

## Green Synthesis of Silver Nanoparticle Loaded Nanogel from Lantana Camera Linn Extract For Anti-Microbial Activity

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### ABSTRACT:

The present study focuses on the phytochemical screening, nanoparticle formulation, characterization, and evaluation of Lantana camara Linn extract incorporated into a silver nanoparticle-loaded nanogel. Preliminary phytochemical analysis revealed the presence of bioactive constituents such as alkaloids, terpenoids, phenols, and flavonoids, indicating potential therapeutic activity. Drug-excipient compatibility studies using FTIR spectroscopy confirmed the absence of chemical interactions, ensuring formulation stability. UV-visible spectroscopic analysis validated the formation of silver nanoparticles through characteristic surface plasmon resonance peaks. SEM analysis demonstrated nanoscale particle size with acceptable morphology for both nanoparticles and nanogel formulations. The formulated nanogel exhibited desirable physicochemical properties including suitable pH, viscosity, homogeneity, spreadability, and non-irritant nature. In-vitro drug release studies showed a sustained release pattern, indicating controlled drug delivery. Furthermore, antimicrobial studies confirmed significant antifungal activity against *Aspergillus flavus* and *Penicillium* species. Overall, the findings suggest that Lantana camara Linn silver nanoparticle-loaded nanogel is a promising formulation for topical antimicrobial applications.

**Keywords:** Lantana camara Linn, Phytochemical screening, Silver nanoparticles, Nanogel, Antimicrobial activity

### I. INTRODUCTION

The prefix “Nano” has found in last decade an ever-increasing application to different fields of the knowledge. Nano-science, nanotechnology, Nano-materials or Nano-chemistry are only a few of the new Nano-containing terms that occur frequently in scientific reports, in popular books as well as in newspapers

and that have become familiar to a wide public, even of non-experts. The prefix comes from the ancient Greek *νᾶνος* through the Latin *Nanus* meaning literally dwarf and, by extension, very small. Within the convention of International System of Units (SI) it is used to indicate a reduction factor of 10<sup>9</sup> times. So, the Nanosized world is typically measured in nanometers (1nm corresponding to 10<sup>-9</sup> m) and it encompasses systems whose size is above molecular dimensions and below macroscopic ones (generally > 1 nm and < 100 nm).

Nanotechnology is the science of the small; the very small. It is the use and manipulation of matter at a tiny scale. At this size, atoms and molecules work differently, and provide a variety of surprising and interesting uses. Nanotechnology and Nano-science studies have emerged rapidly during the past years in a broad range of product domains. It provides opportunities for the development of materials, including those for medical applications, where conventional techniques may reach their limits. Nanotechnology should not be viewed as a single technique that only affects specific areas. Although often referred to as the ‘tiny science’, nanotechnology does not simply mean very small structures and products. Nano-scale features are often incorporated into bulk materials and large surfaces.

Nanotechnology represents the design, production and application of materials at atomic, molecular and macromolecular scales, in order to produce new Nanosized materials. Pharmaceutical nanoparticles are defined as solid, submicron-sized (less than 100 nm in diameter) drug carrier that may or may not be biodegradable. The term nanoparticle is a combined name for both Nanospheres and Nano-capsules. Nano-spheres are matrix system in which drug is uniformly dispersed, while Nano-capsules are the system in which the drug is surrounded by a unique

polymeric membrane. This systemic review focuses on Classification, method of preparation, Characterization, application, health prospective and Pharmacological aspects of nanoparticles. Nanoparticles are the fundamental components of Nano technology. Nano particles size ranges from 1 to 100nm which are made up of metal, metal oxides, organic matter, carbon.

The pharmaceutical industries are now facing a challenge to improve the dissolution characteristic of poorly water soluble drugs which is the key factor in enhancing drug bioavailability. For instance, they help to increase the stability of drugs/proteins and possess useful controlled release properties. This review predominately focused on synthesis of different types of nanoparticles using

chemical, physical and biological methods. However, chemical and physical methods are expensive and harmful but biological method is simple, non-toxic, rapid and eco- friendly. It also explains about the characteristics of nanoparticles and concluded with various applications.

## II. PLANT PROFILE

- ✚ **Binomial Name:** Lantana camara Linn.
- ✚ **Synonyms:** Lantana aculeata Linn., Camara vulgaris Benth., Lantana scabrida S.Moore
- ✚ **Common Names:** Lantana, Spanish Flag, Tick Berry, Sleeper Weed, Wild Sage
- ✚ **Tamil Name:** Unni Chedi



Fig: 1 Lantana camara Linn

### 1.1 Classic Applications:

**Medicinal Use:** Whole plant, leaves, roots, and bark.

S.NO.	DETAILS	INDICATIONS
1.	Powdered Leaves	Application for cuts, wounds, ulcers, and swellings
2.	Infusions from Leaves	Treatment for bilious fever, eczema, and eruptions
3.	Fruits	Management of fistula, pustules, tumors, and rheumatism
4.	Roots	Utilized for malarial issues, rheumatism, skin conditions, and respiratory tract infections
5.	Decoction from Fresh Roots	Gargle for odontalgia
6.	Respiratory Infections	Treatment of cough, cold, asthma, bronchitis, and related conditions
7.	Conditions traditionally addressed	Tetanus, epilepsy, dysentery, and gastropathy
8.	Various purposes	Diaphoretic, carminative, antispasmodic, and tonic

Table No: 1 Classic Applications

### 2.2.8 PHARMACOLOGICAL PROFILE OF LANTANA CAMARA:

S.NO.	ACTIVITY	DETAILS
1.	Antibacterial Activity	Efficacy against <i>S. aureus</i> , <i>P. vulgaris</i> , <i>P. aeruginosa</i> , <i>E. coli</i> , <i>V. cholerae</i> , and multiresistant strains.
2.	Antifungal Activity	Efficient against white and brown wood-destroying fungi. Ethanol extract potent at 0.01%.
3.	Hemolytic Activity	Minimal hemolytic activity. Order: Chloroform > Hexane/ethyl acetate > Aqueous > Ethanol > Methanol.
4.	Antimotility Activity	Inhibited charcoal transit at 1 g/kg. Reduced fecal output in castor oil-induced diarrhea.
5.	Anti-mutagenic Activity	22 $\beta$ -dimethylacryloyloxy and 22 $\beta$ -acidacetoxyl lantanolic acid exhibited high efficacy against Mitomycin-C induced mutagenesis. Compounds lantanilic acid and camarinic acid showed high antimutagenic activity in mice; at 6.75 mg/kg.
6.	Antioxidant Activity	Premature leaves and essential oil exhibited significant antioxidant activity.
7.	Antiuro lithiatic Activity	Reduced calcium oxalate deposition and decreased urinary excretion of calcium, oxalate, and creatinine.
8.	Mosquito Controlling Activity	Significant larvicidal activity against <i>Ae. Aegypti</i> and <i>Cx. Quinquifasciatus</i> larvae, more potent against <i>Ae. Aegypti</i> .
9.	Anthelmintic Activity	Nematicidal activity against <i>Meloidogyne incognita</i> ; antifilarial activity in vitro and in vivo.
10.	Anti-protozoal Activity	Low anti-plasmodial activity; in vitro antiplasmodial activity against <i>P. falciparum</i> strains.
11.	Antiviral Activity	Essential oil demonstrated cytotoxicity and in vitro inhibitory activity against various viruses.
12.	Antiinflammatory, Analgesic, Sedative, Antipyretic	Sedative properties; oleanonic acid displayed antiinflammatory activity.
13.	Antiproliferative and Cytotoxic Activity	Antiproliferative effects on HeLa cells; compounds from roots showed cytotoxicity.
14.	Antiulcerogenic Activity	Methanolic extract demonstrated antiulcerogenic effects in different ulcer models.
15.	Anti-fertility Activity	Effects on reproduction evaluated.
16.	Anticoagulant Activity	Inhibited human R-thrombin.

**Table No: 2Pharmacological Profile Of Lantana Camara**

### III. MATERIALS AND METHODS

#### 3.1 Plant Collection:

Fresh stem barks of lantana camera linnwere collected from the local area of Thiruvannamalai district. It was washed gently with distilled water in order to remove the dust particles may present on the surface of the stem bark and it was dried under shade for 5 days straight. The stem barks are crushed into smaller pieces and stored in air tight container for further use.

#### 3.2 Preparation Of Plant Extract:

Fresh lantana camera linnwere collected. It was washed gently with distilled water in order to remove the dust particles. It was dried under shade for 5 days straight and dried under direct

sunlight for 1 hour. The stem barks are crushed into smaller pieces and stored in an air-tight container for further use. Set up the magnetic stirrer. Take 25g of bark powder in 100ml De ionized water & set temperature to 80°-90°C. Filter the bark extract using filter paper to use as a reducing agent and capping agent.

#### 3.3 Synthesis Of Silver Nanoparticles With Extract:

Take 10mg of silver nitrate in 100ml DI-water & set temperature to 80°-90°. The lantana camera linnextract has been mixed dropwise until the color develops to light brownish orange. The plant lantana camera linn extract has been used as a reducing agent and capping agent. The mechanism involved in the synthesis of AgNPs is reduction.

The product has been centrifuged using centrifugal apparatus. AgNPs are stored in an air tight

container.



**Fig: 2 Extract Preparation**



**Fig: 3 Nanoparticle Preparation**

### 3.4 Nano-Particle Loaded Nanogel:

For the preparation of silver nanoparticle-loaded nanogels, chitosan was dissolved in 1% acetic acid to obtain a 0.2–0.5% (w/v) solution, and

the pH was adjusted to 5.0–5.5. The synthesized silver nanoparticles were then slowly added to the chitosan solution under constant stirring to ensure uniform dispersion. Nanogel formation was

achieved by the dropwise addition of sodium tripolyphosphate solution (0.1–0.3% w/v), which acted as an ionic crosslinking agent. The resulting nanogel suspension was stirred for 30–45 min, leading to the formation of stable silver nanoparticle-loaded nanogels. The nanogels were purified by centrifugation and washed with distilled water to remove excess crosslinker and unbound particles. The final formulation was either freeze-dried or stored as an aqueous suspension for further characterization and biological evaluation.

### 3.5 Evaluation Of AgNP'S :

Specific methods must first confirm the formation of AgNPs before they can be used for their intended application. The most basic method to monitor AgNPs production by visually observing the change in the color of the solution from yellow to brown. A spectrophotometer can further confirm the tracking process and detect nanoparticle peaks in the visible area of the UV–vis spectrum at a wavelength between 400 and 450 nm. Other techniques, including SEM can be used to investigate the size, morphology, dispersion, and composition of nanoparticles. Moreover, FTIR spectroscopy can help track biomolecules that influence nanoparticle formation and stability.

#### 3.5.1 UV–Vis Spectrophotometry Of AgNPs:

UV–Visible spectroscopy is an effective technique that can help characterize synthesized AgNPs. The absorbance spectra can confirm the formation of synthesized AgNPs in a solution, The analysis measures the intensity of light transmitted through the sample and compares it with a reference measurement of the incident light source. Wavelengths ranging from 400 to 800 nm are commonly used to indicate the presence of nanoparticles. AgNPs are established to induce surface plasmon resonance (SPR) at a certain range of wavelengths. Lower and higher maximum wavelength ( $\lambda_{max}$ ) values are associated with a smaller average size and higher concentration of AgNPs, respectively.

Moreover, broad and narrow peaks at higher and shorter wavelengths, respectively, indicate an increase and decrease in AgNPs size, respectively. The quality of the synthesized nanoparticles can be illustrated by the intensity and position of the SPR peak, which occurs at wavelengths between 380 and 450 nm. A narrow and low wavelength absorption peak implies a small size of the nanoparticles, while a broad peak at a high wavelength implies a large size or

aggregated AgNPs, as, Additionally, SPR peaks of the same wavelength, obtained using UV–Visible spectroscopy, indicate that the stability of green synthesized AgNPs can be maintained for several months. Thus, UV–vis spectroscopy is a valuable technique for characterizing synthesized AgNPs. Sharma et al. (2020) presented spectroscopic results of AgNPs synthesized using Terminalia catappa aqueous leaf extract.

#### 3.5.2 SEM Imaging Of Nanoparticles:

Among other electron microscopy techniques, SEM can determine the surface morphology of nanoparticles, such as their shape, size, and size distribution. Field emission SEM (FESEM) involves the emission of electrons that are accelerated using a powerful electric field. In SEM imaging, an electric current passed through electromagnetic coils and lenses to generate a focused beam of electrons that collide with a sample surface to create secondary electrons. The information on the resulting electrons is utilized to reconstruct a very detailed representation of the sample surface morphology. SEM scans the surface of a test sample and records the backscattered rays.

Metal nanoparticles, such as silver and gold nanoparticles, are very electrically conductive, making them easy to scan employing SEM. This microscopy tool offers a significant advantage because it can be performed by placing the samples directly on a black surface to avoid undesirable incident beam scattering. Although SEM cannot observe the internal structure of samples, it can provide helpful information regarding the purity and aggregation of particles. AgNPs are typically spherical, cubical, triangular, oval, pebble-like, and circular in shape, and appear as single or aggregated particles. The variations in shape may be caused by changes in the synthesis parameters such as pH, temperature, and plant concentrations. Most particles have sizes ranging from 20 to 30 nm.

#### 3.5.3 Drug Excipients Compatibility:

The IR spectrum of substance was compared with that obtained concurrently for the corresponding USP reference standard provides perhaps the most conclusive evidence of the identity of the substance. Compatibility studies were carried out to study the possible interactions between drug and other inactive ingredients. After the storage of drug-excipients for a period of 30 days at 50°C, the compatibility studies should be performed using FTIR. Potassium bromide (KBr)

pellet method was carried out. All the ingredients were individually mixed with KBr(1:10) and compressed under 10 tones pressure in a hydraulic pressure to form a transparent KBr pellets. The pellets was scanned from 4000 to 400cm<sup>-1</sup> in FTIR spectrometer. From the spectrum, the spectral studies between active and other inactive ingredients were analyzed.

### 3.5.4 In- Vitro Drug Release:

Dialysis bags (cut off 12-14kDa) were filled with a fixed amount of formulation put into 100ml of buffer solution (pH 7.4) and stirred at 50 rpm was used as receptor phase. The dissolution medium was phosphate buffer having pH 7.4. The dialysis sacs were equilibrated with dissolution medium for few hours prior to experiment. The experiment was conducted at 37°C±0.5°C. sampling was performed with interval of every half an hour once for upto 24 hours, 1ml of sample was withdrawn and 1ml of phosphate buffer pH 7.4 was replaced into the same to maintain sink condition. After appropriate dilutions the samples were analyzed by UV spectrophotometer at 250 nm. The sample procedure was repeated for studying the in-vitro drug release.

### 3.6 EVALUATION OF AgNP'S LOADED NANOGEL :

Evaluating Nanogels involves assessing their properties, performance, and suitability for specific applications. This evaluation typically includes various physical, chemical, and mechanical tests. Below is an overview of the key aspects considered when evaluating Nanogels:

**3.6.1 Appearance:** The formulations physical appearance was analyzed visually. The Nanogels was Soft, flexible with a smooth surface. Moderately firm, as the borax concentration provides some cross-linking but not excessive stiffness. Elastic and slightly sticky, due to unreacted starch molecules retaining water.

**3.6.2 Color:** The color of the formulation was checked out against white & black backgrounds. The Nanogels was white or translucent in color.

**3.6.3 Odor:** The odor of the Nanogels was checked by taking smell of little amount of Nanogels. The Nanogels was mild or odorless.

**3.6.4 Determination of PH:** To determine the PH of the product, dilute the product in distilled water (1:10) then measure the PH of the dilution. The PH of the Hydro gel was 7.0-7.4. Citric acid is used to adjust the PH of the product.

**3.6.5 Rheology:** Viscosity of Nanogels is evaluated by using Cone plate type viscometer under constant temperature at 4°C. This viscometer is highly specific for the evaluation of viscosity.

**3.6.6 Spreadibility study:** The apparatus was made of wooden block with scale and two glass slides having a pan mounted on a pulley. Excess formulation was placed between two glass slides and 100 gm weight was placed on upper glass slide for 5 minutes to compare the formulation to achieve uniform thickness. Weight can be added and the time to separate the two slides was taken as spreadibility time.

$$S = (m \times l) / t$$

Where,

- S is spreadibility,
- m is weight tied on upper slide,
- l is length of glass slide and
- t is time taken in seconds

**3.6.7 Viscoelastic Properties:** Rheological tests are conducted to measure the Nanogels viscoelastic behavior, which includes both its elastic (solid-like) and viscous (liquid-like) responses.

**3.6.8 Gel Fraction:** The gel fraction represents the proportion of the Nanogels that is cross-linked and does not dissolve in water. It is measured by extracting the soluble components from the Nanogels and weighing the remaining material.

$$GF (\%) = W_g / W_o \times 100$$

- W<sub>g</sub> = weight of the dried gel after extraction (i.e., after removing soluble fractions)
- W<sub>o</sub> = initial dry weight of the polymer before extraction.

**3.6.9 Scanning Electron Microscopy (SEM):** SEM can be used to provide information about the sample's composition, surface topography, and other properties such as electrical conductivity.

**3.6.10 Homogeneity:** All developed Nanogels were tested for homogeneity by visual inspection after the gels have been set in the container. They were tested for their appearance and presence of any aggregates.

**3.6.11 Irritancy Test:** Mark an area (1sq.cm) on the left hand dorsal surface. The gel was applied to the specified area and time was noted. Irritancy, erythema, edema, was checked if any for regular intervals up to 24 hrs and reported.

**3.6.12 In-Vitro Diffusion Study:**  
**Cellophane Membrane Treatment for Permeations study:** Cellophane membrane was boiled in the distilled water for 1 hour and washed with fresh distilled water for three times and kept in ethanol for 24 hours. It was treated with 0.3% sodium sulphite and soaked in distilled water for 2 min at 60°C followed by acidified with 0.2% sulphuric. Finally the membrane was dipped in boric acid buffer pH (9) till it is used for permeation study.

**In-vitro diffusion study:** The in-vitro permeation rate of selected formulations of gel were evaluated by open ended tube through using pH 7.4 as diffusion medium upto 10 hours studies. The cellophane membrane was tied in one end of the tube and then immersed in the receptor compartment containing 200ml of 7.4 buffer solution which was stirred at 100±10 rpm and maintained at 37°C ±2°C. A quantity of 5ml samples were withdrawn from the receptor fluid at the time intervals of 0, 1, 2, 4, 6, 7, 8, 10 hr. and 5ml

of phosphate buffer of pH 7.4 was replaced immediately each time.

**3.7 Antimicrobial Testing:**

**Inoculate the agar plate:** Using a sterile swab, dip it into the bacterial suspension and evenly spread it over the surface of an agar plate (blood agar or nutrient agar). Make sure the entire surface is covered, ensuring uniform bacterial growth.

**Apply antimicrobial discs:** If performing the disk diffusion method, place sterile antibiotic discs (or antimicrobial agents) onto the inoculated agar surface using sterile forceps. Ensure they are spaced sufficiently apart to avoid overlap of inhibition zones.

**Incubation:** Place the inoculated plate in an incubator at 37°C for 18-24 hours.

**Interpretation:** After incubation, check the plate for clear zones of inhibition around the antibiotic discs. The size of the inhibition zones helps to assess the susceptibility of *Streptococcus pyogenes* to the antimicrobial agents. Measure the diameter of these zones and compare them with standard susceptibility charts to determine the effectiveness.

**IV. RESULTS AND DISCUSSION:**

**4.1 Preliminary Phytochemical Screening:**

Results of the Preliminary Phytochemical Constituents present in extract of *Lantana camera linn*

S. NO	CONSTITUENTS	EXTRACT OF LANTANA CAMERA LINN
1.	Alkaloids	+
2.	Carbohydrates	-
3.	Protein	-
4.	Terpinoids	+
5.	Phenols	+
6.	Tannins	-
7.	Flavonoids	+
9.	Glycosides	-
10.	Saponins	-

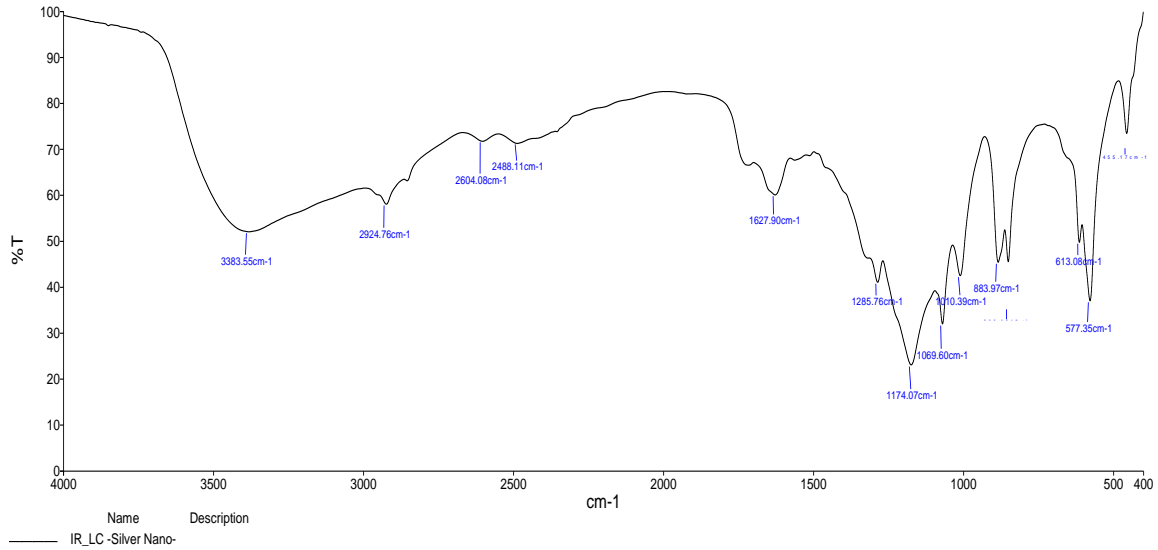
**Table No: 3 Preliminary Phytochemical Screening**

+ = Present  
 - = Absent

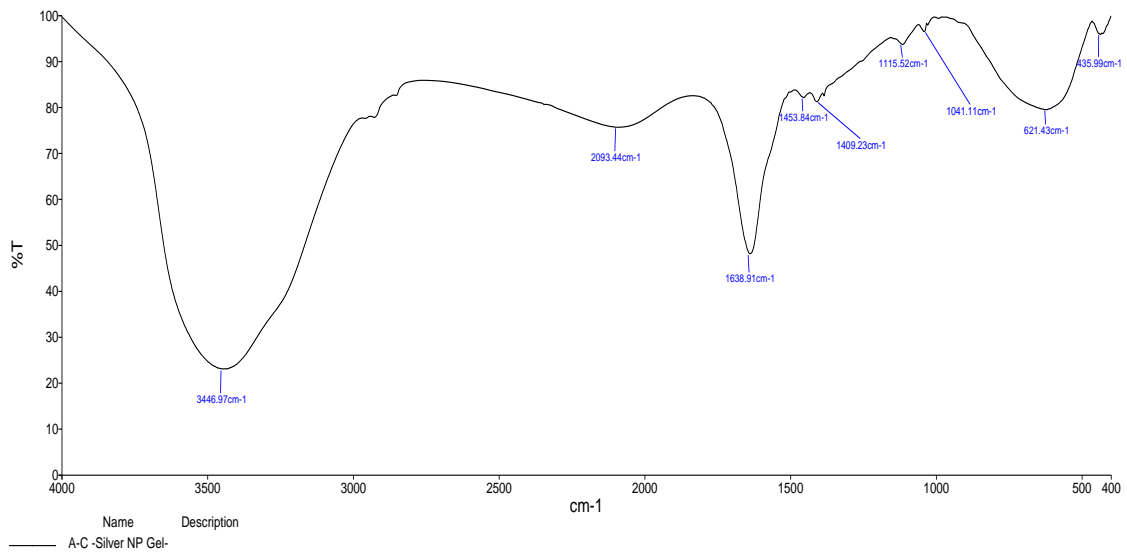
**4.2 Drug Excipients Compatibility Studies:**

The spectrum obtained with the drug excipients mixtures was compared to spectrum

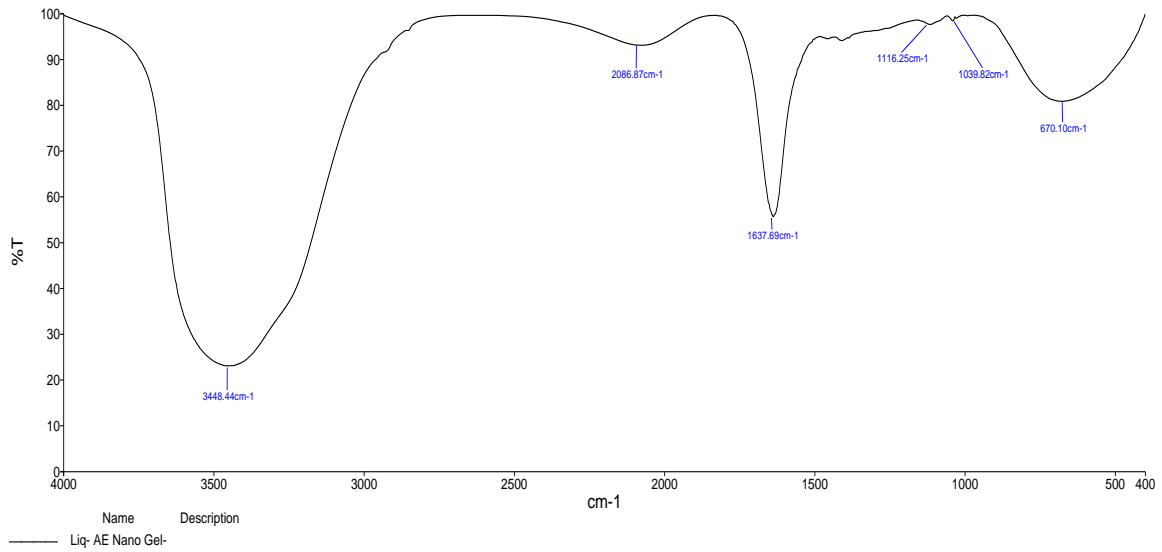
obtained for the drug alone and excipients alone. Changes in the spectrum, additional or losses from peaks are considered to be significant.



**Fig: 4 FTIR Spectrum OfLantana Camara Containing Nanoparticle**

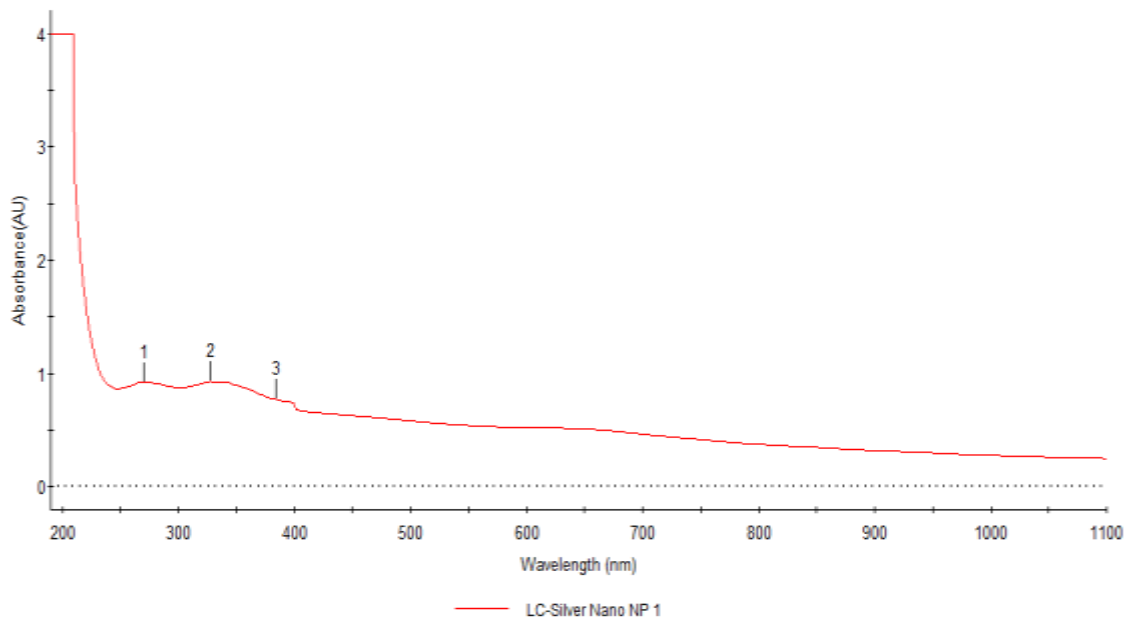


**Fig: 5 FTIR Spectrum OfLantana Camara Containing Nanoparticle Loaded Nanogel**



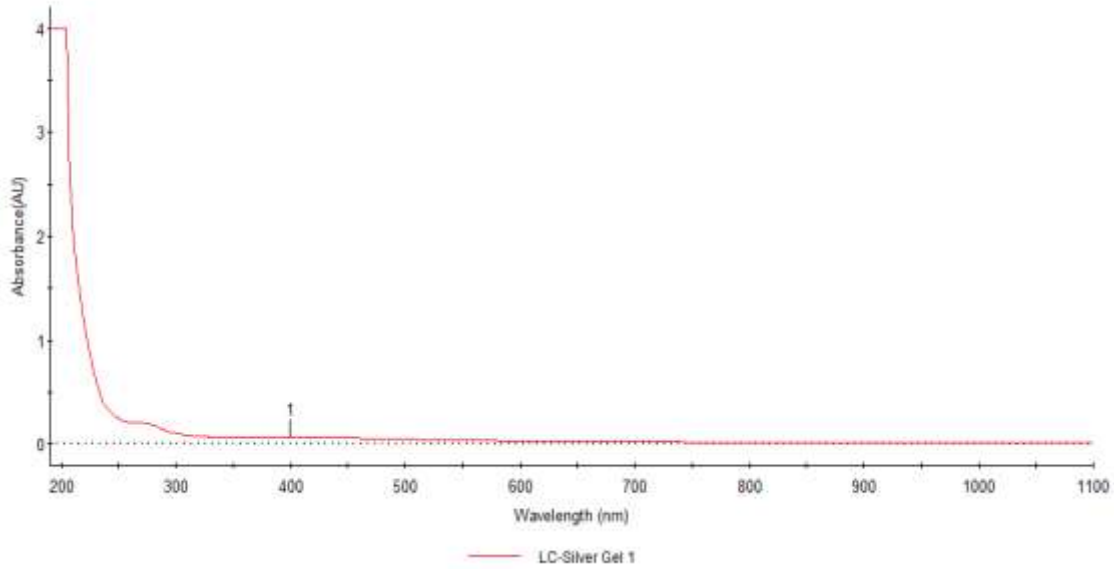
**Fig: 6 FTIR Spectrum Of Lantana Camara Extract**

**4.3 UV- Analysis:**



**Fig: 7 UV Spectrum Of Silver Nanoparticle**

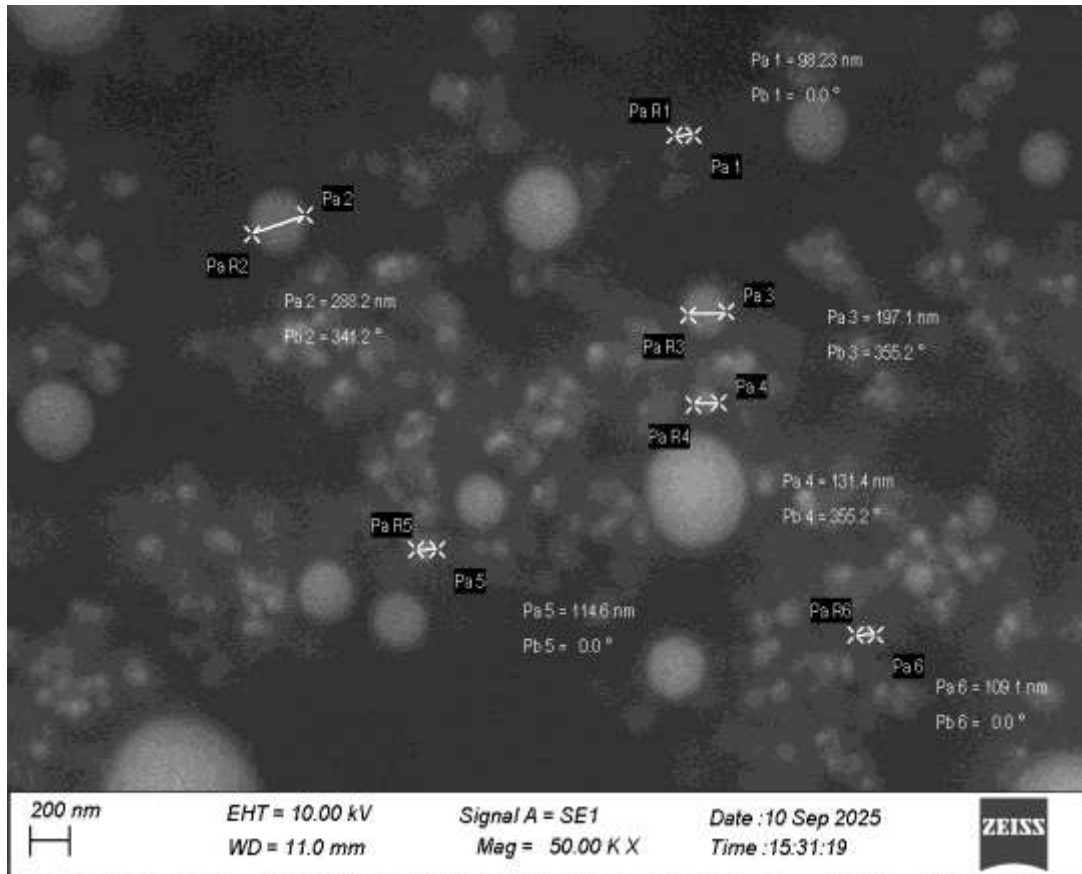
Name	No.	Peak(nm)	Peak(AU)	No.	Valley(nm)	Valley(AU)
LC-Silver Nano NP	1	270.0	0.93			
	2	327.0	0.93			
	3	383.9	0.78			



**Fig: 8 UV Spectrum Of Silver Nanoparticle Loaded Nanogel**

Name	No.	Peak(nm)	Peak(AU)	No.	Valley(nm)	Valley(AU)
LC-Silver Gel 1		398.8	0.07			

**4.4 SEM ANALYSIS:**



**Fig: 9 SEM Analysis ( Nanoparticles )**

S.NO	PARTICLES	SIZE
1	Particle 1	98.23nm
2	Particle 2	288.2nm
3	Particle 3	197.1nm
4	Particle 4	131.4nm
5	Particle 5	114.6nm
6	Particle 6	109.1nm

Table No: 4SEM Analysis ( Nanoparticles )

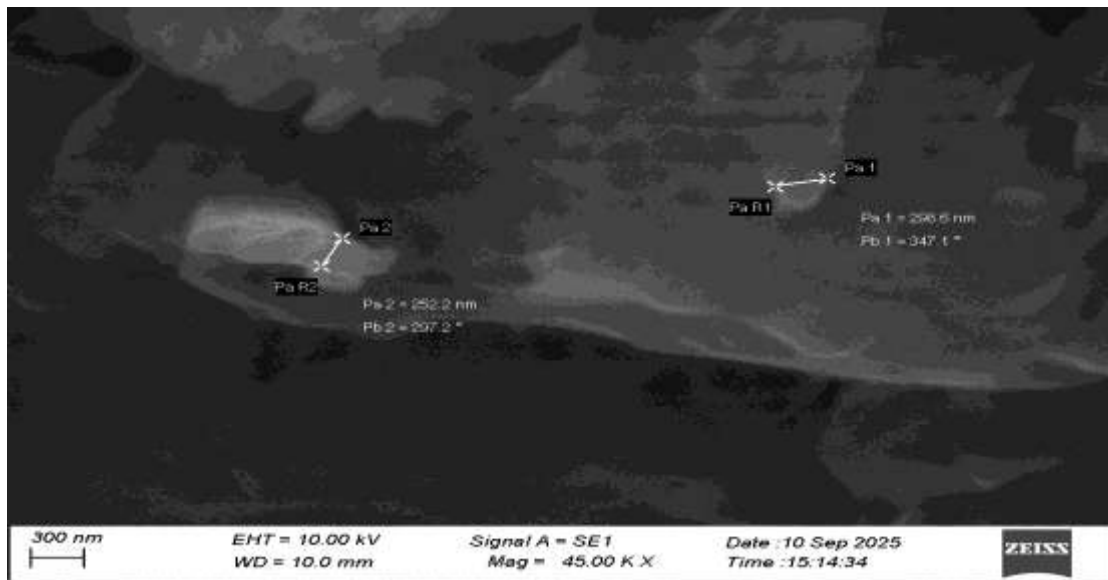


Fig: 10 SEM Analysis ( Nanoparticles Loaded Nanogel )

S.NO	PARTICLES	SIZE
1	Particle 1	296.6nm
2	Particle 2	252.2nm

Table No: 5SEM Analysis ( Nanoparticles )

4.5 EVALUATION OF GEL:

S.NO	PARAMETERS	NANOPARTICLE LOADED NANOGEL
1.	State	Semi Solid
2.	Color	Dark Brown
3.	Odor	Odorless
4.	pH	8.11
5.	Grittiness	Smooth
6.	Viscosity	7543
7.	Sensitivity Test	No Irritation
8.	Irritation Test	No Irritation
9.	Spreadability	6.9 cm
10.	Homogeneity	Homogenous
11.	Gel Fraction	65%
12.	Viscoelastic	Higher Elasticity Gel-Like Behavior

Table No: 6 Evaluation Of Gel

**4.6 IN-VITRO DRUG RELEASE STUDIES:**

Time (Hr)	cumulative % drug released	% drug remaining	Square root time	log Cumu % drug remaining	log time	log Cumu % drug released	% Drug release d	Cube Root of % Remaining(Wt)	Wo-Wt
0	0	100	0.000	2.000	0.000	0.000	100	4.642	0.000
0.5	5.31	94.69	0.707	1.976	-0.301	0.725	5.31	4.558	0.084
1	8.67	91.33	1.000	1.961	0.000	0.938	3.36	4.503	0.139
2	13.65	86.35	1.414	1.936	0.301	1.135	4.98	4.420	0.222
4	29.11	70.89	2.000	1.851	0.602	1.464	15.46	4.139	0.503
6	38.21	61.79	2.449	1.791	0.778	1.582	9.1	3.953	0.689
8	55.32	44.68	2.828	1.650	0.903	1.743	17.11	3.548	1.094
12	73.71	26.29	3.464	1.420	1.079	1.868	18.39	2.973	1.669
14	86.35	13.65	3.742	1.135	1.146	1.936	12.64	2.390	2.252

**Table No: 7In-Vitro Drug Release Studies ( Nanoparticle )**

Time (Hr)	Cumulative % Drug Released	% Drug Remaining	Square Root Time	Log Cumu % Drug Remaining	Log Time	Log Cumu % Drug Released	% Drug Released	Cube Root Of % Drug Remaining(Wt)	Wo-Wt
0	0	100	0.000	2.000	0.000	0.000	100	4.642	0.000
2	5.531	94.469	1.414	1.975	0.301	0.743	5.531	4.554	0.088
4	18.143	81.857	2.000	1.913	0.602	1.259	12.612	4.342	0.300
6	35.083	64.917	2.449	1.812	0.778	1.545	16.94	4.019	0.623
8	60.035	39.965	2.828	1.602	0.903	1.778	24.952	3.419	1.223
10	96.335	3.665	3.162	0.564	1.000	1.984	36.3	1.542	3.100

**Table No: 8In-Vitro Drug Release Studies ( Nanoparticle Loaded Nanogel )**

**4.7 Anti-Microbial Activity:**



**Fig: 11 Anti-Microbial Activity**

S.NO	Microorganism	Control	1 (Nanogel)	2 (Extract)	3 (Nanoparticle)	Ketoconazole (Standard)
1	Aspergillus flavus	-	16	7	12	10
2	Penicillium sps	-	11	8	13	16

Table No: 9 Anti-Microbial Activity

## V. DISCUSSION

Preliminary phytochemical screening of *Lantana camara* Linn extract revealed the presence of alkaloids, terpenoids, phenols, and flavonoids, which are known for their antimicrobial, antioxidant, and anti-inflammatory properties. The absence of carbohydrates, proteins, tannins, glycosides, and saponins suggests selective extraction of bioactive secondary metabolites responsible for therapeutic efficacy.

Drug–excipient compatibility studies carried out using FTIR spectroscopy showed no significant changes in characteristic peaks, indicating the chemical stability of the drug within the formulation. This confirms the suitability of excipients used in the development of nanoparticle and nanogel systems.

UV–visible spectroscopic analysis confirmed the successful synthesis of silver nanoparticles, as evidenced by characteristic absorption peaks between 270–398 nm. The shift in peaks in the nanoparticle-loaded nanogel further indicates effective incorporation of nanoparticles into the gel matrix.

SEM analysis demonstrated that the synthesized nanoparticles were within the nanometer range, with particle sizes ranging from approximately 98 nm to 288 nm. The nanogel-loaded nanoparticles showed slightly increased particle size due to polymeric encapsulation, which is desirable for sustained drug release and improved stability.

Evaluation of the nanogel formulation revealed acceptable physicochemical properties such as semi-solid consistency, smooth texture, good spreadability, high viscosity, and appropriate pH. The formulation was found to be non-irritant, indicating its suitability for topical application.

In-vitro drug release studies demonstrated a controlled and sustained release profile for both nanoparticles and nanoparticle-loaded nanogel, with the nanogel exhibiting prolonged drug release compared to nanoparticles alone. This controlled release behavior enhances therapeutic effectiveness and patient compliance.

Antimicrobial activity studies showed that the nanoparticle-loaded nanogel exhibited significant antifungal activity against *Aspergillus flavus* and *Penicillium* species, outperforming the crude extract and demonstrating comparable or enhanced activity relative to the standard drug.

## VI. CONCLUSION:

The study successfully demonstrated the formulation and evaluation of *Lantana camara* Linn silver nanoparticle-loaded nanogel. The presence of bioactive phytoconstituents, combined with nanoscale drug delivery, resulted in enhanced antimicrobial efficacy and sustained drug release. The developed nanogel showed excellent physicochemical properties, stability, and non-irritant behavior, making it a promising candidate for topical antimicrobial therapy. Further in-vivo and clinical studies are recommended to establish its therapeutic potential and safety profile.

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