area for the development of the latent fingerprint in the short duration and having a small amount of silver nitrate solution. Moreover, this method of silver nanoparticles is also simple and easy to utilize as compared to the silver physical developer method (Wan *et. al*., 2022). The complete mechanism for visualizing the fingerprints of the silver nanoparticles. The distribution of particle size of the AgNPs is also determined through the utilization of the image software. This complete analysis was also performed by converting the pixels into nanometres while setting the scale bar as well as the part of the TEM image was also selected. The selected portion of every particle measured individually as well as the measurement of the data was plotted utilizing a histogram (Ula, 2022).

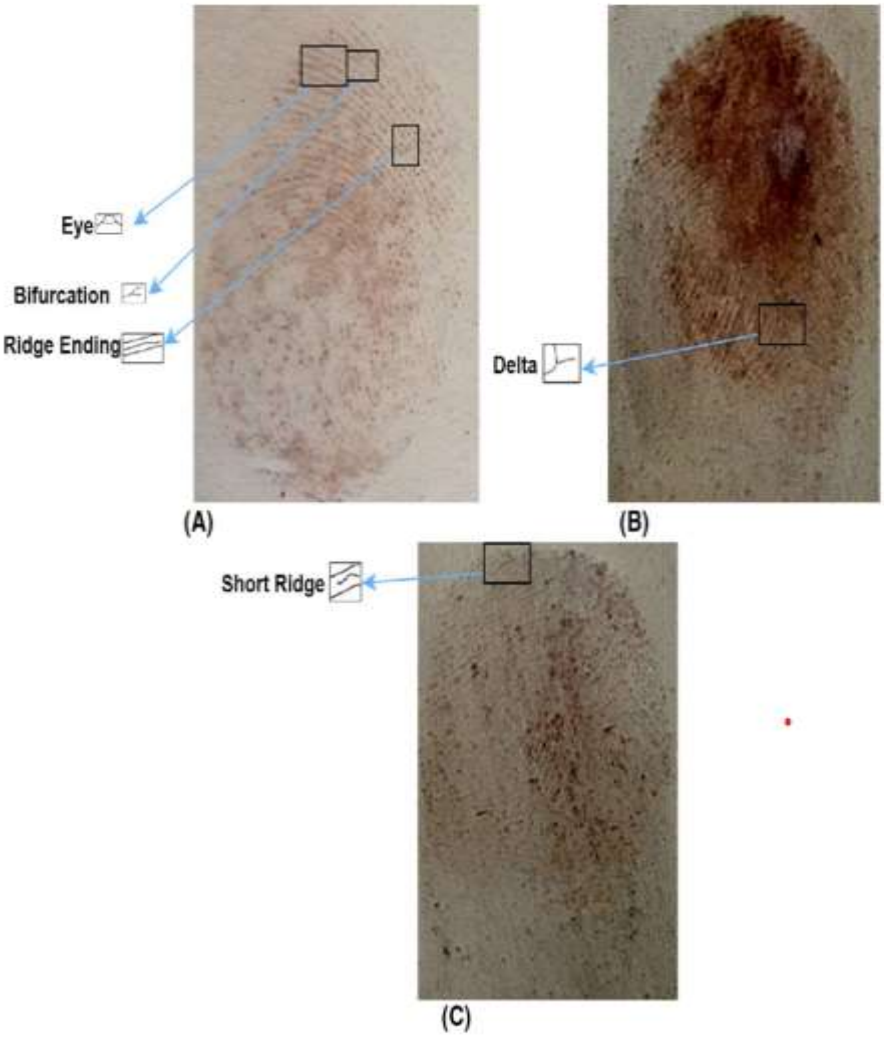


Figure 9. Development of fingerprints on the porous plane surface of the paper

(Source: www.onlinelibrary.wiley.com, 2023)

3. Comparative study among the silver nanoparticle and silver nitrate on latent fingerprint

The study revealed that the development of latent fingerprints with the Silver Nitrate at the molar concentration of 0.1 moles has stability for around 20 days, but the concentration at 0.01 and 0.001 moles decreases the complete stability of the fingerprints diminishes because the diffusion of the ions of chloride which may take place within the surface of the paper within this period. Moreover, the development of fingerprints with the silver nanoparticles also prepared with the various types of molar concentrations of the $AgNO_3$ where the 10.66 $\pm$1.22 nanometres for the 0.01 moles and 12.5 $\pm$ 2.64 nanometre at the molar concentration of 0.01 moles as well as 14.44 $\pm$ 2.68 Newton meter for the molar concentration of 0.1 moles represented this stability which gets persisted for around 30 days but in the minor decrement in the stability of the AgNPs. Fingerprints are also observed based on the earlier studies of the decrement of the AgNP concentration; the particle sizes decrease, as well as the collision rate of the particles gets enhanced, resulting in faster movements (Assis *et. al*., 2023).

Small particles also created aggression as well as the decrement and stability of the AgNPs. Moreover, the development of fingerprints with the $AgNO_3$ represented the high amount of degradation in the visibility of the fingerprints as well, and the concentration also gets reduced, hence in Figure 10. It also represented the consistency among the stability of the development of fingerprints with the silver nanoparticles compared to the Silver Nitrate. Moreover, the AgNPs have better performance in comparison with Silver Nitrate in the imaging of fingerprints because of the intact nature of the AgNPs with its organic component of the Residue of fingerprints that also offers the stable development of the fingerprint on the sheet of paper for the following duration of time (Andrade *et al.*, 2018).

4. CONCLUSION

It is concluded that an effective and simple method is introduced for developing the latent fingerprint on the piece of paper at room temperature. The study was also conducted and learn about the influence of the AgNPs at various types of concentrations as well as the $AgNO_3$ for the development of the Latin fingerprints on the substance of the paper. The AgNPs, as well as $AgNO_3$, were also prepared at room temperatures; AgNPs prepared at various types of concentrations of the $AgNO_3$, which represent the various types of formations of the AgNPs related to the shapes of wavelength, size distribution, and morphology of the AgNPs formation of the three different types of concentrations of the AgNO3 was also confirmed by the images of HR-TEM.

These images of HR-TEM based on AgNPs having various types of concentrations of $AgNO_3$ represent the variations in the size of the particle as well as the shape. The variations in the shape are also observed at the 0.01 mole, having the average diameter of the particle is around 10.66 $\pm$1.22 NM for the 0.01 moles and 12.5 $\pm$ 2.64 nanometre at the molar concentration of 0.01 moles as well as 14.44 $\pm$ 2.68 Newton meter for the molar concentration of 0.1 moles represented this stability which gets persisted for around 30 days but in the minor decrement in the stability of the AgNPs. It also represented the consistency among the stability of the development of fingerprints with the silver nanoparticles compared to the Silver Nitrate. Moreover, the AgNPs have better performance in comparison with Silver Nitrate in the imaging of fingerprints because of the intact nature of the AgNPs with its organic component of the Residue of fingerprints that also offers the stable development of the fingerprint on the sheet of paper for the following duration of time.

It is also evident that the 0.1 to 0.0001 moles of concentration of the AgNPs solution method also did a good number of results on the plane sheet of paper because of the size of the particle, which is around 10 to 14 Newton meters as measured with the HRM as well as comparatively having the large amount of surface area that also provides the sample area in the development phase of the fingerprint latent within the faster rate. Silver nitrate prepared at various types of molar concentrations is also applied as the spraying solution for developing the fingerprints, which are deposited on the Porous blank sheet of paper.

The solution of silver nanoparticles was also sprayed on the blank sheet of paper and placed in the ultraviolet chamber for around 10 minutes. This process is repeated two times for the complete development of the latent fingerprints on the sample of paper. In the second method, a solution of silver nitrate was sprayed on top of the blank sheet of paper. The concentration of the Silver Nitrate also gets reduced from 0.1- 0.0001, and the characteristics of the Ridge also get diminished because of the lower concentration of the $AgNO_3$, which ultimately also lowers the production of the ions of silver for the complete creation of the AgCl with the components of salt in the residue fingerprint. Figure 7 also represents that the complete visibility of the developed latent fingerprint with the $AgNO_3$ at the 0.1- 0.0001 moles also gets reduced due to the course of this duration.

The poor visibility of the fingerprints was also developed through the $AgNO_3$ solution, which also represented the same type of ridge patterns; only a few of the characters, like the bifurcation, ridge ending, and the eye, were visible at 0.1 moles. The Delta at the 0.01 moles, as well as the short ridges, are visible at 0.001 Mole as depicted in the histogram. The images of HRM as well as the histogram of the distribution of sizes of the AgNPs synthesised with the various types of concentrations of the silver nitrate solution.

Image of TEM of the AgNPs at the value of 0.01 moles represented the irregular shape and morphology of particles with its overall average diameter of the particles around 10.66 to 1.22 high low in which the images of TEM of the silver nanoparticles at 0.01 moles demonstrated the good amount of distribution of the particles which follows the spherical shape having the average diameter of the particle size of around 12.50 to 2.64 high low.

The particle size also depends on the SPR surface plasmon resonance; if the particle size is smaller, the wavelength will also get shorter, but when there is an increase in the size of the particle, the wavelength curve also shifts towards the red colouration. The spectra absorbance of the AgNPs prepared with the three various types of molar concentrations (0.1- 0.001M) of the Silver Nitrate were observed with the wavelength of (400-newton meters for 0.1M) and (402-newton meters for 0.001M). Due to these SPR phenomena in the AgNPs, a slight increase or decrease in the size of the particle is related to the change in wavelength of the colloidal solution.

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