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FORMULATION AND EVALUATION OF SILVER NANOPARTICLES USING AQUEOUS EXTRACT OF LANTANA CAMARA FRESH LEAVES

Dr. Sudha Bansal[1*], Ayesha[2], B. Sridhar Reddy[2], M. Koojitha[2], U. Harish[2]

[1]Department of Pharmacology, Bhaskar Pharmacy College, Moinabad, R.R. District, Telangana,India, 500075

[2]Student, Bhaskar Pharmacy College, Moinabad, R.R. District, Telangana, India, 500075

Abstract:

The aim of this study was to investigate the effectiveness of a strategy based on the development of Silver Nanoparticles as an innovative formulation of Lantana camara extract with improved therapeutic efficacy. Lantana camara Silver Nanoparticles were prepared by green synthesis. FTIR studies indicated no interaction between Extract and excipients. Silver nanoparticles were characterized for particle size, zeta potential, entrapment efficiency and surface morphology. In vitro drug release studies were performed in phosphate buffer of pH 7.4 using diffusion technique. The F5 batch had shown maximum entrapment up to 85.55 % and sustained drug release for 8 h. The scanning electron microscopy and zeta potential study showed formation of good Silver nanoparticles dispersion. The stability study showed successful formation of stable silver nanoparticles.

Key words: *Lantana camara, silver nanoparticles, Green synthesis technique, FTIR, in-vitro drug release.*

Corresponding author:

Sudha Bansal,
Department of Pharmacology,
Bhaskar Pharmacy College, Moinabad, R.R. District,
Telangana,India, 500075

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INTRODUCTION:

Nanotechnology has emerged as a promising interdisciplinary field with wide-ranging applications in medicine, pharmaceuticals, electronics, and environmental sciences. Among various nanomaterials, silver nanoparticles (AgNPs) have attracted significant attention due to their unique physicochemical properties, including high surface-to-volume ratio, optical characteristics, and potent antimicrobial activity.[1] Lantana camara is a widely distributed medicinal plant belonging to the family Verbenaceae and is known for its rich phytochemical composition and diverse pharmacological activities. The leaves of Lantana camara contain bioactive constituents including phenolic compounds, flavonoids, triterpenoids, and essential oils, which exhibit antimicrobial, antioxidant, anti-inflammatory, and wound-healing properties.[2] These phytoconstituents make Lantana camara an excellent candidate for the green synthesis of silver nanoparticles. The use of aqueous leaf extracts for nanoparticle synthesis is particularly advantageous as it avoids the use of organic solvents, enhances biocompatibility, and aligns with the principles of green chemistry.[3] Furthermore, the phytochemicals present in the extract not only facilitate the reduction of silver ions to metallic silver but also stabilize the nanoparticles, thereby influencing their size, morphology, and biological activity.[4] In this context, the present study focuses on the formulation and evaluation of silver nanoparticles using aqueous extract of Lantana camara fresh leaves.[5] The synthesized nanoparticles were characterized for their physicochemical properties using suitable analytical techniques, and their stability and biological potential were evaluated.[6] The outcomes of this research are expected to provide an environmentally benign and economically viable approach for the synthesis of silver nanoparticles with potential pharmaceutical and biomedical applications.[7]

MATERIALS

Lanana camara L, were collected from the Tirupati. Silver nitrate was obtained from Synpharma Research Labs, Hyderabad. Other chemicals and the reagents used were of analytical grade.

METHODOLOGY

LANTANA CAMARA EXTRACT PROCESS [8]

Soxhlet Extraction

1. Use dried, powdered Lantana camara leaves (30–50 g).
2. Load the powder into a thimble and place it in the Soxhlet extractor.
3. Use ethanol (95%) or hydroalcoholic solvent as the extracting solvent.
4. Allow extraction to proceed for 6–8 hours or until the solvent in the siphon becomes colorless.
5. Collect the extract and evaporate the solvent using a rotary evaporator.
6. Dry and store the extract in an amber vial under refrigeration (4–8°C).

Fig-1: Extraction process

Fig-2: Extract

FT-IR spectral study

The stretching vibrations characteristic of the silver nanoparticles was studied by obtaining the FT-IR spectra of silver nanoparticles. [9]

FORMULATION DEVELOPMENT

Table-1: Formulation development of Zinc oxide nanoparticles

Ingredients	F1	F2	F3	F4	F5	F6
Plant extract (ml)	20	20	20	20	20	20
Silver nitrate(ml)	5	10	15	20	25	30
Water	10	10	10	10	10	10

Precipitation method

A solution of $AgNO_3$ was prepared by dissolving it in 100 mL of water and stirring for 1-hour. Add the various concentrations of extract solution to silver nitrate solution. Stir the mixture continuously at room temperature or slightly warm (~40–60°C). After one hour of incubation observe color change from pale yellow to brown, that appeared confirmed the formation of silver nanoparticles (AgNO3 NP). [10]

Evaluation of lantana camara extract loaded silver nanoparticles

Particle size: The particle size of the Silver nanoparticles was determined by a light scattering particle size analyzer. The particles were coated with gold sputter on a metal stub and was scanned with an electron beam to obtain magnified image of the surface. The surface characteristics were observed from the image. [11]

Zeta Potential: The surface charge (Zeta potential) was determined by measuring the electrophoretic mobility of the nanoparticles using a Malvern zetasizer (Malvern Instruments, UK). Samples were prepared by diluting with distilled water.[12]

Surface Morphology (SEM) Analysis: The morphology of the Silver nanoparticles was studied with the help of scanning electron microscopy. The particles were coated with gold sputter on a metal stub and was scanned with an electron beam to obtain magnified image of the surface. The surface characteristics were observed from the image. [13]

Drug entrapment efficiency: The entrapment efficiency was studied by dissolving the Lantana camara extract loaded silver nanoparticles in 7.4 phosphate buffer and analysing the solution at 260 nm by UV spectroscopy and amount of Lantana camara extract was calculated from the calibration curve.[14]

$$\text{DEE (\%)} = \frac{\text{Amount entrapped}}{\text{Total drug loaded}} \times 100$$

In-vitro drug release studies: In vitro release of Lantana camara extract from the silver nanoparticles was carried out on modified Franz diffusion cell, and the temperature was maintained at 37°C±1°C. The formulation was placed into the donor chamber. Diffusion test was carried out in one media: phosphate buffer (pH 7.4) At specific time intervals (namely 1, 2, 3, 4,5 6, 7 and 8hours), aliquots of 1 mL were withdrawn and immediately restored with the same volume of fresh dissolution media. The amount of the drug released was determined by measuring the absorbance at 260 nm using a double-beam UV–visible (Vis) spectrophotometer. [15]

Fig-3: Franz diffusion cell apparatus

Stability studies[16]

Selected Formulation was subjected to stability studies as per ICH guidelines.
Following conditions were used for Stability Testing.
1. 25^0C/60% RH analyzed every month for period of three months.
2. 30^0C/75% RH analyzed every month for period of three months.
3. 40^0C/75% RH analyzed every month for period of three months.

RESULTS AND DISCUSSION:

Drug-excipient compatibility studies (FT-IR)

The compatibility between the drug and the selected excipients was evaluated using FTIR peak matching method. There was no appearance or disappearance of peaks in the extract and excipients mixture, which confirmed the absence of any chemical interaction between the extract and various excipients.

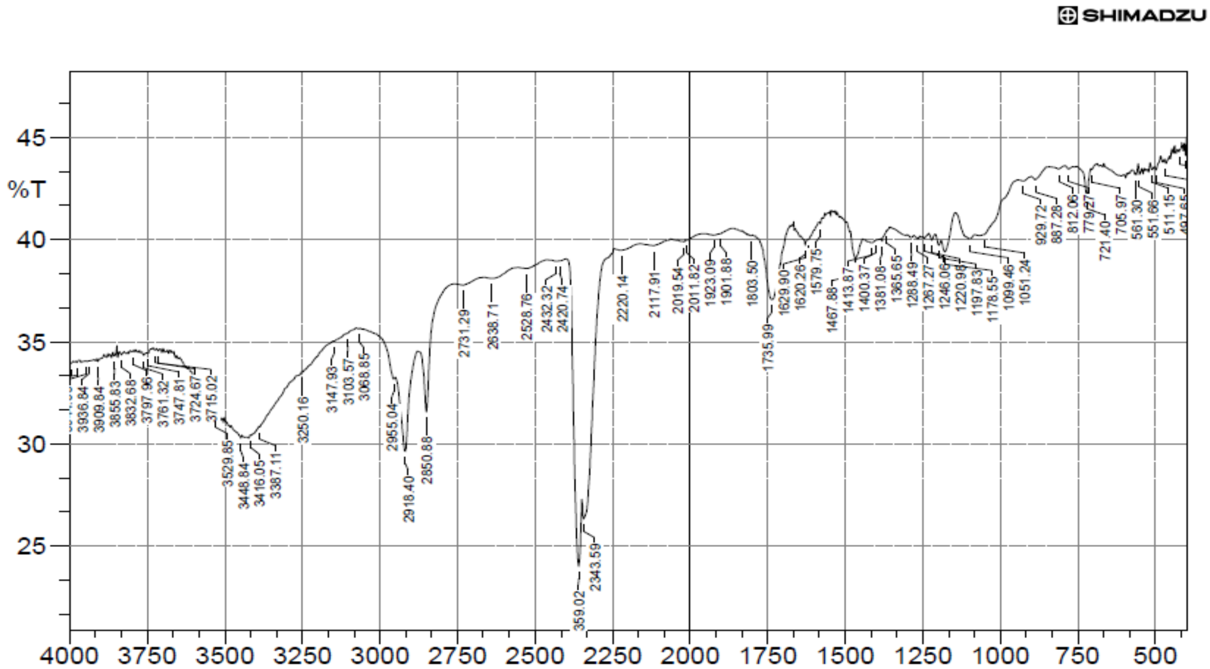

Fig-4: FTIR Studies of Lantana camara

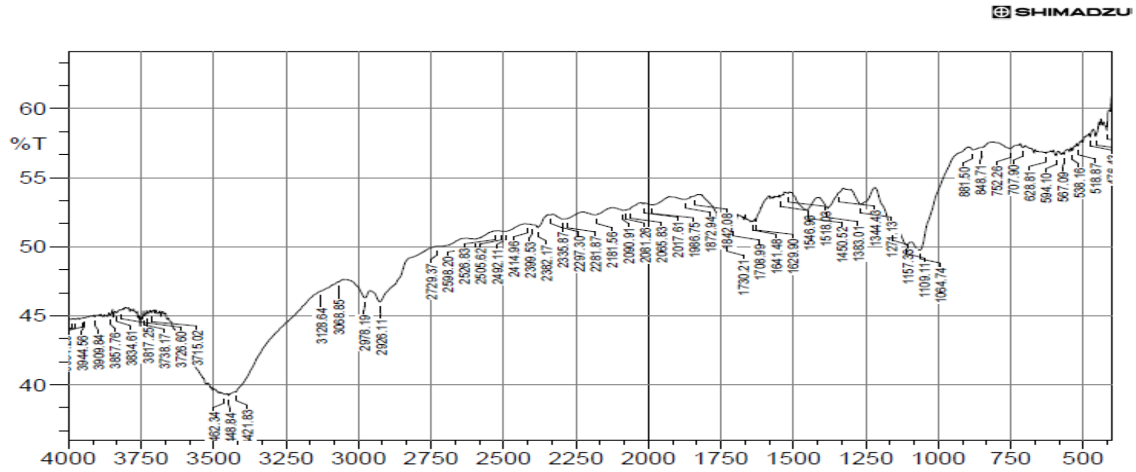

Fig-5: FTIR Spectra of physical mixture of drug and excipients

Compatibility studies were performed using IR spectrophotometer. The IR spectrum of Pure drug and physical mixture of drug and excipients were studied. The characteristic absorption of peaks were obtained as above and as they were in official limits (±100 cm^{-1}) the drug is compatible with excipients.

Particle size

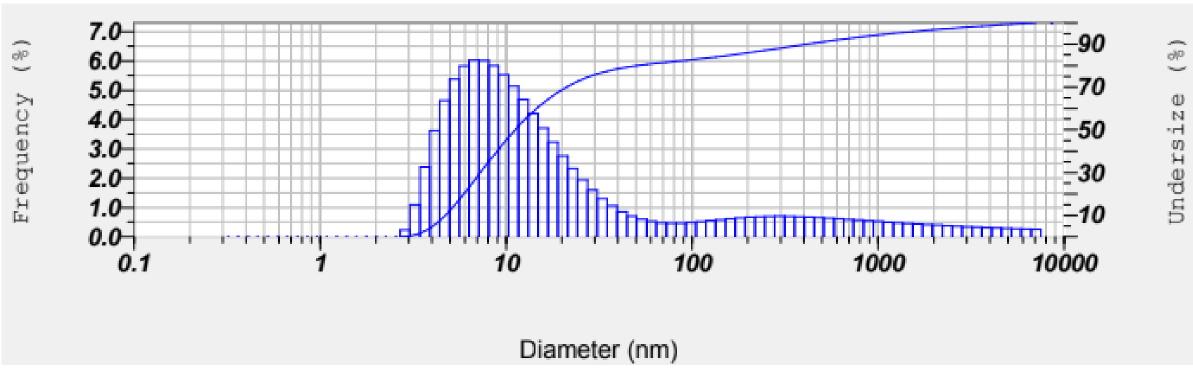

Fig-6: Particle size of optimized formulations

The mean particle size of optimized silver nanoparticles was found to be 71 nm

Determination of Zeta potential:

Zeta potential is a measure of charge present on the vesicle surface. It was determined by using phase analysis light scattering with Malvern zetasizer at field strength of 20V/cm in distilled water and based on electrophoretic mobility of charged particles present in the nanocarrier system. Charged particles were attracted to the electrode with the opposite charge when an electric field is applied.

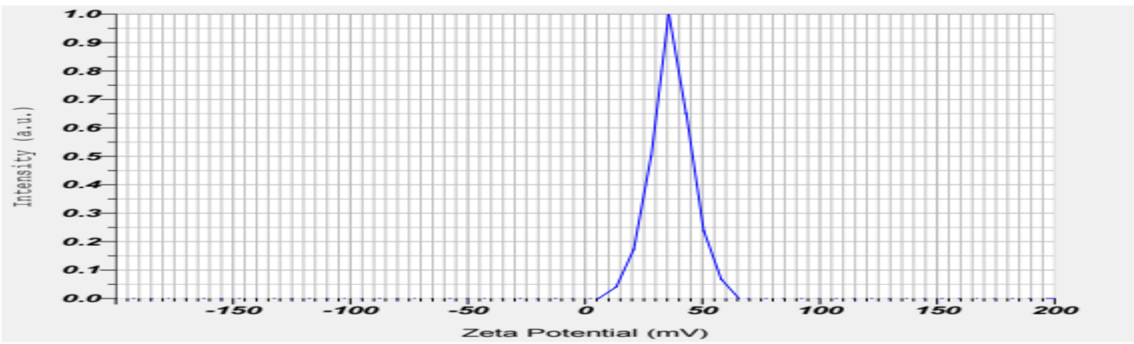

Fig-7: Zeta potential of Optimized formulation

The addition of membrane additives affects zeta potential value depending on the type of membrane additives. Zeta potential of optimized Lantana camara extract Silver nanoparticles formulation was measured and found to -29 mv. The obtained result of the zeta potential of the prepared formulation indicates particles in the formulation remains suspended and so were found to be stable.

Scanning Electron Microscopy:

The surface characteristic of prepared crystal was studied by SEM (ZEISS Electron Microscope, EVO MA 15). Powder samples was mounted onto aluminium stub using double sided adhesive tape and sputter coated with a thin layer of gold at 10 Torr vacuum before examination. The specimens were scanned with an electron beam of acceleration potential of 20 kV and the images were collected as secondary electron mode.

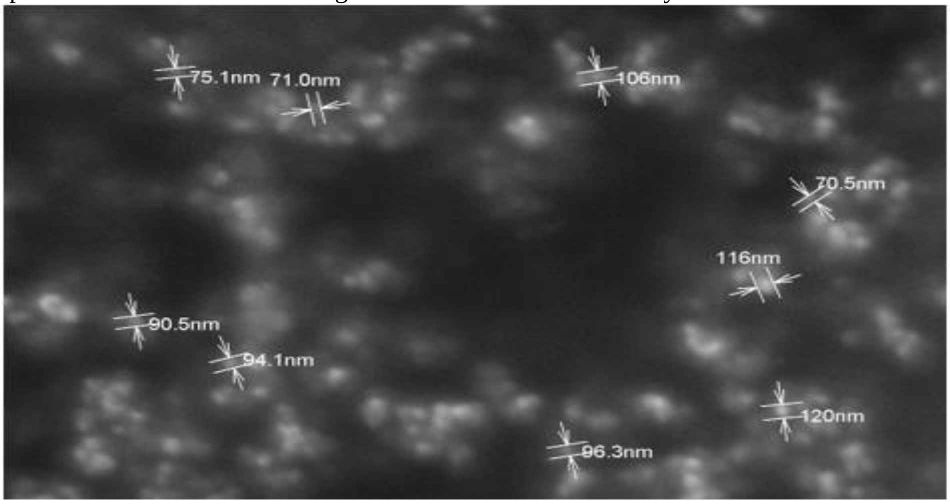

Fig-8: SEM Analysis of Lantana camara silver nanoparticles

The morphology of the prepared diverse types of nanoparticles was found to be virtually spherical in shape and have a rough surface, as illustrated in SEM photomicrographs of the nanoparticles.

Characterization of Silver nanoparticles of Lantana camara extract

Table-2: Evaluation Studies of particle size and Zeta potential of Lantana camara extract Silver nanoparticles

F. no	Particle size (nm)	Zeta Potential(mV)
F1	116	-28
F2	105	-27
F3	75	-28
F4	90.5	-26
F5	71	-29
F6	95	-30

Entrapment efficiency

The drug entrapment efficiency of all 6 formulations was evaluated. From the F5 formulation showed maximum drug entrapment efficiency 85.55 % compared to other formulations. The zeta potential or the change on the surface of colloidal particles in Lantana camara extract Silver nanoparticles was measured by electrophoretic light scattering mode using zetasizer nano ZS. The particle charge of Lantana camara extract Silver nanoparticles were quantified at 25^{o} C. The samples were diluted approximately with the deionized water for the measurements of particle size.

Table-3: Evaluation Studies of Entrapment Efficiency of Silver nanoparticles

F. no	Entrapment Efficiency (%)
F1	80.59
F2	82.53
F3	79.99
F4	83.67
F5	85.55
F6	81.20

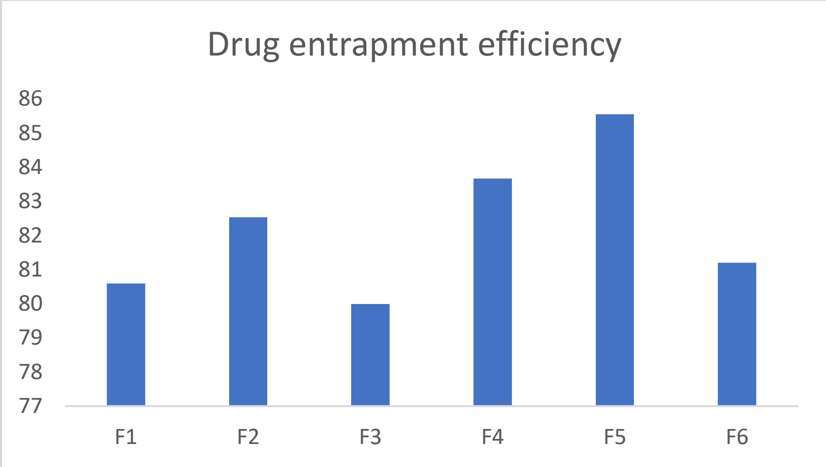

Fig-9: Entrapment efficiency Silver nanoparticles

In vitro drug release studies

Table-4: In vitro drug release studies of all formulations

Time (hrs)	F1	F2	F3	F4	F5	F6
0	0	0	0	0	0	0
1	26.93	25.19	24.58	27.18	28.56	27.45
2	37.48	35.48	37.10	38.17	39.10	33.25
3	43.28	40.16	42.59	43.25	45.17	44.16
4	51.16	50.88	53.67	55.18	56.98	55.20
5	60.19	61.96	63.96	65.80	66.78	67.13
6	70.28	71.47	73.51	75.19	79.81	75.89
7	81.64	80.39	82.59	80.33	83.58	82.96
8	93.69	94.53	95.82	96.79	98.10	96.47

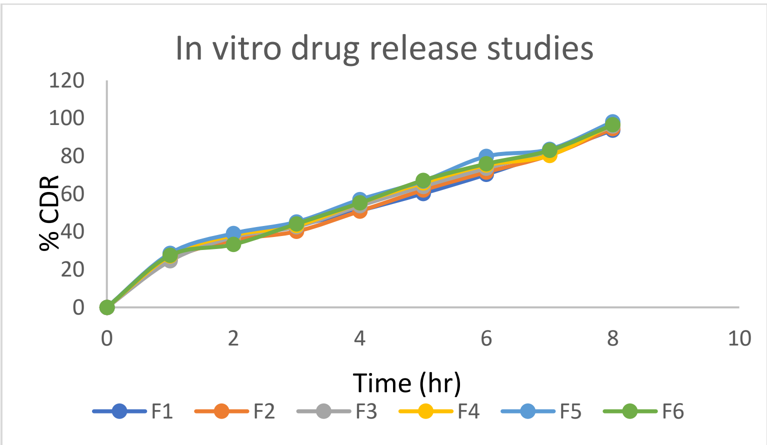

Fig-10: In vitro drug release studies of (F1-F6) Formulations

The drug release studies of all formulations of Lantana camara extract Silver nanoparticles were conducted by means of diffusion apparatus for a time period of 8 hrs. From the drug release studies as depicted in Figure, the results showed that 8 formulation showed maximum drug release rate of 98.10 % within 8 hrs.

Stability studies : There was no significant change in physical and chemical properties of the Silver nanoparticles of formulation F-5 after 90 days. Parameters quantified at various time intervals were shown.

Table-5: Stability studies of all formulations

	Parameters	Initial	1st Month	2nd Month	3rd Month	Limits as per Specifications
F-5	**25^0C/60%RH**	98.10	97.86	96.37	95.78	**Not less than**
F-5	**30^0C/75% RH**	98.10	97.58	96.29	95.51	**Not less than**
F-5	**40^0C/75% RH**	98.10	97.50	96.20	95.25	**Not less than**

CONCLUSION:

The green synthesis of silver nanoparticles (AgNPs) using Lantana camara extract provides an eco-friendly, cost-effective. The phytochemicals present in the Lantana camara leaves, such as flavonoids, phenols, and terpenoids, act as natural reducing and stabilizing agents, effectively converting silver ions (Ag^+) into silver nanoparticles (Ag^0). The synthesized AgNPs were typically spherical and nanoscale in size, confirmed by UV-Vis spectroscopy, FTIR, and SEM analysis. A drug encapsulation effectiveness of up to 85.55 % has been attained in this study. Lantana camara extract Silver nanoparticles containing silver nitrate is prepared by using green synthesis method, then the particle size was decreased by sonication formulation using Silver nanoparticles performed well in terms of medication content and encapsulation effectiveness. This shows that the formulation procedure was suitable and reproducible in nature, and it provided a good yield. The formulation with the best encapsulation efficiency was (F-5). It was discovered that the percentage of encapsulation efficiency. According to the method described, permeation studies with dialysis membrane were conducted. The in vitro drug release profiles of all the formulations indicated an initial burst effect, followed by a gradual drug release. These nanoparticles exhibited promising antimicrobial, antioxidant, and catalytic properties. Overall, Lantana camara-mediated silver nanoparticles represent a valuable advancement in green nanotechnology, promoting the development of safer and more sustainable nanomaterials.

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