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Formulation and Evaluation of Silver Nanogel of *Delonix Regia* & Its Antimicrobial Activity

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ABSTRACT:

Silver nanoparticles (Ag-NPs) possess exceptional properties such as surface plasmon resonance, thermal and electrical conductivity, size-dependent optical properties, and catalytic activities that make them enduringly appealing to society. The present study was based on the Formulation and evaluation of silver nanogel of *Delonix regia* & its antimicrobial activity. The *seeds, leaves & bark* of *Delonix regia* were collected from a local market in Lucknow, UP, India. The plant material, *bark, leaves* and *seeds* of *Delonix regia* were identified and authenticated by Dr. Sunita Garg, Scientist, Plant Diversity, Systematics and Herbarium Division, CSIR-NIScPR, New Delhi. The dried *seeds, leaves* and *bark* of *Delonix regia* were extracted using Soxhlet apparatus and concentrated through rotatory evaporator. Phytochemical screening was performed for all the extracts. *Bacillus subtilis, Escherichia coli* and *Pseudomonas aeruginosa* were procured from the Institute of Microbial Technology (IMTECH), Chandigarh, India. Firstly, nanoparticles were synthesized and evaluated for UV-visible spectroscopy. The silver nanogel was formulated by dispersing a gel-forming agent. The nanogel was characterized for physical appearances, droplet size & polydispersity index (PDI) and SEM analysis. The antimicrobial activity of silver nanogels was determined by the zone of Inhibition using cup plate method. From the antimicrobial potential of silver nanogels it can be concluded that, silver nanogel namely Silver nanogel of *Delonix regia seed, bark (Ethanollic extract, Silver nanogel of Delonix regia seed, leaves, bark (Hexane extract), Silver nanogel of Delonix regia leaves, seed & bark (Hydroalcoholic extract)*, showed good antimicrobial activity against microbial strain.

Keywords: Silver nanoparticles, nanogel, *Delonix regia*, *Escherichia coli*, antimicrobial activity.



INTRODUCTION

Silver nanoparticles (Ag-NPs) possess exceptional properties such as surface plasmon resonance, thermal and electrical conductivity, size-dependent optical properties, and catalytic activities that make them enduringly appealing to society. [1]. Controlling size and size distribution is a crucial challenge that often arises from modifications to the synthesis techniques, reducing agents, and stabilizers. Numerous capping and stabilizing agents have been documented so far for the surface-functionalization of Ag-NPs. Ag-NPs are often made via a number of physical and chemical processes that fall into one of two categories: "top to bottom" or "bottom to up" [2]. In order to get Ag-NPs and avoid the creation of dangerous materials, green synthetic approaches have recently been created and used [3].

Delonix regia tree, sometimes referred to as Gulmohar, Royal Poinciana, and Flamboyant, in its original Madagascar environment in the early 19th century [4]. *D. regia*, belonging to the Caesalpiniaceae legume family, is well recognized as the emblematic tree of the Nigerian forest. This striking, mostly deciduous tree can grow to heights of around 18 metres. Usually, propagation is accomplished by using seeds, although the process of germination might be somewhat sluggish. The leaflets, often measuring less than 12mm in length, are arranged in an opposing sequence and are embellished with numerous crimson flowers carried on long stalks. The tree produces elongated, hanging pods that initially appear green and tender during their early stages, but progressively adopt dark brown, inflexible forms as they mature. Upon reaching maturity, these pods break open, revealing long, robust seeds. *Diaphorina regia* is acknowledged for its therapeutic qualities, as it contains bioactive substances or secondary metabolites of high biological importance. The whole plant possesses intrinsic medicinal properties, since its components provide diverse therapeutic advantages. The botanical name "delonix" conjures the concept of visibility, while "regia" embodies the majestic grandeur of the tree, underscoring its splendour and significance within its ecosystem [5].

Taxonomy

Kingdom: Plantae

Class: Magnoliopsida

Order: Fabales

Family: Fabaceae

Genus: *Delonix*

Species: *regia*



Flower



Stem



c. Seeds

Fig 1. Different parts of *Delonix regia* plant

Primary plant constituents refer to fundamental nutritional components present in plants, such as common sugars, amino acids, proteins, and chlorophyll, which typically do not possess substantial therapeutic capabilities [6]. In contrast to core components, secondary metabolites have significant importance in plant defence systems and ecological interactions [7]. They are generally considered powerful agents in both traditional and modern medicine because of their wide range of bioactive qualities [8][9]. A comprehensive investigation of *D. regia* using pharmacological, phytochemical, and proximate methods has identified the existence of bioactive substances and vital minerals such as tannin, saponin, phenolics, flavonoids, reducing sugars, triterpenoids, anthraquinones, amino acids, alkaloids, sodium, potassium, calcium, phosphorus, and iron [10]. Upon conducting a comprehensive examination of the active compounds present in the acetone extracts of *D. regia* leaves, it was shown that 2-Pentanone,4-hydroxy-4-methyl-, exhibited the highest percentage peak area at 33.16%. Phytol followed closely at 29.15%, and Vitamin E at 19.79%. The chemical compounds detected in the acetone extract fraction include Vitamin E, sitosterol, azulene, naphthalene, heptadecene, nonadecane, and octadecane [11].



MATERIALS AND METHODS

Collection of Plant Material

The *seeds, leaves & bark* of *Delonix regia* were collected from a local market in Lucknow, UP, India.

Identification and Authentication of Plant Material

The plant material, *bark, leaves* and *seeds* of *Delonix regia* were identified and authenticated by Dr. Sunita Garg, Scientist, Plant Diversity, Systematics and Herbarium Division, CSIR-NIScPR, New Delhi.

Drying of Plant Material

The *seeds, leaves & bark* was dried in shade at room temperature. The dried *seeds, leaves* and *bark* of *Delonix regia* were pulverized into coarse powder and sieved through no. 23 and stored in the container.

Preparation of Extracts [12]

Extraction of Ethanolic extract of *Delonix regia* seed, leaves and bark

127g of powdered seeds, leaves and bark were extracted with 2000ml of ethanol at a temperature range of 70-80°C successively for 28 days. Isolation extract was filtered and solvent was removed using a vacuum rotary evaporator (Buchi type). After the complete extraction obtained residue was kept in desiccator.

Extraction of Hexane extract of *Delonix regia* seed, leaves and bark

100g of powdered leaves were extracted with 1500ml of hexane at a temperature range of 68-70°C successively for 15 days. Isolation extract was filtered and solvent was removed using a vacuum rotary evaporator (Buchi type). After the complete extraction obtained residue was kept in desiccator.

Extraction of Hydroalcoholic extract of *Delonix regia* seed, leaves & bark

100g of powdered seeds were extracted with 1500ml of ethanol at a temperature range of 60-70°C successively for 10 days. Isolation extract was filtered and solvent was removed using a vacuum rotary evaporator (Buchi type). After the complete extraction obtained residue was kept in desiccator.

Phytochemical screening [13][14]

➤ **Test for Carbohydrates**

Molisch's Test:

To about 2 ml extracts, few drops of α -naphthol (20% in ethyl alcohol) was added. Then about 1 ml of conc. H_2SO_4 was added along the side of test tube, reddish violet ring at junction of the two-layer appeared in the presence of carbohydrates.

Reduction of Fehling's solution:

10 ml of Fehling's solution (copper sulphate in alkaline condition) were added to conc. Extracts and heated on steam bath; brick red ppt. indicates the presence of carbohydrates.



➤ **Test for Proteins**

Biuret Test:

To 3 ml of extracts added 4% sodium hydroxide and few drop of 1% copper sulphate solution, violet or pink color appeared.

Million's Test:

Mixed 3 ml of extracts with 5 ml Million's reagent, white ppt., warm ppt. turn brick red or the ppt. dissolved to give color solution.

➤ **Test for Amino acids**

Ninhydrin Test

Heated 3 ml of extracts added 2 ml chloroform and 2 ml of conc. sulphuric acid shake well, chloroform layer appears red and acid layer showed greenish yellow fluorescence.

➤ **Test for Steroids**

Salkowski Test:

To 2 ml of extracts added 2 ml chloroform and 2 ml of conc. sulphuric acid, shake well, chloroform layer showed greenish yellow fluorescence.

Liebermann-Burchard Reaction:

The extracts evaporated to dryness and the residue was extracted with petroleum ether and acetone. The insoluble residue left after extraction were dissolved in chloroform and few drop acetic anhydride were added along with few drops of conc. sulphuric acid from the side the tube, the appearance of blue red color indicated the presence of sterols in the extract.

➤ **Test for Glycosides**

About 2 ml of extract were taken separately and subjected to the following test:

Killer-Killani Test

1ml of glacial acetic acid containing traces of ferric chloride and 1ml of conc. sulphuric acid were added to extract carefully. A reddish-brown color is formed at the junction of two layer and upper layer turn bluish green in presence of glycosides.

Legal Test:

Concentrated extract was made alkaline with few drops of 10% sodium hydroxide and then freshly prepared sodium nitroprusside was added to the solution. Presence of blue colour solution indicated the presence of glycosides.

➤ **Test for Saponins**

The extracts evaporated to dryness and the residue was extracted with petroleum ether and acetone. To insoluble residue left after the extraction, a few ml of water was added and shaken well, and the residue gave a positive foam test in the presence of saponin.



➤ **Test for Alkaloids**

About 5 ml of alcoholic extract was evaporated to dryness and alcoholic residue was treated with 5 ml of 2% hydrochloric acid, saturated with sodium chloride and filtered. The filtrate was treated as following tests:

Dragendroff's Test:

To 2-3ml filtrate, added few drops Dragendroff's reagent, orange-brown ppt. was formed.

Wagner's Test:

To 2-3 ml filtrate, added few drops Wagner's reagent, reddish-brown ppt. was formed.

➤ **Test for tannins and phenolic compounds**

Ferric Chloride Test:

A few ml. of extract was evaporated to dryness and residue was further extracted with water then ferric chloride (5%) solution was added to it, blue-green color was formed in presence of phenolic compounds.

Vanillin-HCl Test:

In few ml of extract added Vanillin-HCl reagent [Vanillin (1g.) ethanol (10ml.) and Conc. HCl (10 ml.)]. A pink or red color is formed due to formation of phloroglucinol.

➤ **Test for Flavonoids:**

Filter paper strips were dipped in the alcoholic solution of extract and ammoniated. The filter strips will turn yellow in the presence of flavonoid.

Microwave-assisted synthesis of silver nanoparticles using *Delonix regia* seed, leaves & bark extract

For the synthesis of *Delonix regia* seed, leaves, bark extract silver nanoparticle weight quantity of extract was taken in a round bottom flask and placed microwave oven that was operated at the power of 700W for 13 min. The colour change of the solution instantaneously turned the characteristic pale yellow to reddish brown, indicating the formation of silver nanoparticles.

Evaluations of microwave assisted silver nanoparticles using *Delonix regia* seed, leaves & bark extracts

▪ **UV-Visible Spectroscopy**

The synthesized silver nanoparticles were characterized by using UV-vis spectrophotometry. The peak observed at 462nm indicated the reduction of silver ions which further confirmed the formation of biosynthesized silver nanoparticles.

Preparation of Nanogel

The gel of the prepared different 6 herbal silver nanogel was formulated by dispersing a gel-forming agent, namely hydroxypropyl methylcellulose (HPMC) K15, Carbopol 940, which had been soaked in hot water for a duration of 24 hours. Subsequently, the leaves/bark/seeds extract of *Delonix regia* silver nanoparticles separately were added to the solution while

ensuring uniform stirring through the utilization of a high-speed homogenizer operating at speeds ranging from 7000 to 10000 revolutions per minute. The pH of the solution was modified to 7.0 by employing triethanolamine to create the gel. The resulting gel, involving silver nanoparticles was thereafter kept at ambient temperature [15][16]. Below table presents list the excipients utilized in the formulation.

Table 1. Composition for the development of nanogel from silver nanoparticles

Composition	Hydroalcoholic extract			Ethanollic Extract			Hexane Extract		
	Leaves	Bark	Seeds	Leaves	Bark	Seeds	Leaves	Bark	Seeds
<i>Delonix Regia</i> (ml)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
HPMC K15 (g)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Carbopol 940 (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Polyethylene glycol (ml)	10	10	10	10	10	10	10	10	10
Triethanolamine (ml)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Propyl paraben (g)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Methyl paraben (g)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Water (ml)	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s

Characterization of silver nanogel

Physical appearance

All types were estimated for their physical appearance i.e., transparency, homogenous/heterogenous, white or turbidity. Homogenous nanogel is the sign of better formulation of nanogel.

Droplet size & Polydispersity index (PDI)

Zetasizer Nano-ZS was used to measure the average globule size of the nanogel (Malvern Instrument, UK). Measurements were taken at a 90-degree angle at 25°C. To make sure the light scattering intensity was within the instrument sensitivity range, twice distilled water was



used to dilute the nanogel. All measurements were made at 25°C. The same instrument was used to calculate the formulation's polydispersity index. The polydispersity index revealed the width of the size distribution [17].

SEM analysis

A scanning electron microscope was used to analyze the nanogel's surface morphology [18]. After drying on a brass stub, the films were vacuum-coated with a thin layer of 150Å gold to make them electrically conductive. The images were captured with a 20 kV excitation voltage.

Evaluation of anti-microbial activity

The inhibition of microbial growth under standardized conditions may be utilized for demonstrating the curative effect of the chemotherapeutic agent. Any subtle change in the molecule which may not be detected by chemical methods will be revealed by a change in the microbial activity and hence antimicrobial assays are very useful for resolving doubts regarding a possible change in the potency of antimicrobial agents. Modern medicines are dependent on chemotherapeutic agents, chemical agents that are used to treat diseases. Some idea of the effectiveness of chemotherapeutic agents against a pathogen can be obtained from the minimal inhibitory concentration (MIC).

Test organisms

Six microorganisms *Bacillus subtilis* (MTCC 441), *Escherichia coli* (MTCC 1573), *Pseudomonas aeruginosa* (MTCC 424), were procured from the Institute of Microbial Technology (IMTECH), Chandigarh, India.

Preparation of inoculums

Loopful of microorganisms were transferred aseptically to the sterile test tubes containing 10 mL of nutrient broth and then incubated for 48 to 72 hrs at 37°C.

Preparation of test samples and standard drug

The 1000µg/mL stock solutions of the silver nanogel were prepared individually by dissolving 10 mg of silver nanogel in ethanolic, hydroalcoholic & Hexane. 1 mL of stock solution was transferred into volumetric flask and further diluted upto 10 mL with the same solvent. Similarly, concentrations like 20, 40, 60, 80 and 100µg/mL were prepared respectively. Norfloxacin and Ciprofloxacin were used as standard.

Table 2. Growth media, Incubation temperature and pH range for the microbial strains

S. no.	Strains	Growth media composition		Incubation temperature (°C)	pH
		Ingredients	Quantity (g)		
1.	<i>B. subtilis</i>	Beef extract Peptone	1	30	6.8-7.0
2.	<i>E. coli</i>	Sodium chloride Agar	1	37	
3.	<i>P. aeruginosa</i>	Distilled water	0.5	37	
			2.0	37	
			100 mL		

Determination of Zone of Inhibition of the silver nanogel using cup plate method

The minimum zone of inhibition of all the silver nanogel was determined against three microbial strains by cup plate method using nutrient agar medium. Measured volume of the microbial inoculums was poured into the sterilized agar media (cooled at 40-50°C) and swirled properly under Laminar Air Flow bench in aseptic conditions. 25mL of inoculum was poured aseptically in the sterilized petri plates and kept aside for the solidification. The cavities were prepared using sterilized steel cork borer on solidified media and filled with solution of silver nanogel and standard separately using separate micropipettes. Inoculated plates were kept at room temperature for 2 hrs to allow for diffusion, and then incubated for 72 hrs. at 37°C. The zone of inhibition was measured and calculated MIC value [19].

RESULTS AND DISCUSSION

Phytochemical screening

On preliminary observation the phytochemicals i.e., tannins, flavonoids and phenols were found in abundance in the hydroalcoholic leaves extract of *Delonix regia*. While, saponins, alkaloids, quinones, terpenoids, steroids, carotene, coumarins and betacyanin were found in moderate amount. However, the ethanolic bark extract showed quinones, terpenoids, phenols, flavonoids and Cardenolides in abundance. Bark extract also showed the presence of Pholobatanin. Hexane *D. regia* seeds extract demonstrated very poor phytochemicals when observed, it showed saponins, phenols and tannins.

Table 3. Phytochemical screening of the different parts *Delonix regia*

Phytochemical	<i>Delonix regia</i>								
	Hydroalcoholic extract			Ethanolic Extract			Hexane Extract		
	Leaves	Bark	Seeds	Leaves	Bark	Seeds	Leaves	Bark	Seeds
Saponins	+	+	+	+	-	+	+	-	+
Alkaloids	+	-	+	+	+	+	-	+	-
Tannins	+	-	-	+	+	-	-	-	+
Quinones	-	-	-	+	++	-	-	-	-
Terpenoids	+	+	-	+	++	+	+	+	+
Steroids	+	+	-	+	+	-	+	-	-
Flavonoids	++	+	+	+	++	+	+	+	+
Phenols	++	+	-	+	++	-	-	-	+
Glycosides	-	-	+	-	-	+	-	+	-
Cardiac glycosides	-	-	-	+	-	-	+	+	-
Coumarins	+	-	+	+	+	-	-	-	+
Anthocyanin	-	-	-	-	+	-	-	-	+
Betacyanin	+	-	-	+	+	-	+	-	-
Cardenolides	-	-	-	-	++	-	-	-	-
Pholobatanin	-	-	-	-	+	-	-	-	-

(+) = moderate presence, (++) abundant presence, (-) = absent

Table 4: UV-Visible Spectroscopy of silver nanoparticles using *Delonix Regia* leaves ethanolic extracts

S. No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.108
3	4	0.231
4	6	0.329
5	8	0.421
6	10	0.521

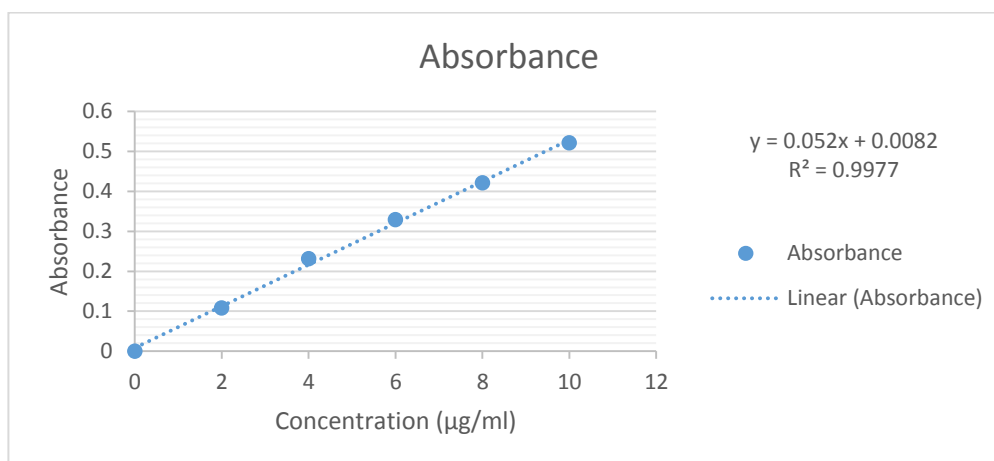


Fig 2: UV-Visible Spectroscopy of silver nanoparticles using *Delonix Regia* leaves ethanolic extracts

Table 5: UV-Visible Spectroscopy of silver nanoparticles using *Delonix Regia* bark ethanolic extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.084

3	4	0.149
4	6	0.223
5	8	0.286
6	10	0.346

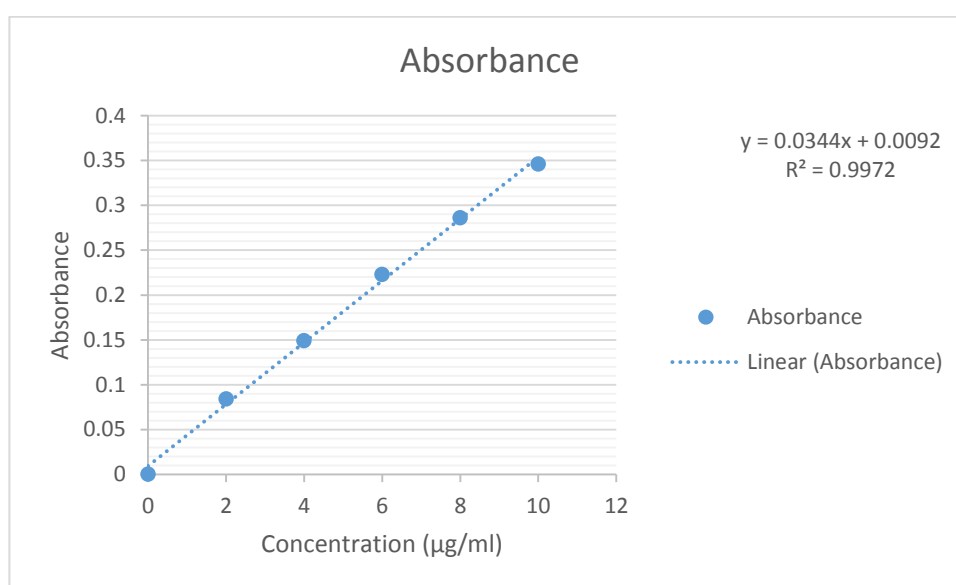


Fig 3: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia bark ethanolic extracts

Table 6: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia seed ethanolic extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.091
3	4	0.165
4	6	0.253
5	8	0.341
6	10	0.411

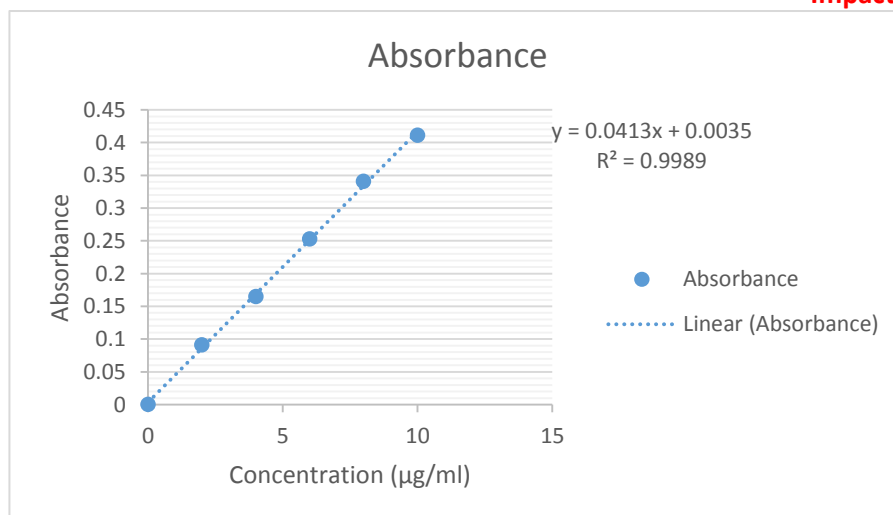


Fig 4: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia seed ethanolic extracts

Table 7: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia leaves Hydroalcoholic extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.154
3	4	0.250
4	6	0.352
5	8	0.414
6	10	0.513

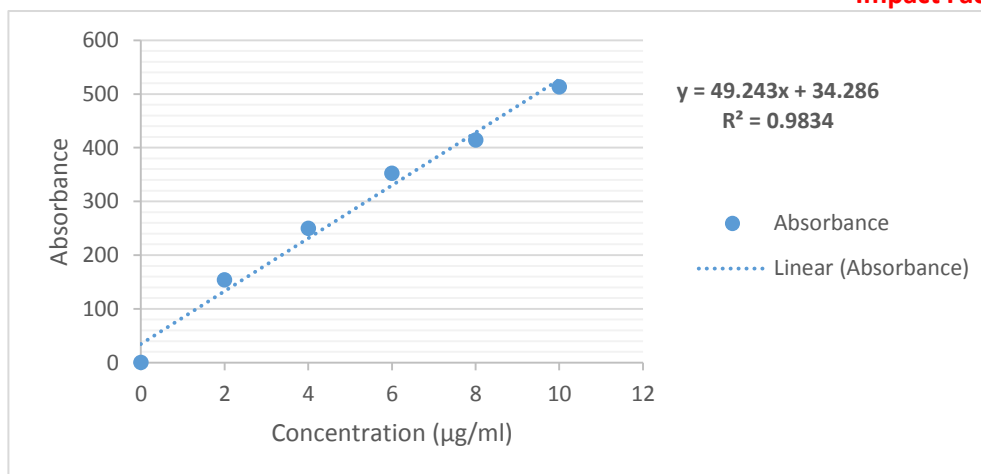


Fig 5: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia leaves Hydroalcoholic extracts

Table 8: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia seed Hydroalcoholic extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.111
3	4	0.223
4	6	0.341
5	8	0.411
6	10	0.513

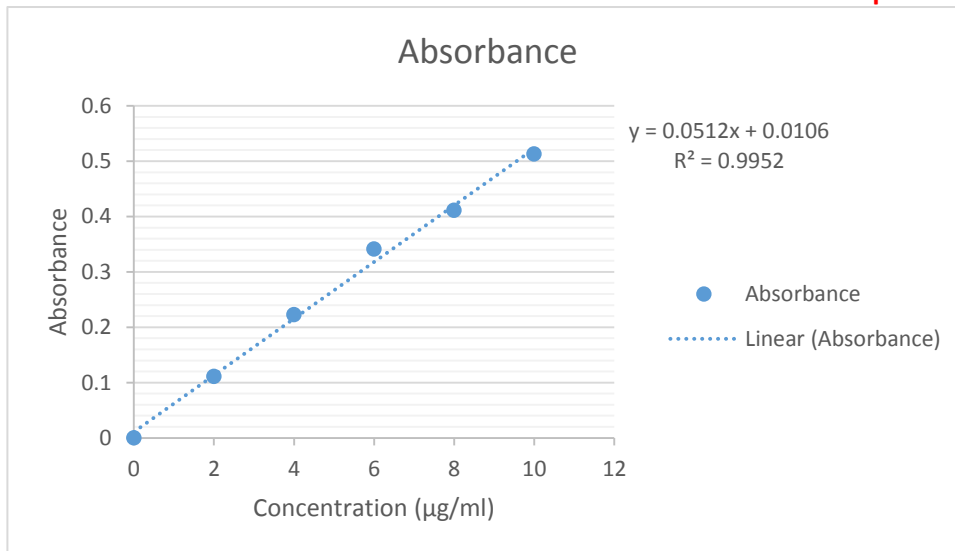


Fig 6: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia seed Hydroalcoholic extracts

Table 9: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia bark Hydroalcoholic extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.124
3	4	0.233
4	6	0.361
5	8	0.522
6	10	0.614

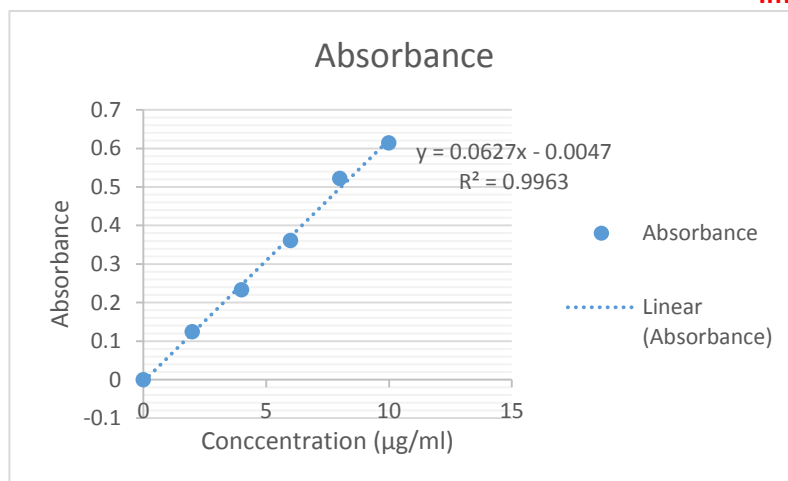


Fig 7: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia bark Hydroalcoholic extracts

Table 10: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia leaves Hexane extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.000
2	2	0.125
3	4	0.259
4	6	0.359
5	8	0.464
6	10	0.553

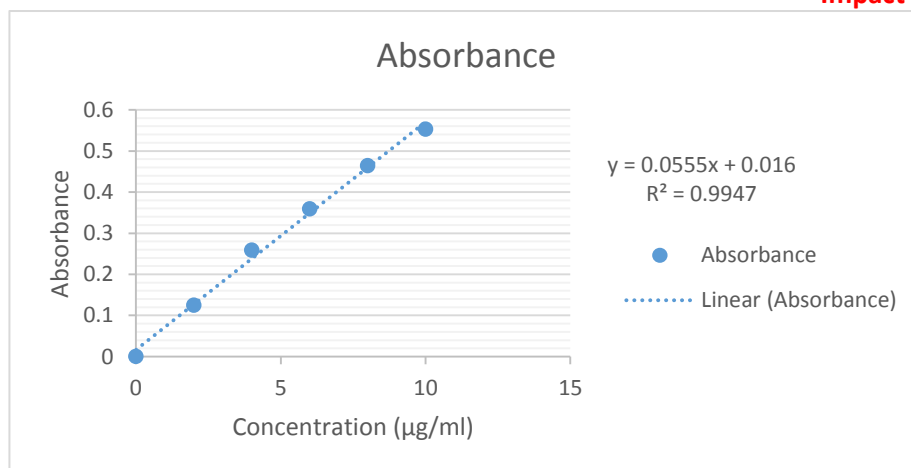


Fig 8: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia leaves Hexane extracts

Table 11: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia seed Hexane extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.101
3	4	0.222
4	6	0.332
5	8	0.421
6	10	0.501

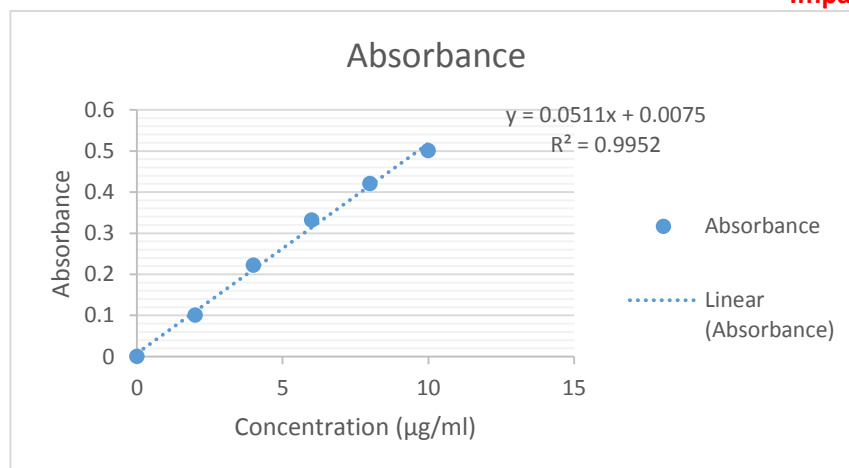


Fig 9: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia seed Hexane extracts

Table 12: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia bark Hexane extracts

S.No.	Concentration (µg/mL)	Absorbance
1	0	0.00
2	2	0.122
3	4	0.245
4	6	0.351
5	8	0.414
6	10	0.511

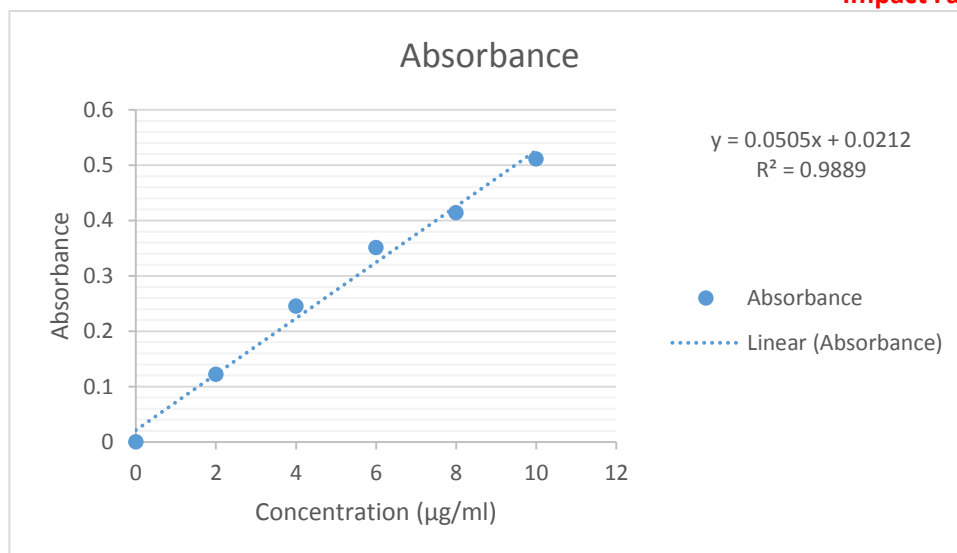


Fig 10: UV-Visible Spectroscopy of silver nanoparticles using Delonix Regia bark Hexane extracts

Characterization parameters

Physical appearance

Table 13. Physical appearance of silver nanoparticles

Silver nanoparticles		Appearance
Ethanolic extract of <i>D. regia</i>	Leaves	Dark greenish, homogenous
	Seed	Brownish, homogenous
	Bark	Brownish, homogenous
Hexane extract of <i>D. regia</i>	Leaves	Dark greenish, homogenous
	Seed	Brownish, homogenous
	Bark	Brownish, homogenous
Hydroalcoholic extract of <i>D. regia</i>	Leaves	Dark greenish, homogenous
	Seed	Brownish, homogenous
	Bark	Brownish, homogenous

Determination of particle size, PDI and zeta potential

In ethanolic extract of *Delonix regia* leaves, seed and bark the particle size was observed as 167.6nm, 163.6nm and 121.5nm respectively. However, PDI was estimated as 0.232, 0.280

and 0.249 in ethanolic extract of *Delonix regia* leaves, seed and bark respectively. Therefore, the lesser particles size was observed in *Delonix regia* ethanolic leaves extract.

Table 14. Ethanolic extract of *Delonix Regia* seed, leaves and bark

Synthesis of Silver nanoparticle	Particle size (nm)	Zeta potential (mv)	PDI
Laves	167.6	-26.9	0.232
Seed	163.6	-27.5	0.280
Bark	121.5	-39.7	0.249

Table 15. Hexane extract of *Delonix Regia* seed, leaves and bark

Synthesis of Silver nanoparticle	Particle size (nm)	Zeta potential (mv)	PDI
Leaves	122.2	-41.7	0.258
Seed	123.4	-38.7	0.267
Bark	121.8	-38.6	0.260

Table 16. Hydroalcoholic extract of *Delonix Regia* seed, leaves and bark

Synthesis of Silver nanoparticle	Particle size (nm)	Zeta potential (mv)	PDI
Leaves	121.5	-38.6	0.249
Seed	121.8	-38.7	0.260
Bark	123.4	-41.7	0.267

SEM Analysis

In SEM analysis, pictures demonstrated the droplet size of the silver nanogels of *Delonix regia* leaves, seed and bark.

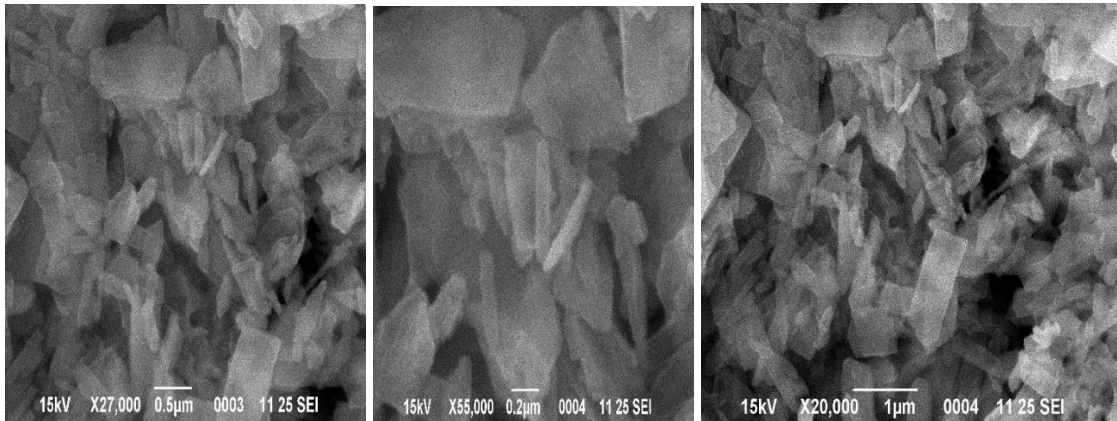


Fig 11: Ethanolic extract of *Delonix Regia* Leaves, Seed & Bark

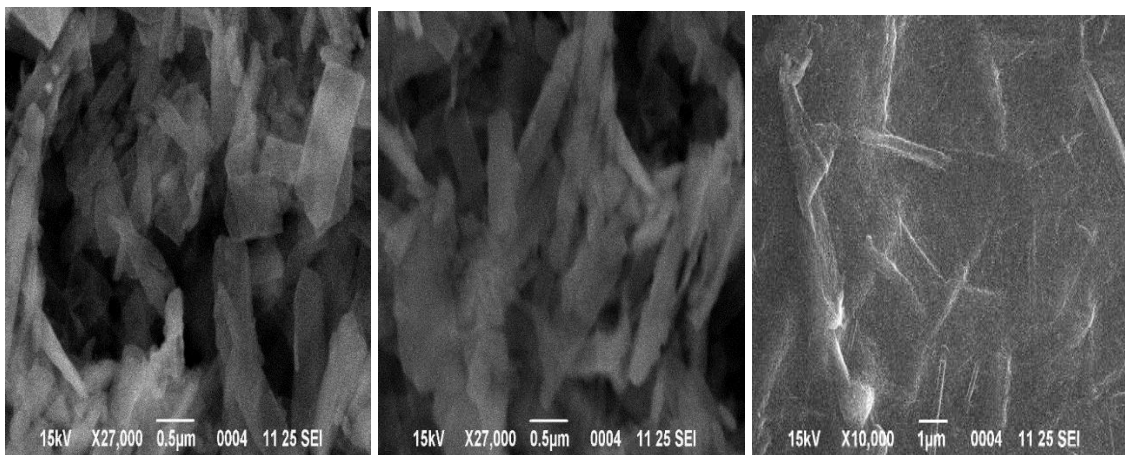


Fig 12: Hexane extract of *Delonix Regia* leaves, seed & bark

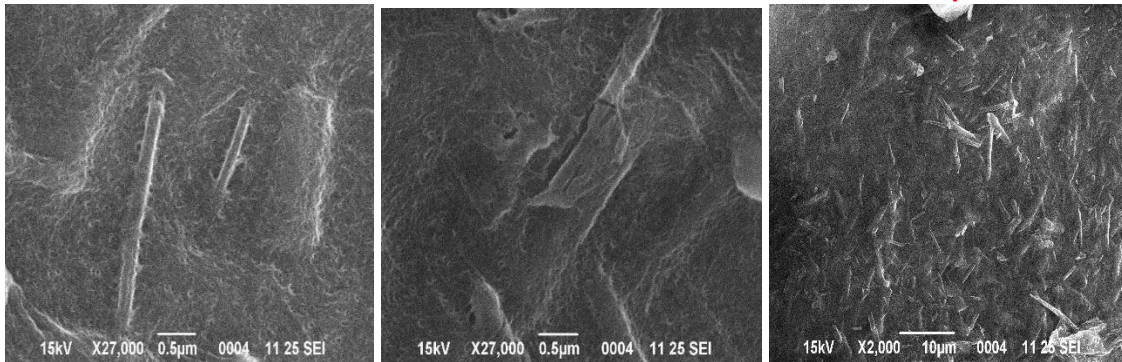


Fig 13: Hydroalcoholic extract of Delonix regia leaves, seed, & bark

Droplet size (nm) estimation of silver nanogel

Table 17. Ethanolic extract of *Delonix Regia* seed, leaves and bark

Development of silver nanogel	Particle size (nm)	PDI
Laves	512.2	0.306
Seed	417.9	0.277
Bark	567.2	0.674

Table 18. Hexane extract of *Delonix Regia* seed, leaves and bark

Development of silver nanogel	Particle size (nm)	PDI
Leaves	534.5	0.655
Seed	438.6	0.297
Bark	648.2	0.392

Table 19. Hydroalcoholic extract of *Delonix Regia* seed, leaves and bark

Development of silver nanogel	Particle size (nm)	PDI
Leaves	496.0	0.323
Seed	431.5	0.578
Bark	720.5	0.538

Table 20. Zone of inhibition (diameter) of silver nanogel against microbial strains by cup plate method

S.No	Test sample	Conc. (µg/ml)	Diameter of zone of inhibition (mm)		
			<i>B. Subtilis</i>	<i>E. coli</i>	<i>P. Aeruginosa</i>
10	Silver nanogel of <i>Delonix Regia</i> Seed (Ethanolic extract)	20	-	-	-
		40	-	-	-
		60	07	-	-
		80	09	07	-
		100	10	09	10
11.	Silver nanogel of <i>Delonix regia</i> leaves (Ethanolic extract)	20	-	-	-
		40	-	-	-
		60	-	-	-
		80	07	-	-
		100	09	10	10
12.	Silver nanogel of <i>Delonix Regia</i> Bark (Ethanolic extract)	20	-	-	-
		40	-	-	-
		60	07	-	-
		80	09	08	08
		100	10	10	09
13.	Silver nanogel of <i>Delonix regia</i> Seed (Hexane extract)	20	-	-	-
		40	-	-	-
		60	-	-	-
		80	08	08	07
		100	09	10	10
14.	Silver nanogel of <i>Delonix regia</i> Leaves (Hexane extract)	20	-	-	-
		40	-	-	-
		60	-	-	-
		80	07	07	07
		100	10	09	10
15.	Silver nanogel of <i>Delonix regia</i> Bark (Hexane extract)	20	-	-	-
		40	-	-	-
		60	-	-	-
		80	08	07	-
		100	09	09	10

16.	Silver nanogel of <i>Delonix regia</i> Seed (Hydroalcoholic extract)	20	-	-	-
		40	-	-	-
		60	-	-	-
		80	09	08	08
		100	10	10	10
17.	Silver nanogel of <i>Delonix regia</i> Leaves (Hydroalcoholic extract)	20	-	-	-
		40	-	-	-
		60	-	-	-
		80	08	07	08
		100	10	10	10
18.	Silver nanogel of <i>Delonix regia</i> Bark (Hydroalcoholic extract)	20	-	-	-
		40	-	-	-
		60	-	-	-
		80	09	09	07
		100	10	09	09
11	Norfloxacin	20	14	08	10
		40	16	10	12
		60	20	11	13
		80	22	13	15
		100	26	15	16
12	Ciprofloxacin	20	12	09	10
		40	15	14	13
		60	17	16	15
		80	20	21	19
		100	22	23	21
13	Control (Blank)	-	-	-	-

Diameter of the cork borer is 5mm.

CONCLUSION

From the antimicrobial potential of silver nanogels it can be concluded that, silver nanogel namely Silver nanogel of *Delonix regia seed, bark (Ethanol extract)*, Silver nanogel of *Delonix regia seed, leaves, bark (Hexane extract)*, Silver nanogel of *Delonix regia leaves, seed & bark (Hydroalcoholic extract)*, showed good antimicrobial activity against microbial strain.



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