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Eco-Friendly Synthesis OfSilver Nanoparticles Using Mimosa PudicaExtract For Leather Preservation

Swetha Shree[1*]

Abstract
This study presents a greenery approach for synthesizing silver nanoparticles (AgNPs) utilizing the aqueous and ethanol extract of Mimosa pudica, a commonly found medicinal plant. This process involves the reduction of silver ions, resulting in the formation of stable AgNPs for which mimosa pudicabarksacts as a reducing and capping agent for silver nanoparticles. The synthesized Mimosa pudicaAgNPs was tested for its antibacterial and antifungal activity in which the sample shows 20-±2 mm and 18-±2 mm zone of inhibition respectively for various strains. As silver nanoparticlesdue to their smaller size and large surface area, can easily penetrate into leather pores, it can be served as preservatives in leather processing at different stages. Various characterization techniques, including UV-Vis spectroscopy, X-ray diffraction (XRD), transmission electron microscopy (TEM), and Fourier-transform infrared spectroscopy (FTIR), were employed to elucidate the size, shape, and chemical composition of the synthesized AgNPs. The study also explores the potential applications of these AgNPs in wastewater owing to their redox properties. This green synthesis method not only offers a sustainable alternative for leather preservation but also highlights the use as vegetable tanning agent and as detoxifying agent in tannery wastewater.

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I. Introduction:

The distillation of medicinal plant extracts can predominantly serve as cutting-edge antibacterial and antifungal agents, exemplified by Mimosa pudica, A. herba alba, C. cinerea, A. tenuifolius, and E. guyoniana, along with Aloe vera, among others. Mimosa pudica, colloquially acknowledged as the responsive flora or non-contactable entity, represents a distinctive and captivating botanical specimen renowned for its unique responsiveness to tactile stimuli and its potential therapeutic attributes when subjected to extraction and subsequent multifarious applications. Mimosa pudica, a creeping perennial plant within the Fabaceae family, showcases its native origins in Central and South America, but has since proliferated across diverse tropical and subtropical ecosystems worldwide. The plant's leaves exhibit an inward folding and drooping reaction upon tactile interaction, a mechanism evolved as a defense mechanism against herbivores, hence earning it the moniker "sensitive plant" or "non-contactable entity." Traditionally, various elements of Mimosa pudica have been harnessed to ameliorate a spectrum of medical conditions, with its leaves, roots, and seeds finding utility in diverse cultural practices for their prospective medicinal attributes. Mimosa pudica emerges as a compelling botanical entity with a gamut of conventional and potential medicinal applications, particularly when its extracts are exploited for their antioxidative, anti-inflammatory, antimicrobial, and gastrointestinal health characteristics. The primary rationale for selecting Mimosa pudica lies in its easy accessibility and adaptability to seasonal conditions, coupled with cost-effectiveness. Notably, it possesses both antifungal and

antimicrobial activities, rendering it a viable option against an array of microbial organisms. According to scientific reports, aqueous leaf extracts of Mimosa pudica encompass a chemical composition comprising alkaloids, saponins, flavonoids, phenols, amino acids, proteins, inulin, steroids, carbohydrates, terpenoids, and tannins. The utilization of plant extracts has emerged as an increasingly advantageous and effective approach in green nanoparticle synthesis, as these extracts inherently function as both reducing and stabilizing agents.The biosynthetic procedure for generating nanoparticles, ranging in size from 1-100nm, utilizing plant extracts has garnered considerable attention as a straightforward and sustainable substitute to conventional chemical and physical methods. This approach boasts advantages such as diminished environmental repercussions compared to physiochemical methodologies, the capacity to yield substantial quantities of nanoparticles devoid of contamination, and the attainment of well-defined morphologies. The key phytochemicals responsible for nanoparticle synthesis from plant extracts encompass terpenoids, flavones, ketones, aldehyde amides, among others. The bactericidal efficacy of metal nanoparticles can be attributed to their minuscule dimensions and elevated surface-to-volume ratio, facilitating interactions with microbial membranes, rather than solely relying on the release of metal ions into solution. Various natural precursors, including plant extracts, microorganisms, and enzymes, fall under the umbrella of "green sources." Notably, polyphenols, which serve as both coating agents and reducing agents, stand out as a prevalent source of antioxidants employed in silver nanoparticle production. Over the past decade, silver nanoparticles (Ag-NP) have emerged as a subject of extensive scientific scrutiny, owing to their unparalleled physical, chemical, optical, and biological properties. They have found applications spanning biomedicine, drug delivery, topical formulations, electronics, optics, catalysis, food industry, agriculture, textile industry, and water treatment. Silver nanoparticles have notably exhibited enhanced antimicrobial attributes, significantly inhibiting the growth of a broad spectrum of Gram-positive and Gram-negative bacteria, as well as fungi, with low minimum inhibitory concentration (MIC) values. In this research endeavour, silver nanoparticles synthesized from Mimosa pudica extract hold promise for application in finished leather and leather products, which are highly susceptible to bacterial degradation. Therefore, it remains imperative to explore naturally-derived compounds with antimicrobial efficacy for integration into the leather industry.

II. Background

Hides, skins, and leather at various stages of production have been susceptible to colonization by diverse bacterial species and fungi in the leather industry. Bacteria primarily inflict damage during pre-tanning stages, while fungi can wreak havoc during the final phases of production. Microorganisms can introduce issues such as odours, oil leakage, spoilage of leather, and irregularities in coloration, which are often challenging or impossible to rectify. Leather production entails a lengthy and intricate process, and any microbial growth can result in significant losses of effort and resources. To address this concern, antibacterial agents have been introduced to enhance leather quality and preservation. During the finishing phase, specific beneficial additives can be applied to leather surfaces, conferring robust antibacterial properties by incorporating suitable antimicrobial compounds to prevent cross-contamination and extend product shelf life, while a multitude of antimicrobial agents are available for thwarting microbial activity in leather production, many of these possess adverse environmental impacts and are cost-prohibitive.

Objectives

The green silver nanoparticles are synthesized using mimosa extract. It is applied for the preservation of skin and hide from bacterial attack which can be used for further leather processing.

III Materials and Methods

Collection of Plant Material

The leaves of Mimosa pudica have been collected along the roadside of Chennai. They are washed thoroughly using tap water and then with ethanol to remove dust particles and stains. The excess water is removed completely by drying in an oven at 40^{o}C for about 1 week.

Silver Nanoparticle Synthesis

The precursor 5mM of $AgNO_3$ is prepared by adding 0.25g of silver nitrate in 300 ml of distilled water and maintained in dark conditions. The 60 ml of mimosa leaf extract is mixed with 40 ml of silver nitrate solution using a magnetic stirrer for 50 minutes.

Figure 1: The synthesis of Mimosa AgNPs

Purification Technique

For purification of silver nanoparticles formed in the aqueous extract, The aqueous leaf extract, containing silver nanoparticles and biomolecules, underwent centrifugation at 10,000 rpm for 20 minutes. Subsequently, the supernatant was removed, and the pellet was rinsed with distilled water before being subjected to another centrifugation at 10,000 rpm for 15 minutes. The pellet acquired was dissolved in 1ml of deionized water and subsequently air-dried. The resulting dry powder is then gathered and stored in air-dried Eppendorf tubes.

Antimicrobial Assays

The Agar Well diffusion method was employed to assess the antimicrobial properties of the plant extracts. Using ethanol as the positive control, the comparative antimicrobial efficacy of plant-extracted silver nanoparticles was assessed in relation to mimosa leaf extract and silver nanoparticles. For this experiment, Bacillus subtilis for antibacterial assay and the penicillium varatti for antifungal assay was selected and isolated. The isolated fungal and bacterial specimens were inoculated in the prepared culture plates separately. Four perforations were generated on the agar surface using a 1cm cork borer. Subsequently, aseptic syringes were employed to introduce ethanol, crude extract from Mimosa leaf, commercially obtained silver nanoparticles, and Mimosa pudica-derived silver nanoparticles into the respective perforations. After a 48-hour incubation period, the zones of inhibition were quantified.

SEM and TEM analysis

In contrast to the manual particle-by-particle measurement method, TEM and SEM dramatically diminish measurement time while notably enhancing measurement precision. The study of silver nanoparticles synthesized from Mimosa pudica extract necessitated a sequence of preparatory procedures aimed at acquiring top-tier imagery through scanning electron

microscopy (SEM). SEM, a formidable imaging apparatus employing an electron beam to generate high-resolution representations of the specimen's surface, was employed in this investigation utilizing the Quanta 200 series SEM, operated at an accelerating voltage of 5 KV. The SEM micrographs yielded intricate insights into the alterations in structure and surface morphology of the synthesized nanoparticles. Utilizing TEM image analysis and Origin for data processing, this semi-automated approach adeptly computes the mean particle size and size distribution of Mimosa pudica extracted AgNPs within a matter of minutes.

FTIR analysis

Fourier-transform infrared (FTIR) spectroscopy is a widely employed analytical approach utilized for the identification and quantification of functional groups within molecules. In this research, FTIR spectroscopy was employed to capture the absorbance spectra of silver nanoparticles extracted from Mimosa pudica leaves that had been synthesized. The procedure involved the incorporation of potassium bromide, followed by the creation of IR-transparent pellets through the compression of the powdered specimens. The FTIR spectra were captured using a Perkin-Elmer spectrophotometer over a range of 400 to 4000 cm^(-1). The acquisition process mirrored that of the pristine KBr control sample, which was initially used to calibrate the background scanning signal. Through analysis of the absorbance spectra, the functional groups and molecular structure of the specimens were elucidated, offering valuable insights into the nature of the sample.

DLS Analysis

Utilizing dynamic light scattering (DLS) analysis, the size distribution of nanoparticles within a solution was ascertained. The specimens were formulated by dispersing nanoparticles in distilled water, followed by a 5-minute sonication to attain homogeneity. Subsequently, a Zetasizer Nano ZS instrument (Malvern Instruments, UK) was employed at a scattering angle of 173° and a temperature of 25°C to quantify both particle size and size distribution. The obtained data were subjected to analysis through the instrument's accompanying software. Furthermore, the polydispersity index (PDI) was computed to assess the uniformity of nanoparticle sizes.

XRD analysis

X-ray diffraction analysis (XRD) is employed for elucidating the crystallographic arrangement within a material. XRD operates through the exposure of the material to incident X-rays, followed by the measurement of both the intensities and scattering angles of the emerging X-rays. The X-ray diffraction (XRD) analysis of the silver nanoparticles sample, in this study, was conducted by running the loaded sample from 20 to 80 degree to identify the structure of silver nanoparticles formation using Mimosa extract.

GCMS analysis

The chemical composition of silver nanoparticles extracted from mimosa leaves was investigated using a Gas Chromatography-Mass Spectrometer (GC/MS) which was performed using a Schimadzu gas chromatograph equipped with a split/spitless injector set at 250°C and a flame ionization detector operating at 250°C. Nitrogen was employed as the carrier gas at a flow rate of 1 ml/min, and a capillary column was utilized. The column temperature was initially maintained at 60°C for 3 minutes, then ramped up to 220°C at a rate of 5°C/min, and held constant at 220°C for 5 minutes.

Leather Processing

The preserved skin is processed to leather by following procedure in table 1

S.no	Process	% chemical	Chemical used	Time	Observation
1.	Soaking	200%	Water	Overnight	Removal of salt &

					Rehydration of skin results in soft and flexible skin
2.	Conventional Dehairing	3% 8%	Sulfide Lime	8 hours	Removal of hair from skin and thus producing a Pelt
3.	a. Reliming a. Enzymatic	8% 2%	Lime Commercial amylase	5 days 2 hours	Complete removal of hair &fibre openings are observed
	c. Experimental	4%	Soybean amylase	1.5 hour	
4.	Deliming	3%	Ammonium salts	5 hours	Removal of dehairing chemicals like sulfide & lime. The pH was observed as 8
5.	Pickling	0.1% 10%	Sulphuric acid Sodium chloride	3 feeds for each 20 minutes	Increases acidity to the pH of 3 & makes the leather receptive to chrome tanning
6.	Chrome tanning	8%	Basic Chromium Sulfate	3 hours	Soft and very Strong leather was observed
7.	Basification	0.5% 0.75%	Sodium formate Sodium bicarbonate	1 hour	Decreases acidity to the pH of 4 & so it facilitates the tanning material to leather
8.	Piling	NA	NA	2 days	Oxation and Olation of leather was observed
9.	Neutralization	150% 0.3%	Water Neutralizing syntan	½ hour	The pH was adjusted to 4.5-6.5 & so removal of acid by hydrolysis of the chromium compounds was observed
10.	Retanning	3% 3% 3% 3% 1% 1%	Acrylic powder G.S Powder Melamine Phenolic syntan Qubracho Gesnut	1 hour	The specific property of that product was gained, giving more fullness to the final product
11.	Fat Liquoring	4%	Synthetic fat	1 hour	The degree of fibre

		2% 1% 1%	liquor Semi-synthetic fat liquor Vegetable		cohesion was increased. Also the physical characteristics like tensile strength,
12.	Dyeing	1% 1%	Green dye Dye level reagent	1 hour	Green colour leather was observed
13.	Fixing	1% 5%	Formic acid Water	1 hour	Better physical strength and Organoleptic properties of leather was observed
14.	Stacking	NA	NA	5 minutes	Leather was stretched and softened so that the total surface area of hide increases
15.	Sammying	NA	NA	5 minutes	Grease and excess moisture was squeezed out by passing through large rollers under pressure
16.	Buffing	NA	NA	5 minutes	The ‘nubuck’ type leather was produced, removing the light defects

Table1: leather manufacturing process of Mimosa AgNPs preserved skin

Qualitative analysis of Mimosa AgNPs preserved Leather

Shrinkage Temperature:

The shrinkage tester plays a pivotal role in assessing the hydrothermal resilience of leather. This evaluation entails taking a 2 cm segment from the tanned leather and securing it within the clamps of the shrinkage tester. Subsequently, the sample is immersed in a solution composed of water and glycerol, contained in a vessel, and subjected to agitation facilitated by a mechanical stirrer. The solution's temperature is incrementally raised, and the point at which the sample commences shrinking is meticulously recorded. This recorded temperature is denoted as the shrinkage temperature, a critical parameter indicative of the leather's thermal durability. It serves as a vital quality control measure for leather processing. A higher shrinkage temperature signifies superior hydrothermal stability in the leather. The shrinkage tester is extensively employed in the leather industry for appraising leather product quality and monitoring the efficacy of leather processing parameters.

Physical property analysis

In order to evaluate the performance of crust leather, physical endurance testing was conducted. The testing was done by subjecting the crust leather samples to a range of tests to determine their tensile strength, elongation at break, tear strength, grain fracture, water vapor

permeability, water vapor absorption and water vapor coefficient. To ensure a consistent testing environment, the samples were first conditioned for 48 hours at room temperature and a relative humidity of at least 65 percent. This allowed the leather to reach equilibrium moisture content and ensured that the tests were conducted under standardized conditions. Tensile strength testing was carried out to determine the maximum force that could be applied to the leather before it broke. This is a critical test as it measures the strength of the leather when it is subjected to tension or pulling forces. The elongation at break test was used to determine the degree of stretching that the leather can undergo before breaking. The tear strength test evaluated the leather's resistance to tearing. This test helps to determine how the leather would perform under conditions of wear and tear. Grain fracture testing was used to assess the leather's ability to withstand cracking on its surface. Water vapor permeability, water vapor absorption and water vapor coefficient tests were conducted to evaluate the leather's breathability and moisture management properties. These tests are important for leather products as they determine how well the leather can release moisture and prevent the build-up of moisture within the product.In conclusion, physical endurance testing provides a valuable tool for assessing the quality and durability of crust leather. By subjecting the samples to a range of tests, manufacturers can determine the leather's suitability for different applications and ensure that their products meet the required performance standards.

Colour analysis

To investigate the variations in colour qualities, coloured leather samples were collected. Using a Gretag Macbeth Spectrolino Spectrophotometer with a measuring geometry of 45/0, all colour measurements were made, and L, a, b, c, and H values were acquired in accordance with normal practise. The equipment was calibrated against a white MgO tile using the illuminant D-65 and 10 standard observer function before measuring the samples. Each sample's reflectance was assessed at 36 distinct visible wavelengths, ranging from 380 nm to 730 nm, at intervals of 10 nm. Four measurements were collected using an 8mm aperture to measure the reflectance. Between each reading, the sample was shifted, and the final reflectance values were averaged over these four readings.

Evaluation of organoleptic properties

Crust leathers were assessed for softness, grain smoothness, fullness and general appearance by tactile evaluation. Three experienced tanners rated the leathers on a scale of 0-10 points for each functional property

Pollution load generated in dehairing process

Leather processing generates a significant amount of waste, which can have a negative impact on the environment if not properly managed. To assess the level of pollution caused by the waste liquor from leather processing, standard method analysis was conducted on the control and experimental samples. After dehairing and fiber opening, the waste liquor was collected and analyzed for Bio Chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), and Total Suspended Solids (TSS). These parameters are commonly used to measure the level of pollution in wastewater. BOD measures the amount of oxygen required by microorganisms to decompose organic matter in the water, while COD measures the amount of oxygen required to oxidize both organic and inorganic pollutants. TDS and TSS measure the amount of solids present in the water. The results were expressed in parts per million (ppm) and compared between the control and

experimental samples. The data obtained from this analysis provides useful information on the level of pollutants in the waste liquor and can be used to improve the treatment and management of waste in leather processing. Overall, proper management of waste in the leather industry is essential to minimize the impact on the environment and ensure sustainable production processes.

IV Results and Discussion

Green Synthesis of Mimosa pudica Silver Nanoparticles:

The mimosa AgNPs are synthesized accordingly and the solution is dried in oven at 60^{o}C for 1 week. The synthesized particles are used for further screening and test.

Characterization of AgNPs

SEM and TEM analysis:

In the investigation conducted by M. Manopriya, B. Karunai Selvi, and J.A. Johnpaul in 2011, they demonstrated the formation of spherical and uniformly sized silver nanoparticles with diameters ranging from 13 to 61 nanometers. In our current study, we have documented silver nanoparticles synthesized through a green process using an extract derived from Plectranthusamboinicus leaves. Analysis of the obtained silver nanoparticles via scanning electron microscopy (SEM) revealed their spherical morphology, with particles exhibiting a diverse size distribution centered around 220 nanometers.Transmission electron microscopy (TEM) was utilized for the examination of the shape, dimensions, and morphology of the obtained AgNO3. The accompanying figure illustrates the TEM micrograph of $AgNO_3$. The TEM analysis substantiated the formation of nano-crystalline silver particles, albeit with some degree of agglomeration, with an estimated average particle size of 220nm.

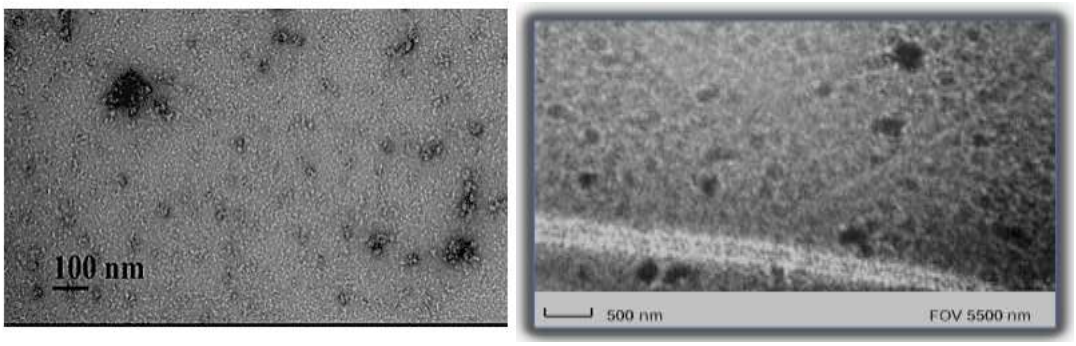

Figure 2: SEM and TEM image of Mimosa AgNPs

FTIR analysis

The FTIR analysis conducted in this study has revealed distinct bond stretching patterns associated with various peaks. Notably, at 3350 cm^{-1}, there is evidence of N-H stretching, while at 2130.56 cm^{-1}, C=C stretching is observed, and at 1639.83 cm^{-1}, there is another instance of C=C stretching. Furthermore, at 1218.38 cm^{-1}, a stretching pattern attributed to C=O or C-N in aliphatic amines is detected, and in the vicinity of 1367.84 cm^{-1}, a C-H rocking motion characteristic of alkanes is evident. It's worth mentioning that in the FTIR spectra of silver nanoparticles, conspicuous peaks are observed at 2130.56 cm^{-1}, 1639.83 cm^{-1}, and 1367.84 cm^{-1}. Specifically, the peak at 1639.83 cm^{-1} is indicative of the stretching vibration of the (NH) C=O group, while the band at 1367.84 cm^{-1} is associated with C-C and C-N stretching vibrations.

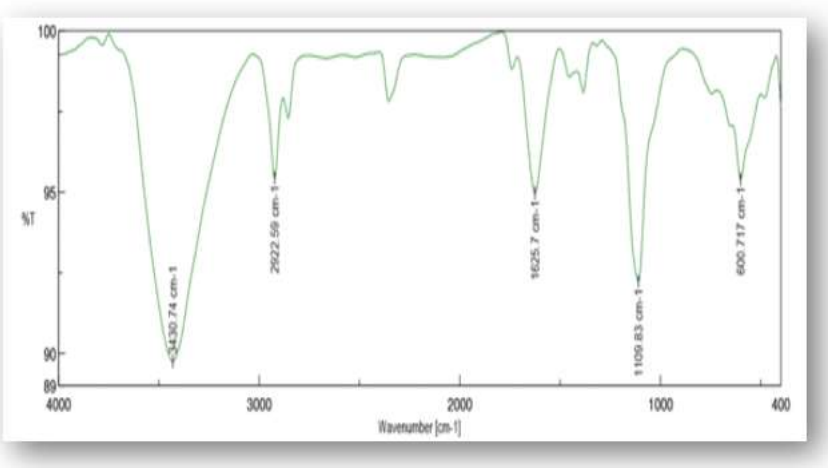

Figure 3: FTIR image of Mimosa AgNPs

DLS Analysis

In 2014, P. Kalainila, V. Subha, R. S. Ernest Ravindran, and Sahadevan Renganathan reported that they assessed particle characteristics such as size distribution and polydispersity index using PSA, revealing an average particle diameter of 156 nanometers. In our current investigation, we present the PSA size distribution image of silver nanoparticles synthesized through a green approach, depicted in the graph above. Notably, the observed size distribution of the silver nanoparticles ranges from 214 nanometers, with a corresponding polydispersity index of 0.968.

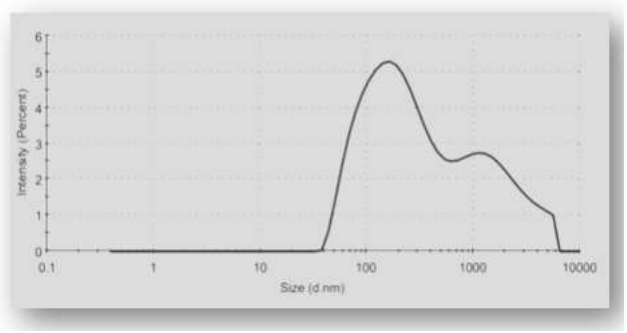

Figure 4: DLS image of Mimosa AgNPs

XRD analysis

N. N. Devi, P. D. Shankar, W. Femena, and T. Paramasivam previously documented that the average grain size of silver nanoparticles was determined to be 41.9 nanometers, and the crystalline planes (111) and (101) were associated with the cubic morphology of these nanoparticles. In our investigation, X-ray diffraction (XRD) analysis corroborated the presence of peaks corresponding to the (111), (220), and (350) planes of the silver nanoparticles, as depicted in Figure 5. The morphology of the silver nanoparticles we obtained was confirmed to be spherical.

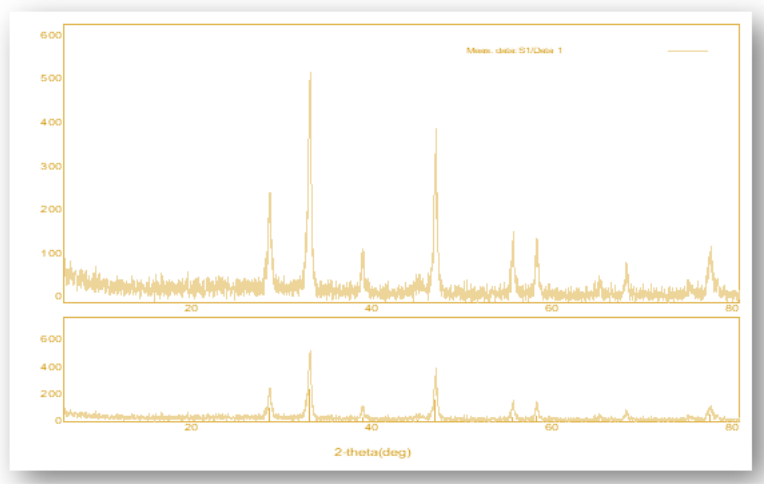

Figure 5: XRD image of Mimosa AgNPs

UV analysis

N. N. Devi, P. D. Shankar, W. Femena, and T. Paramasivam previously documented that the UV-Visible spectrum exhibited a surface plasmon resonance band within the range of 400 to 470 nanometers for silver nanoparticles. In our investigation, we deduced that the silver nanoparticles we obtained displayed a peak at 449 nanometers, thus affirming their presence, as corroborated by the data presented in Graph.

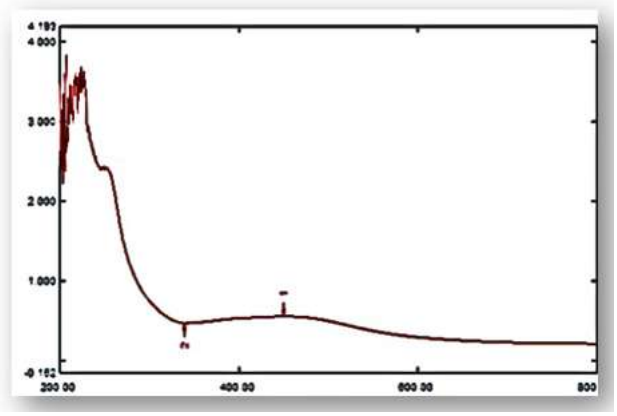

Figure 6: UV image of Mimosa AgNPs

GCMS analysis

The graph depicts the results of a comprehensive GC/MS analysis conducted on the various chemical components present in the extract of Mimosa pudica leaves. Notably, the extract from Mimosa pudica leaves is replete with diverse polyphenolic compounds, each possessing distinct properties including antifungal, antivenom, antifertility, anticonvulsant, antidepressant, and antibacterial characteristics. Furthermore, the stability of bio-functionalized silver nanoparticles (AgNPs) derived from A. spinosissima extract is attributed to the reducing and capping agents inherent in its primary phytochemical constituents, which effectively encapsulated the Ag+ ions.

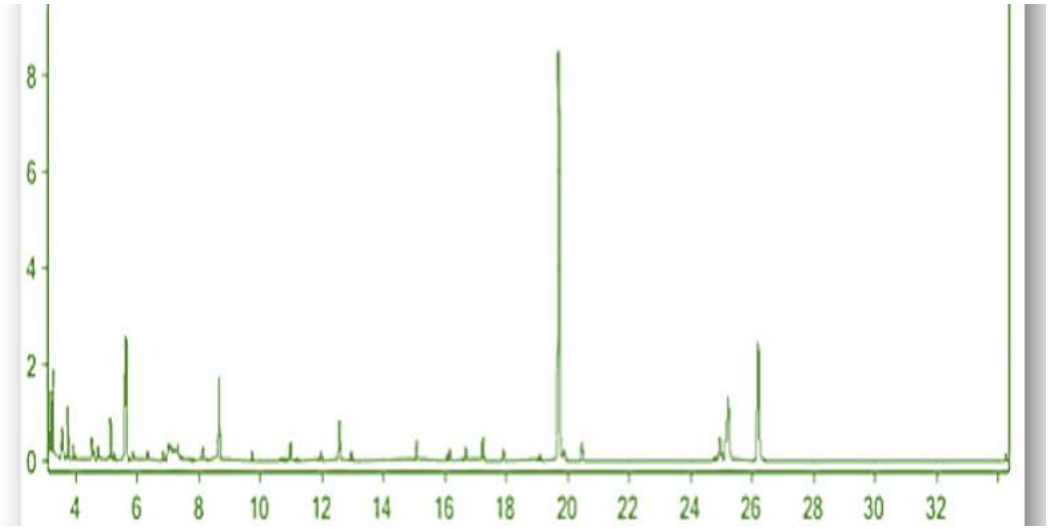

Figure 7: SEM and TEM image of Mimosa AgNPs

Antimicrobial Properties of Mimosa pudicaAgNPs

According to the data presented in Table 1, our inference is that the acquired silver nanoparticle demonstrates notable efficiency in comparison to the plant extract. The zone of inhibition closely resembles that of the control ethanol, surpassing both the plant extract and commercial silver nanoparticles. The silver nanoparticle exhibits a high level of antibacterial efficiency. The Mimosa pudicaAgNPs inhibit fungal growth as efficient as bacterial growth inhibition. The sample, silver nanoparticles, and plant extract show a similar zone of inhibition.

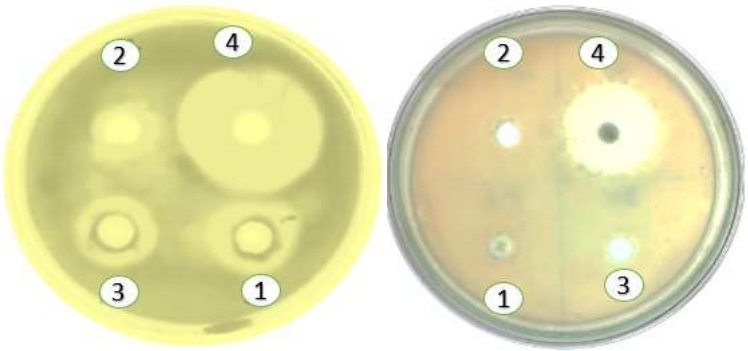

Figure 8: Antibacterial and antifungal assay image of Mimosa AgNPs

S.No	Sample	Zone measurement fo antibacterial assay (mm)	Zone measuremen for antifungal activity (mm)
1	Mimosa pudicaAgNps	18	18
2	Mimosa pudica leave extract (control 1)	10	1
3	Commercial AgNps (control 2)	12	2.1

4	Ethanol (control 3)	20	17

TABLE 2: Zone of inhibition representing antibacterial activity

Application:
The synthesized Mimosa pudica extracted silver nanoparticles have been used to preserve the goat skin to prepare for leather processing.

Optimization:
The various dosage (0.1g, 0.5g, 1g, 2g, 4g, 5g, 6g, 7g, 10g) of synthesized nanoparticles is mixed with 500 ml of tap water which is consistent to apply for one kg goat skin. The trails are attempted and the time is noted. The pH of Mimosa PudicaAgNPs solution is 7.1 and it works more effectively in room temperature than in cold conditions. It is also efficient when the temperature slightly increases up to 32^{o}C but the skin gets damaged and soupy if temperature is increased. Hence the temperature is optimized to 25^{o}C. pH is not varied in this research project as the acidic buffer will damage the collagen fiber of the skin and results in acid swelling. The alkaline buffer itself preserves the skin from

microorganisms due to its high pH.
The dosage of synthesized experimental AgNPs was optimized to 1g to apply on the flesh side of the skin.

Quantity of AgNPs	Period of Preservation
0.1g	8 hours
0.5g	2 days
1g	5 days
2g	1 week
4g	3 weeks
5g	5 weeks
6g	5 weeks
7g	5 weeks
10g	5 weeks

Figure 9: Mimosa pudica AgNPs application on the skin and TABLE 3: Zone of inhibition representing antibacterial activity

The antimicrobial activity exhibited by the synthesized AGNPs, confirmed by antimicrobial assay, preserved the skins for 1 month.

Quality analysis of Mimosa pudicaAgNPs preserved skin

After one month, Mimosa PudicaAgNPs preserved leather is subjected to leather processing to check the leather quality in comparison with control leather processed from salt-preserved skin

Quality analysis in Pretanning

The skin is soaked in 1 litre of water. The nanoparticles, dust and cell debris are completely removed in 3rd soak. Further the skin is subjected to conventional dehairing in which keratins are removed effectively. It is observed that skin is undamaged. The skin is visually observed after the process of liming, deliming, pickling, degreasing and bating. It is evident that the pre-tanned pelt exhibits no damage and retains its original characteristics, with no discernible differences compared to the conventionally pretanned pelt used as a control.

Figure 10 (a):Pretanned pelt converted from Mimosa pudicaAgNPs preserved skin in which complete removal of keratin protein

Quality analysis in Tanning

The experimental pretanned pelt is chrome-tanned and analyzed for chrome exhaustion. The chrome liquor is collected and tested for DPC method which concluded that the chromium uptake is upto 75% in experimental tanned leather as like conventional tanned leather. Hence it is confirmed that the uptake of chromium is not affected by synthesized nanoparticles used for preservation. The chromium is penetrated in experimental leather at pH at 2.6 and chromium is fixed in surface at Ph 4. The chromium is binded with inter fibers of leather by oxation and olation.

Figure 10 (b):Chrome tanned leather converted from Mimosa pudicaAgNPs preserved skin in which chromium – surface fixation is observed

Quality analysis in Post tanning and finishing

The chrome-tanned leather is drummed at 15 RPM with phenolic syntans to gain strength properties and fatliquors for lubrication and softness for 1 hour. The leather is dyed for 1 hour in drum and then dried. After a day, the dried leather is spray dried for an aesthetic look.

Figure 10(c):Chrome tanned leather converted from Mimosa pudicaAgNPs preserved skin in which chromium – surface fixation is observed

Shrinkage Temperature Analysis:

The leather is checked for its shrinkage property. . The skin shrinks at 60^{o}C but when it is tanned to leather it gains thermal stability upto 100^{o}C. The conventional leather starts to shrink when the temperature reached 140^{o}C and the experimental leather shrinks at 110^{o}C. This concludes that the thermal stability of leather is not affected by new Mimosa AgNPs skin preserving technique.

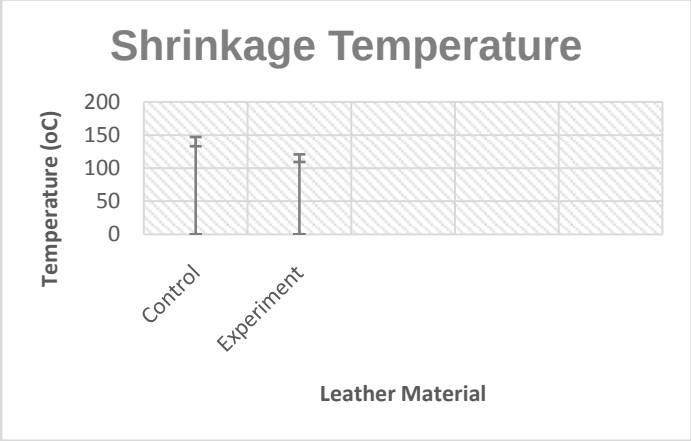

Figure 11. Shrinkage temperature of control and experiment.

Physical strength properties

In a cutting-edge analysis, the physical strength attributes of the experimental leather were rigorously examined and juxtaposed against the stringent ISO guidelines governing leather's physical characteristics. This assessment aimed to gauge the influence of employing Mimosa AgNPs (Silver Nanoparticles derived from Mimosa) in preserving the integrity of leather articles. The evaluation encompassed various key parameters, including tensile strength, percentage of elongation at break, tear strength, load at grain crack, and distention at grain crack (measured in millimeters). The outcomes obtained for the experimental leather demonstrated a remarkable alignment with the established benchmarks outlined in the ISO guidelines. These findings have been meticulously tabulated for reference. Notably, these results lend credence to the assertion that the utilization of Mimosa AgNPs in leather preservation does not inflict

any discernible harm to the collagen matrix at the fiber level. This underscores the potential viability of Mimosa AgNPs as an effective and non-detrimental agent in leather preservation practices.

S.No	Strength Properties	Experiment	ISO std norms
1.	Tensile Strength (N/mm^2)	$16N/m^2$	$15N/m^2$
2.	Elongation (%)	75%	40-80%
3.	Tear Strength (kg/cm)	42N	40N
4.	Load at grain crack (kg)	260N	200N
5.	Distention at grain crack(mm)	9mm	7mm

Table 4: Strength properties of Experimental leather

Organoleptic property Analysis:

Three seasoned leather experts conducted an evaluation of the Mimosa pudicaleather's organoleptic attributes, which encompassed aspects like the evenness of leather chemiccals distribution, depth of dye penetration, smoothness of the grain, draping and softness. This assessment utilized established manual and visual appraisal methods, and the resulting scores for each property were recorded on a scale ranging from 1 to 10, as depicted in Table 5. A higher numerical rating indicates superior quality in these properties**.**

S.No	Organoleptic properties	Points
1	**Dye uniformity**	**10**
2	**Penetration of Chemicals**	**10**
3	**Draping quality**	**8**
4	**Softness**	**7**
5	**Aesthetic view**	**10**

Table 5: Organoleptic properties of Experimental leather

Colour Analysis:

In order to delve deeper into the diversity of surface coloration, we conducted color coordinate measurements, and the results are presented in the accompanying table. Both the experimental and control leather samples were subjected to dyeing using a cutting-edge green complex, which exhibited a heightened color intensity characterized by a vivid green hue. This effect was attributed to the consistent and uniform bonding of the dye with both the grain and flesh sides of the leather. The Lightness (L) values recorded for both the experimental and control samples underscore the positively vibrant shade achieved in the leather. This results in similar penetration of dye in both the salt preserved conventional control leather and Mimosa AgNPs preserved experimental leather. The new preservation technique has no affect with dyeing process.

Sample name	L	a*	b*	C	H
Experiment	70	0.889	21.432	20.975	96.743
Control	70	0.838	22.293	19.438	94.746

Table 6: Strength properties of Experimental leather

Mimosa pudicaAgNPs as vegetable tanning agent

The Mimosa pudicaAgNPs preserved goat skin weighed 1 kg is pretanned and then tanned using 6% of mimosa puidica silver nanoparticles mixed with 100% pickled water at pH 3.4 for 1 hour. The pickled pelt is well tanned with Mimosa pudicaAgNPs by crosslinking with active sites of collagen fibers of the skin. The Mimosa pudicaAgNPs tanned leather is compared with EI vegetable tanned leather which results in similar strength properties with jhard nature. More fatliquor is added in post tanning step for flexible of experimental leather. The dark color of mimosa is vanished by dyeing the leather using dark colors. The dye color does not mixed or interruptted the color of brown mimosa bark color. The results of color fastness and colour measurements vary with conventional vegetable tanned leather. Therfore using Mimosa AgNPs as tanning agent and as syntan to gain hard property and stiffness can be a scope for future researchers.

Figure 12: Mimosa pudicaAgNPs tanning process of leather.

Mimosa pudicaAgNPs as wastewater detoxifying agent

The Mimosa AgNPs contained soaked liquor and tanned liquor and post tanned liquors are collected together in tannery to release into environment. The pollution parameters are highly decreased when compared to conventional leather processed liquor. This is because the silver nanoparticles are well known AOP that degrades the phenolic compound and dye complex into simple components. Thus the Mimosa pudicaAgNPs acted as the detoxifying agent. When silver nanoparticle is impregnated in Mimosa pudica, the liquor can be dried to regain the nanoparticles to reuse for next process.

S.No	Spent liquor	TS (%)	TDS (%)	TSS (%)	COD (%)	BOD (%)
1.	Final Tannery liquor	20±4	45±6	59±3	70±2	78±2

Table 7: Reduction in pollution parameter of experimental leather processing liquor compared to conventional liquor

V Conclusion

In this study, the synthesized silver nanoparticles (AgNPs) are successfully synthesized using a green approach involving an extract from Plectranthusamboinicus leaves. The AgNPs exhibited spherical morphology with a diverse size distribution. Various characterization techniques confirmed their composition and properties. Additionally, the AgNPs displayed promising antimicrobial activity against both bacteria and fungi. These nanoparticles also showed potential for use in preserving hides. Overall, this research demonstrates the viability of green-synthesized AgNPs for various practical applications, including antimicrobial and leather preservation purposes.

The analysis revealed that the synthesized AgNPs had a spherical morphology with a diverse size distribution, centred around 220 nanometers. TEM confirmed the formation of nano-crystalline silver particles, though some agglomeration was observed, with an estimated average particle size of 220nm. FTIR analysis indicated the presence of distinct bond stretching patterns in the AgNPs, suggesting the involvement of various chemical groups, such as N-H stretching, C=C stretching, C=O or C-N stretching, and C-H rocking motion. These patterns were characteristic of the functional groups present. Particle size distribution analysis using PSA revealed a size range of 214 nanometers for the AgNPs, with a corresponding polydispersity index of 0.968. X-ray diffraction (XRD) analysis confirmed the crystalline nature of the AgNPs, with peaks corresponding to the (111), (220), and (350) planes, supporting their spherical morphology. UV-Visible spectrum analysis displayed a surface plasmon resonance peak at 449 nanometers, confirming the presence of silver nanoparticles. GC/MS analysis of the extract from Mimosa pudica leaves revealed the presence of diverse polyphenolic compounds with various beneficial properties, which contributed to the stability of the bio-functionalized AgNPs. Furthermore, the synthesized AgNPs exhibited promising antimicrobial properties, with a notable zone of inhibition against both bacteria and fungi, surpassing the efficacy of the plant extract and commercial silver nanoparticles. The AgNPs were also utilized for preserving hides, demonstrating their potential practical applications. Further the Mimosa AgNPs can be used as syntan to get hard leather to use as shoe insole and AgNPs being nanoparticles automatically reduces the COD and BOD upto 75% which gives sustainability. It can be used in leather industry to protect environment in order to escape from criticization.

Overall, this study highlights the successful green synthesis of silver nanoparticles using plant extract and their potential for various applications, including antimicrobial and leather preservation.