FINAL PROJECT REPORT

(July 2011 to June 2014)

UGC sponsored major research project

"DEVELOPMENT OF SILVER BASED POLYMERIC MATRIX NANOCOMPOSITE"

UGC Reference code no – F NO. 40-463/2011 (SR)

DEPARTMENT OF MATERIALS SCIENCE

SARDAR PATEL UNIVERSITY

VALLABH VIDYANAGAR-388120

Sardar Patel University

Annexure -III

Final Report of the work done on the Major Research Project

1)	Project report No.	**Final**
2)	UGC Reference No.	**F-40-463/2011 (SR)**
3)	Period of report:	**1-7-2011 to 30-6-2014**
4)	Title of research project:	**Development of silver based polymeric matrix nanocomposite**
5)	(a) Name of the Principal Investigator:	**Prof. L. M. Manocha**
	(b) Deptt. and University/College	**Department of Materials Science, Sardar Patel University, Vallabh Vidyanagar-388 120**
6)	Effective date of starting of the project:	**1-7-2011**

7) Grant approved and expenditure incurred during the period of the report:

a)	Total amount approved	**Rs. 8,50,800/-**
b)	Expenditure during 2011-14	**Rs. 5,86,800/-**
c)	Total expenditure (2011-14)	**Rs. 5,86,800/-**
d)	Report of the work done	**Appendix I**

A) Brief objective of the project

i. Development of functionalized silver nanoparticles through sol-gel route,

ii. Study on effect of processing parameter on particles size and functionality,

iii. Development of silver nanoparticles and their characterization like dispersity of silver particles, concentration, permeability of composite, dissolution of polymer film,

iv. Study of the nanocomposite for antimicrobial activity

B) Work done so far and results achieved and publications : **Appendix II**

C) Has the progress been according to original plan of work and towards achieving the objective. if not, state reasons : **Yes, the progress of the project has been as per the original plan of the work**

D) Please indicate the difficulties, if any, experienced in implementing the project: **There is no difficulty experienced in implementing the project.**

E) If project has not been completed, please indicate the approximate time by which it is likely to be completed. A summary of the work done for the period (Annual basis) may please be sent to the Commission on a separate sheet

-------Not Applicable-------

F) If the project has been completed, please enclose a summary of the findings of the study. Two bound copies of the final report of work done may also be sent to the Commission

-------Not Applicable-------

G) Any other information which would help in evaluation of work done on the project. At the completion of the project, the first report should indicate the output, such as

(a) Manpower trained	:One project fellow appointed
(b) Ph. D. awarded	Mr. Nitin Lohar (Not yet completed)
(c) Publication of results	: Development and characterization of PVA-chitosan-silver nanocomposite film, S. Manocha, Nitin Lohar, L.M.Manocha, XXVI Gujarat Science Congress, 26th Feb 2012
(d) other impact, if any	**Training of M.Sc. students:** Topic: Development of silver based polymeric matrix nanocomposite By Dhaval Rathava and Priyank Kachhiya 2012-2013, Year 2010-11: Bhavesh Pipaliya, Darshana Patel and Kinjal Patel Year 2008-09: Sumitha Niar

SIGNATURE OF THE PRINCIPAL INVESTIGATOR

REGISTRAR/PRINCIPAL

Registrar
Sardar Patel University
Vallabh Vidyanagar

SARDAR PATEL UNIVERSITY V. V. NAGAR

Sardar Patel University

Annexure - V

STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR RESEARCH PROJECT

1. Name of Principal Investigator: **Prof. L. M. Manocha**

2. Deptt. of University/College: **Department of Materials Science, Sardar Patel University, Vallabh Vidyanagar-388 120**

3. UGC approval No. and Date: **F - 40 – 463/2011 (SR) & 1-7-2011**

4. Title of the Research Project: **"Development of silver based polymeric matrix nanocomposite"**

5. Effective date of starting the project: **1-7-2011**

6. a. Period of Expenditure: **1-7-2011 to 30-6-2014**
   b. Details of Expenditure

S.No.	Item	Amount Approved Rs.	Expenditure Incurred during 2012-13 Rs.
i.	Books & Journals	75,000/-	40,543/-
ii.	Equipment	2,00,000/-	25,804/-
iii.	Contingency	60,000/-	22,042/-
iv.	Field Work/Travel	50,000/-	39,163/-
v.	Hiring Services	30,000/-	24,049/-
vi.	Chemicals & Glassware	1,00,000/-	99,399/-
vii.	Overhead	47,800/-	47,800/-
viii.	Any other items (Please specify)		
ix.	Honorarium to principle investigator		
x.	Staff (project fellow) from 1st November 2011	2,88,000/-	2,88,000/-
Total		**8,50,800/-**	**5,86,800-**

c . Staff : One project fellow

Date of Appointment: 01-02-2013

S.No.	Expenditure Incurred	From to	Amount Approved (Rs.)	Expenditure Incurred(Rs.)
1.	Honorarium to PI (Retired Teachers) Rs.12,000/- p.m.	Nil	Nil	Nil
2.	Post-Doctoral Fellow Fellowship @ Rs. 12,000/- p.m.	Nil	Nil	Nil
3.	Project Associate salary @ Rs.10,000/- p.m.	Nil	Nil	Nil
4.	Project Fellow salary @ Rs.14000/- p.m.	March -2013 to May-2014	2,88,000/-	2,88,000/-

1. It is certified that the appointment(s) have been made in accordance with the terms and conditions laid down by the Commission.

2. It as a result of check or audit objective, some irregularly is noticed, later date, action will be taken to refund, adjust or regularize the objected amounts.

3. Payment @ revised rates shall be made with arrears on the availability of additional funds.

4. It is certified that the grant of **Rs. 5,86,800/-** (Rupees five lakh eighty six thousand eight hundred rupees only) received from the University Grants Commission under the scheme of support for Major Research Project **"Development of silver based polymeric matrix nanocomposite"** vide UGC letter No. **F-40–463/2011 (SR)** dated **1-7-2011**and **5,86,800/-** (Rupees five lakh eighty six thousand eight hundred rupees only) has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission.

SIGNATURE OF PRINCIPAL INVESTIGATOR

REGISTRAR/PRINCIPAL

I/c Registrar
Sardar Patel University
Vallabh Vidyanagar

SARDAR PATEL UNIVERSITY V. V. NAGAR

Sardar Patel University

Annexure - VI

STATEMENT OF EXPENDITURE INCURRED ON FIELD WORK

Name of the Principal Investigator: Prof. L. M. Manocha

Name of the Place visited	Duration of the Visit		Mode of Journey	Expenditure Incurred (Rs.)
	From	To		
Delhi	19-01-2014	27-01-2014	By Air, By Train and By Car	9,549/-

Name of the Project fellow: Mr. Hasmukh L. Gajera

Name of the Place visited	Duration of the Visit		Mode of Journey	Expenditure Incurred (Rs.)
	From	To		
Jammu University, Jammu	1-2-2014	10-2-2014	By Train	3,012/-

Certified that the above expenditure is in accordance with the UGC norms for Major Research Projects

SIGNATURE OF PRINCIPAL INVESTIGATOR

I/c. Registrar
Sardar Patel University
Vallabh Vidyanagar

REGISTRAR/PRINCIPAL

SARDAR PATEL UNIVERSITY V. V. NAGAR

23236351, 23232701, 23237721, 23234116

23235733, 23232317, 23236735, 23239437

विश्वविद्यालय अनुदान आयोग
बहादुरशाह जफर मार्ग
नई दिल्ली-110 002
UNIVERSITY GRANTS COMMISSION
BAHADURSHAH ZAFAR MARG
NEW DELHI-110 002

Annexure-IX

PROFORMA FOR SUPPLYING THE INFORMATION IN RESPECT OF THE STAFF APPOINTED UNDER THE SCHEME OF MAJOR RESEARCH PROJECT

UGC FILE NO. F – 40-463/2011 **(SR)** **YEAR OF COMMENCEMENT** 01072011

TITLE OF THE PROJECT: "Development of silver based polymeric matrix nanocomposite."

1.	**Name of the Principal Investigator**	Prof./Dr. L. M. Manocha				
2.	**Name of the University/College**	G.H.Patel Institute of Materials Science, Sardar Patel University, Vallabh Vidyanagar-388 120.				
3.	**Name of the Research Personnel appointed**	Nitinkumar Lohar				
4.	**Academic qualification**	S.No.	Qualification	Year	Marks	% age
		1.	M.A./**M.Sc.**/M. Tech.	April 2011	--	62
		2.	M.Phil	--	--	--
		3.	Ph.D	--	--	--
5.	**Date of Joining**	4-11-2012				
6.	**Date of Birth of Research Personnel**	5-7-1986				
7.	**Amount of HRA, if drawn**	--				
8.	**Number of Candidate applied for the post**	4				

CERTIFICATE

This is to certify that all the rules and regulations of UGC Major Research Project outlined in the guidelines have been followed. Any lapse on the University will liable to terminate of said UGC project.

Principal Investigator

Head of the Deptt.

13/6/14

Prof. L. M. Manocha
Head
Department of Materials Science
Sardar Patel University
Vallabh Vidyanagar-388 120.

Registrar / Principal

I/c. Registrar
Sardar Patel University
Vallabh Vidyanagar

SARDAR PATEL UNIVERSITY V. V. NAGAR

9/6/14

23236351, 23232701, 23237721, 23234116

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Annexure-IX

PROFORMA FOR SUPPLYING THE INFORMATION IN RESPECT OF THE STAFF APPOINTED UNDER THE SCHEME OF MAJOR RESEARCH PROJECT

UGC FILE NO. F – 40-463/2011 (SR) **YEAR OF COMMENCEMENT** 01072011

TITLE OF THE PROJECT: "Development of silver based polymeric matrix nanocomposite."

1.	**Name of the Principal Investigator**	Prof./Dr. L. M. Manocha				
2.	**Name of the University/College**	G.H.Patel Institute of Materials Science, Sardar Patel University, Vallabh Vidyanagar-388 120.				
3.	**Name of the Research Personnel appointed**	Hasmukh L. Gajera				
4.	**Academic qualification**	S.No.	Qualification	Year	Marks	% age
		1.	M.A./**M.Sc.**/M. Tech.	April 2010	--	71
		2.	M.Phil	--	--	--
		3.	Ph.D	--	--	--
5.	**Date of Joining**	01-02-2013				
6.	**Date of Birth of Research Personnel**	22-9-1986				
7.	**Amount of HRA, if drawn**	--				
8.	**Number of Candidate applied for the post**	3				

CERTIFICATE

This is to certify that all the rules and regulations of UGC Major Research Project outlined in the guidelines have been followed. Any lapse on the University will liable to terminate of said UGC project.

Principal Investigator

13/6/13

Head of the Deptt.

Prof. L. M. Manocha
Head
Department of Materials Science
Sardar Patel University
Vallabh Vidyanagar-388 120.

I/c. Registrar

Registrar / Principal

Sardar Patel University
Vallabh Vidyanagar

SARDAR PATEL UNIVERSITY V. V. NAGAR

Appendex II

Yes,

1. **"Development and characterization of PVA-chitosan-silver nanocomposite film"**
   S. Manocha, Nitin Lohar and L.M.Manocha, presented at XXVI Gujarat Science Congress, 26th Feb 2012

2. **"Synthesis of silver nanoparticles-PVA film for wound healing"**
   L. M. Manocha, H. L. Gajera, B. Pipaliya, D. Patel, K, Patel and S. Manocha (In communication)

Appendix I

INTRODUCTION AND LITERATURE SURVEY

Nanoscale materials have unique chemical, biological and physical properties compared to their macro scaled counterparts. Synthesis of noble metal nanoparticles for applications such as catalysis, medicine, environment and biotechnology is an area of constant interest (*Schmid et al* 1992, *Pileni et al* 2002)

***Singh et al* (2008)** proposed that silver nanoparticles have several important characteristics make them candidate for application in medicine as antimicrobial agent. Antimicrobial agents are compound having properties to kill microbes (microbicidal) or reduce the rate of microbial growth (microbistatic). There are various natural compound (antibiotic, inorganic substance) having antimicrobial properties. However, among them silver ion have strong and broad spectrum of antimicrobial activity. Different studies suggesting that inhibitory effect of silver ion is because of its interaction with SH groups of proteins and play important role in inhibition of bacterial cell.

***Dallas et al* (2011)** reported that silver ion uncouple respiratory electron transport from oxidative phosphorylation, which inhibits respiratory chain enzymes or interferes with membrane permeability to protons and phosphate. Silver is also widely known as a catalyst for the oxidation of methanol to formaldehyde and ethylene to ethylene oxide. Silver nanoparticles can be prepared and stabilized by physical methods, biological methods and chemical methods.

***Asta Sileikaite* et al (2006)** was given the chemical approach, such as chemical reduction of silver ion with the help of reducing agent such sodium borohydrate, trisodium citrate, Starch, glucose, Maltose. The size, morphology, stability, and properties (chemical and physical) of silver nanocomposite are strongly influenced by the experimental conditions, the kinetics of interaction of reducing agent with silver nanoparticles.

***S. Anil Kumar* et al (2007)** were giving the biological method includes the extracts from bio-organisms may act both as reducing and capping agents in Ag NPs synthesis. The reduction of Ag+ ions by combinations of biomolecules found in these extracts such as enzymes/proteins, amino acids, polysaccharides, and vitamins is environmentally benign, yet chemically complex. An extensive volume of literature reports successful Ag NP

synthesis using bioorganic compounds. For example *Mahdi Mohseniazare et al* (2011) were synthesized silver nanoplates at room temperature using the extract of unicellular green algae *Chlorella vulgaris*.

Virender K. Sharma et al (2008) was shown that proteins in the extract provide dual function of Ag+ reduction and shape-control in the nanosilver synthesis. The carboxyl groups in aspartic and/or glutamine residues and the hydroxyl groups in tyrosine residues of the proteins were suggested to be responsible for the Ag+ ion reduction. Carrying out the reduction process by a simple biofunctional tripeptide Asp-Asp-Tyr-OMe further identified the involvement of these residues. This synthesis process gave small Ag nanoplates with low polydispersity in good yield (N55%). Physical methods of silver nanoparticles involving use of physical agent such as ultraviolet radiation, Gamma radiation.

***Varaprasad et al (*2009)** were developed silver based nanocomposites using hydrogel. Silver-polymer nanocomposite with dispersed silver nanoparticles could be most effective antimicrobial material due to its ability to controlled release of silver ion from silver nanocomposite over the period of time. *Z. H. Mbhele* et al (2003) were developing silver PVA nanocomposite film. PVA (Polyvinyl alcohol) having excellent biological properties such as wound dressing, bioreactor property, non toxic, steric stability, biocompatible, permeable to air and controlled, release of silver nanoparticles.

***Vimala* et al (2011)** were developed PVA- chitosan co-polymer film loaded with silver nanoparticles. Chitosan is polymer composed of poly (β-(1, 4)-2-amino-2-deoxy-glucose. However, it is obtained by the deacetylation of natural biopolymer chitin found in shell of crustaceous and cell wall of fungi. Deacetylation of chitin into chitosan is done by either of treatment of enzyme chitin deacetylase or concentrated NaOH (Alkaline condition). The excellent properties like biocompatibility, non-toxicity, biodegradability, anti-inflammatory, antibacterial, antifungal, make them suitable candidate for biomedical application of wound healing, tissue engineering and drug delivery. Antimicrobial activity of silver nanoparticles is enhancing by chitosan because of its interaction with cell wall, DNA and protein.

***Bokgi Son* et al (2008)** determine MIC (minimum inhibitory concentration) is least amount of silver nanoparticles require to kill microbial cell could be determine using

various model bacterial strain (*E.coli, S. aureus, S. typhi*) and fungal strain (C. albican, A. niger) for in vitro study of effectiveness of silver nanoparticles.

***Haijun Yu* et. al. (2007)** worked on synthesis of PVA/PVA hydrogel containing Ag nanoparticles by repeated freezing-thawing treatment which gives antibacterial effect of hydrogels against E.coli. and S. aureus. The size of Ag nanoparticles is 20-100nm.

***K. Madhumathi* et al (2011)** were studied biological activity such as cytotoxicity test and apatite forming ability of silver core shell particles loaded biopolymer nanocomposite film to confirm its biocompatibility and bone tissue engineering ability respectively. The characterizations of Silver PVA- chitosan nanocomposite film could be done by TGA (Thermo gravimetric analysis), FTIR (Fourier Transform infrared spectroscopy), XRD (X-Ray diffraction), and TEM (Transmission Electron Microscopy) and SEM (Scanning Electron Microscopy).

***T. N. V. K. V. Prasad* et. al. (2010)** worked on synthesisand antibacterial activity of Ag nanoparticles using leaves of Euphorbia Hirta results in antibacterial effect of hydrogels against B.cereus and S.aureus.

***Tsermaa Galya* et. al. (2008)** reported that the preparation and characterization of the structure, mechanical, thermal and antibacterial properties of polymer film based on PVA and silver nitrate. They investigated polymer nanocomposites containing silver nanoparticles with PVA demonstrated strong antibacterial activity against E. coli and S. aureus starting from the lowest level of addition of silver nitrate and increasing with the modifier contant.

***Shuxia Liu* et. al. (2009)** synthesized Ag nanoparticles loaded PVA film. There transparent Ag-PVA film containing Ag nanoparticles with size of 5-20 nm. These nanocomposite film showed excellent antimicrobial performance toward bacteria suck as E. coli.

***K. Varaprasad* et. al (2010)** fabricated hydrogel-silver nanoparticles nanocomposites and those can be directly used for antibacterial and wound dressing application. The size of the silver nanoparticles was regulated to 2-3 nm by PVA chains available throughout the hydro gel at all the cross linker concentrations.

PROGRESS MADE

Based on literature survey Silver nanoparticles has been prepared by using different chemical reduction methods

- Reduction and capping of silver ion by Trisodium citrate
- Reduction of silver ion by Sodium borohydrate and its capping with Trisodium citrate
- Reduction of silver ion by D-Glucose and its capping with PVP (Poly vinyl pyrollidone)

The prepared silver sol with different reducing agents was characterized by using UV-VIS spectrophotometer:-

PVP (Poly vinyl pyrollidone) was used as capping agent. Absorbance peak at 400 nm indicates silver nanoparticles formation.

- Define molarities of Glucose, PVP and Silver nitrate solution was prepared and heated at 60◦C.
- Define molarities of silver nitrate and Trisodium citrate was mixed and kept at 4◦ C followed by addition of Sodium borohydrate.
- Mixture was heated at 70◦ C and UV-VIS Spectra were taken at different time interval.
- Silver nanoparticles was getting aggregated after 7 hour continues heating at 70° C

Preparation of silver sol with different reducing agent:-

- 0.002 M AgNO3 aqueous solution was prepared at 80°C in the reflux condition for 30 min. the hydrolysis of AgNO3 solution was carried out by using this technique and Ag+ ions are produced in the solution.
- After 0.02 M of trisodium citrate was added drop by drop into the aqueous AgNO3 solution. Trisodium citrate is used as a reducing agent and also acts as a stabilizing agent at a room temperature.

Incorporation of Silver sol into PAV alcohol matrix:-

- 2% poly vinyl alcohol was added drepwise in ti 50 ml of silver sol to obtain nano silver PVA film. This solution was poured into plastic container and dried at 80°C in oven.

Mechanical analysis of Ag-nanoparticles PVA nanocomposite films:-

- The tensile strength of Ag-nanoparticles PVA films were measured by using universal testing instrument INSTRON-5500R model. The films with different mass loading of Ag nanoparticles were analyzed. The Ag nanoparticles mass loading was 0 gm means as such PVA film, 0.0054 gm and 0.0075 gm.

Antibacterial properties of Ag nanoparticles loaded PVA nanocomposites:-

- The antibacterial properties of the silver nanoparticles dispersed in PVA films were assessed by using the ager diffusion test. A piece of sample with size of 8 mm in diameter was placed on the surface of an individual nutrient agar plate, where bacterial solution containing the micro-organisms chosen like E. coli and S. aureus had been swabbed uniformly. After 24 hr incubation at 37°C, the dimensions of the inhibition zones around the samples were measured in five directions and the average values were used to calculate the circle zone area.

RESULTS AND DISCUSSIONS

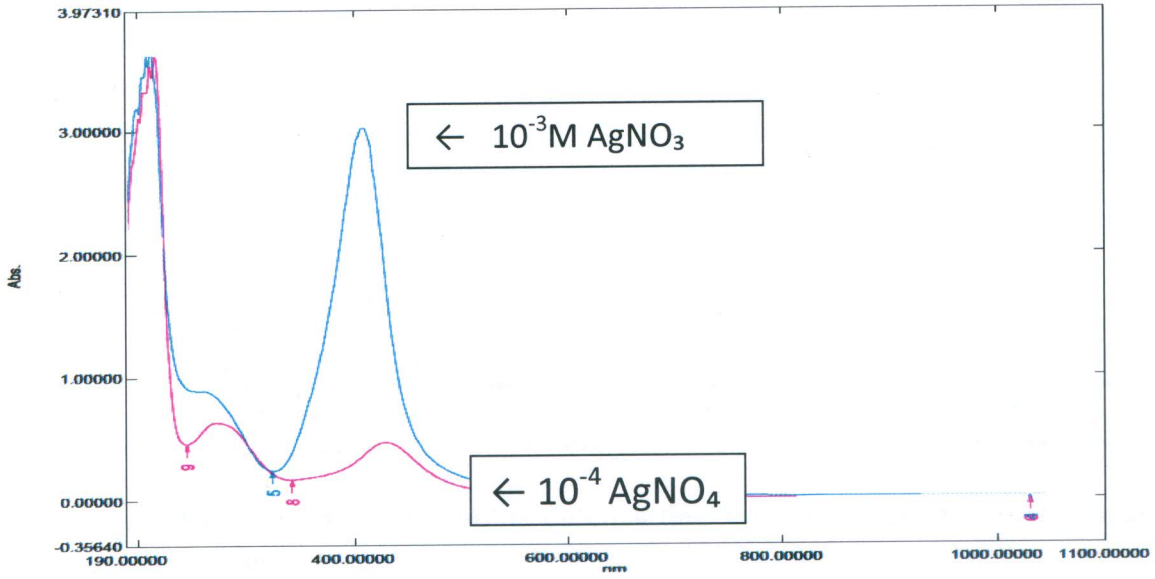


Figure 1: UV-VIS Spectra of Silver sol prepared by using D-Glucose as reducing agent

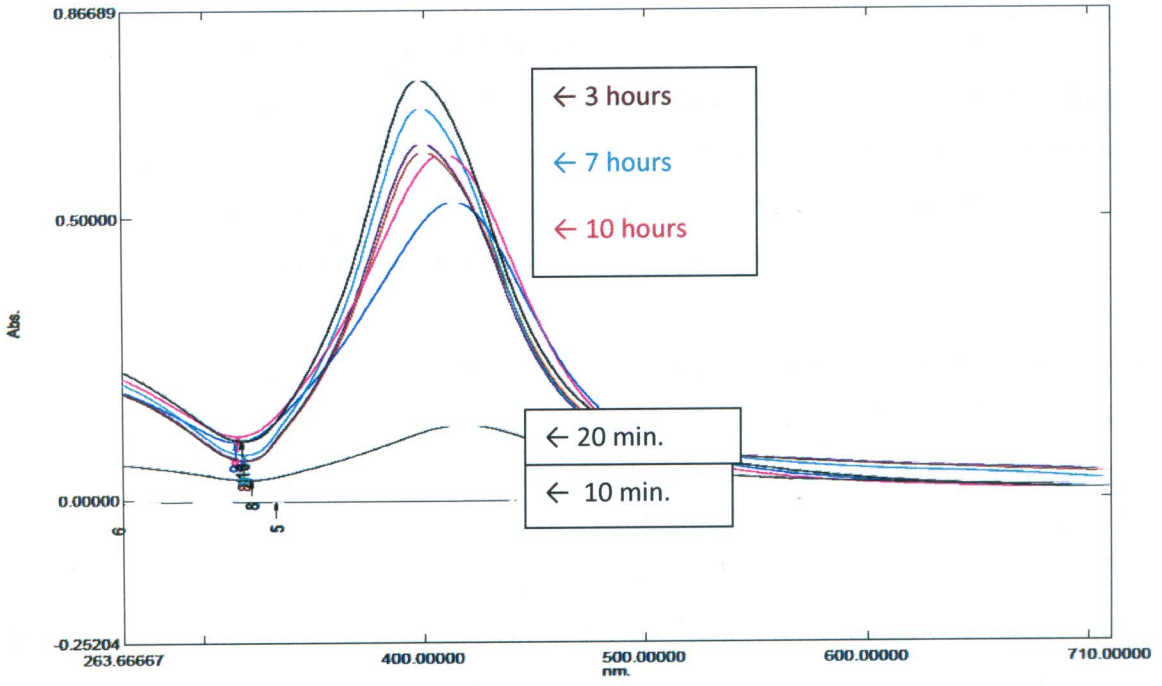


Figure 2: UV-VIS Spectra of silver sol at different time interval reduction of silver ion at 70◦ C with Sodium borohydrate and trisodium citrate. Absorbance at 400 nm indicates silver nanoparticles formation.

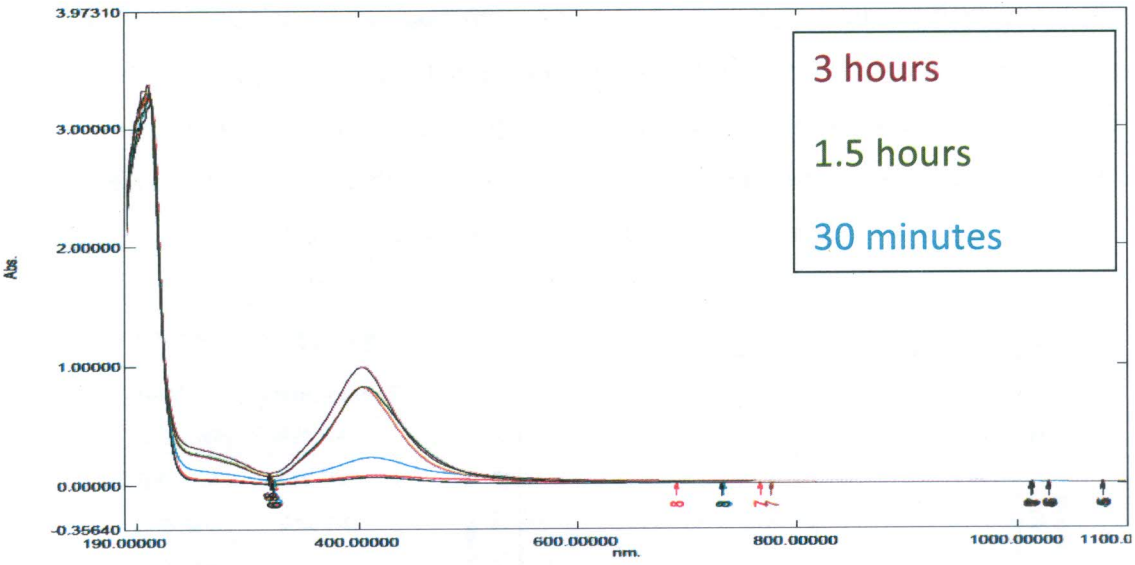


Figure 3: UV-VIS Spectra of Silver sol at different time interval reduction of silver ion at 70◦ C by Trisodium citrate.

Absorbance peak at 400 nm at indicates formation of silver nanoparticles.

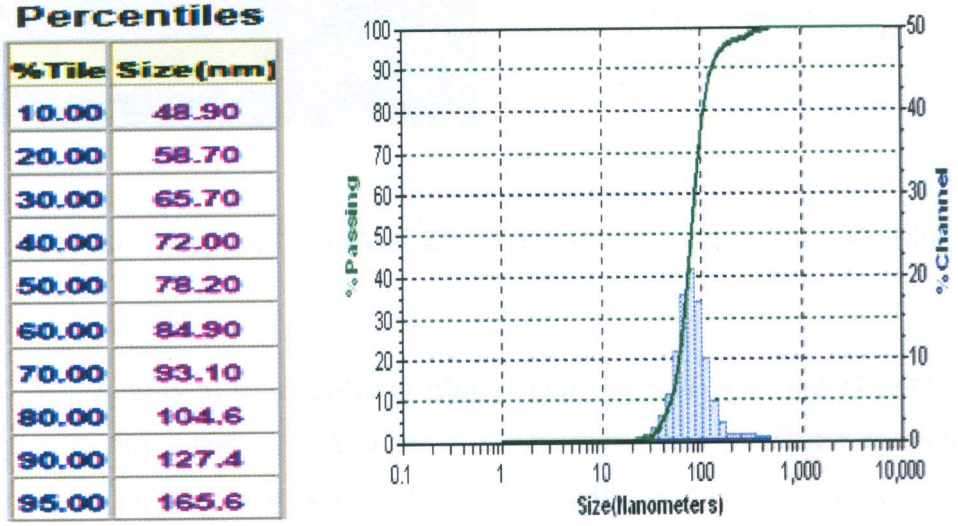
- Define molarity of silver nitrate and Trisodium citrate was mixed and heated at 70◦ C
- UV-VIS Spectra were taken to confirm the synthesis of silver nanoparticles.

UV-VIS Spectra (Fig. 1, 2, 3) of silver sol prepared by different chemical reduction methods confirmed the synthesis of silver nanoparticles. However, silver nanoparticles synthesized using glucose as reducing agent is given up sharp absorbance peak at 400 nm as compared to other reducing agent was indicated that glucose is a strong reducing agent for silver ion reduction.

Zeta potential of silver nanoparticles was also measured using Microtrac Zetatrac (Microtrac Inc., USA) and was found to be 45 mv. This value indicates that stability of silver nanoparticles is good enough in alkaline PH. Particles size distribution curve (Fig. 4) shown the Gaussians distribution of silver nanoparticles in water as dispersing medium.

Silver polymer nanocomposite films were developed by dispersing silver nanoparticles sol in to polymer mixture of PVA-Chitosan and PVA alone. Appropriate volume of silver nanoparticles sol was mixed to PVA-chitosan solution under stirring for 2 hours following solution was poured into plastic mold and dry at 60◦ C to prepared uniform film. Similarly PVA- silver nanocomposite was prepared.

The developed films was characterized by SEM (scanning Electron Microscopy) (fig. 5 and 6) to confirmed presence of silver nanoparticles and pore in to PVA chitosan matrix and PVA matrix. SEM image of silver loaded PVA-chitosan and PVA shows even distribution of pore of 1 μm to 5μm thought out polymer matrix and the silver nanoparticles are present at rim of the pore which was leading to opening of it.



Percentiles

%Tile	Size(nm)
10.00	48.90
20.00	58.70
30.00	65.70
40.00	72.00
50.00	78.20
60.00	84.90
70.00	93.10
80.00	104.6
90.00	127.4
95.00	165.6

Figure 4: Study of silver nanoparticles size distribution in silver nanoparticles sol

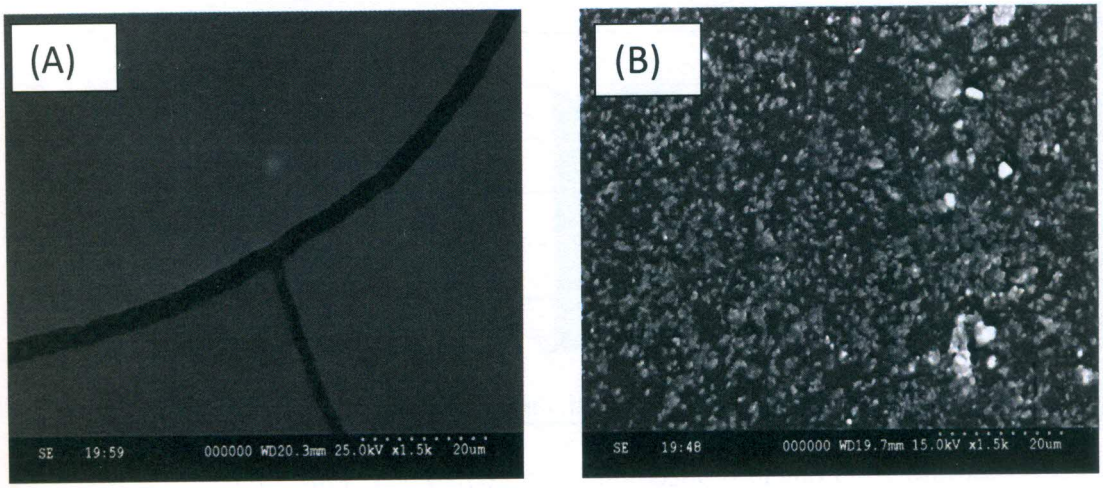


Figure 5: SEM images of (A) PVA- Chitosan film and (B) silver loaded PVA chitosan film

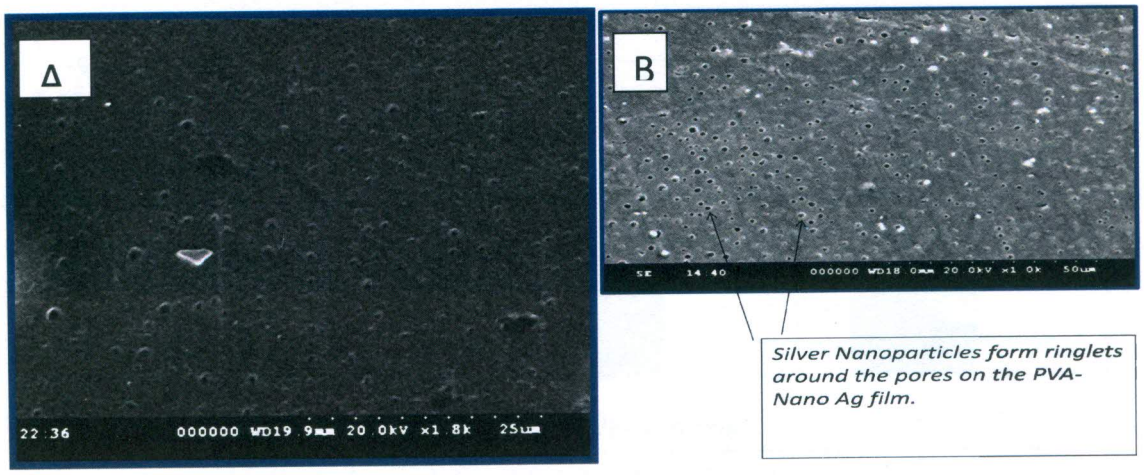


Figure 6. SEM micrographs of (A) PVA- film, (B) PVA silver nanocomposite film

Air permeability of silver polymer films (figure-7,8,9,10) was studied using oxygen and nitrogen. It was found to be that silver nanoparticles and chitosan were helping in opening pores in polymer matrix leading to increase the permeability of silver polymer nanocomposite film nitrogen and oxygen.

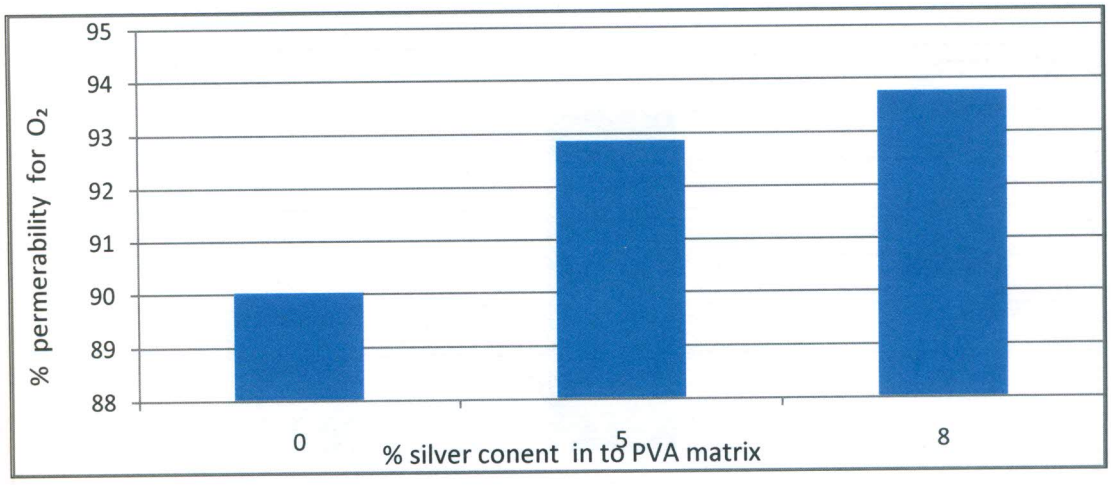


Fig.7. Air permeability study PVA silver nanocomposite film and PVA film for O_2

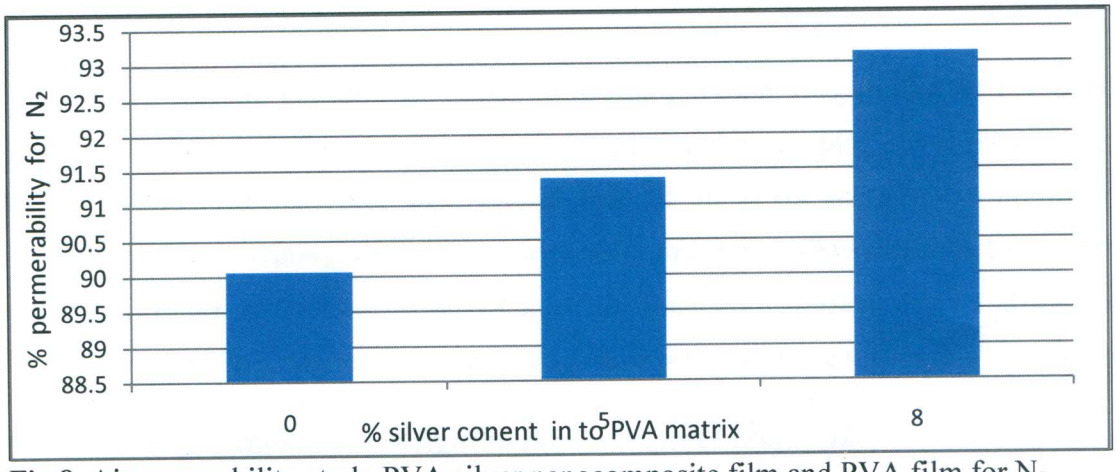


Fig.8. Air permeability study PVA silver nanocomposite film and PVA film for N_2

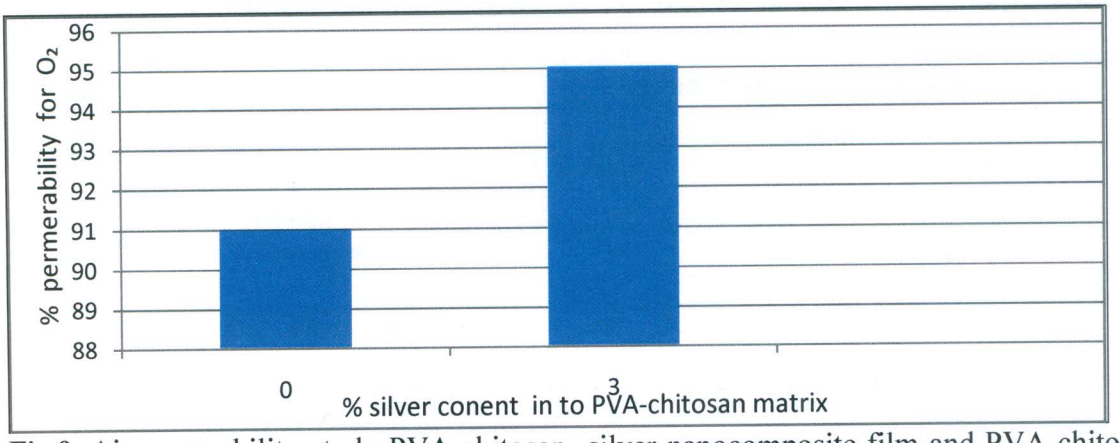


Fig.9. Air permeability study PVA-chitosan- silver nanocomposite film and PVA-chitosan film for O_2

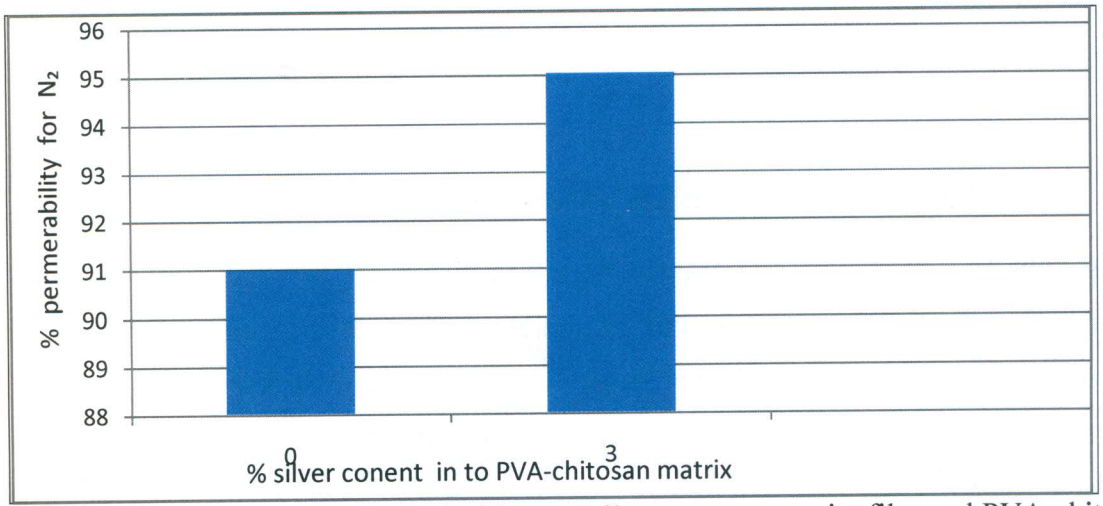


Fig.10. Air permeability study PVA-chitosan- silver nanocomposite film and PVA-chitosan film for N_2

Drug loading capacity of silver PVA-chitosan film was studied in compared to PVA-chitosan film. Define weight of silver NPs PVA chitosan film, silver NPs PVA film, PVA-Chitosan film and PVA were dipped into 10 ml (4 ml acetone + 6 ml water) in different flasks containing 4 mg curcumin (model drug) and allowed flasks to standing at room temperature of 24 hour. After 24 hour all films were washed, dried and weight for total content. The % Drug loading capacity of films were calculated from following formula

% Drug loading capacity = (weight in film / weight of film) x 100

Table 1: The study of curcumin loading capacity of film by varying the composition of film

Film type	**% Curcumin holding capacity**
PVA	1.32
PVA-silver nanocomposite	2.84
PVA-chitosan-silver nanocomposites	3.78
PVA-chitosan	2.84

The Curcumin loading capacity of films shows (table 1) that silver nanoparticles and chitosan form chemical bond with Curcumin.

Synthesis of silica-silver core shell particles by sol-gel method

Define molarity of TEOS (Tetraethyl orthosilicate) was mix with 2 M ethanol and was stirred for 1 hour. Followed by addition of 100 ml silver nanoparticles sol. To this solution 12 M deionized water was added and stirred content at 1000 rpm for 5 hours, followed by addition of 15 ml ammonia as catalyst and solution was stirring continuously till solution was get turn to colorless.

The sol was dried at 70° C for 10 hours following sintering at two different temperatures 400° C and 500° C for 20 minutes.

Size of particles and its distribution in acetone were determined using Microtrac Zetatrac (Microtrac Inc, USA).

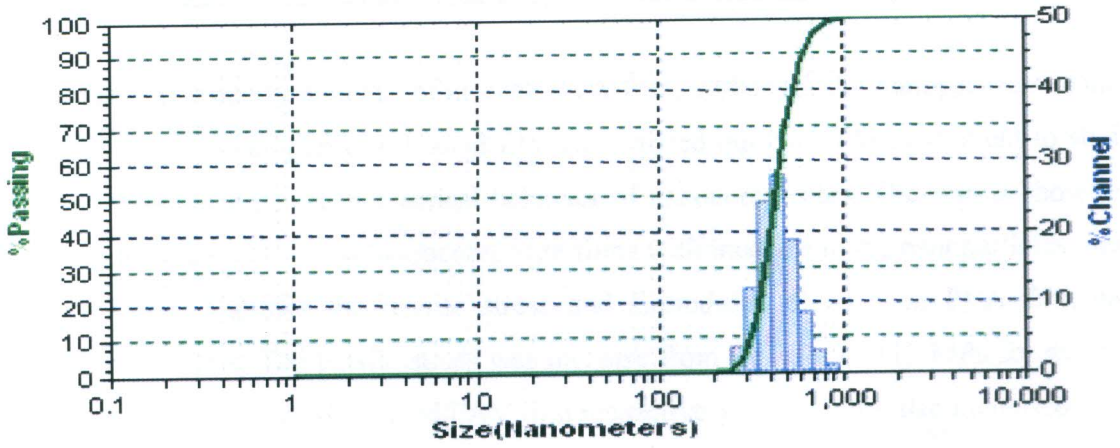


Figure11: Study of distribution of silica core shell silver particles in acetone as dispersing media

Distribution of particles were ranging between 300 nm to 600 nm.

Estimation of silanol groups concentration on surface of silver silica core shell particles:

Silica- silver core shell particles	**Silanol group concentration (X mole / gm)**
Without heating	1.75
Heating at 400° C for 20 minutes	1.127
Heating at 500° C for 20 minutes	0.75

Heating was leading to reduction in silanol groups by forming aggregation of particles and increasing particles size.

A particle without heating have high silanol group concentration is desirable for biological application such as in wound healing film. Silanol groups promoting growth of fibroblast near the wound and leading to enhancing wound healing process.

Mechanical property analysis of Ag loaded PVA nanocomposite films

The mechanical property analysis of as such PVA film, 0.0054gm Ag nanoparticles loaded and 0.0075 gm Ag nanoparticles loaded film was carried out by UTM instrument to study the effect of Ag loading on mechanical behavior of nanocomposites. The results show the increase in tensile properties of nanocomposite films with increase in Ag nanoparticles mass loading. Table 2 shows the tensile stress and E-modulus of as such PVA film and nanocomposite films. The tensile stress was increase from 94 MPa to 115 MPa for as such PVA film and 0.0075 gm AG loaded PAV film respectively. E-modulus also increased from 3110 MPa to 3839 MPa for as such PVA film and 0.0075 gm AG loaded PAV film respectively.

Table 2: Tensile stress and E-modulus of as such PVA film and nanocomposite films

Samples	Tensile Stress (MPa)	E-Modulus (MPa)
As such PVA film	94	3110
0.0054 gm Ag-PVA film	109	3517
0.0075 gm Ag-PVA film	115	3839

Antibacterial sensitivity test of Ag loaded PVA nanocomposite films

Antibacterial sensitivity test of Staphylococcus aureus was done by Kirby Bruaer method as shown in figure 12and 13. The nanocomposite film samples with different mass loading were analyzed for antibacterial sensitivity.

The bacterial solution was swabbed uniformly on the film surface of film and after 24 hr incubation at 37°C inhibition zone was measured in five directions and average values were calculated for effective zone.

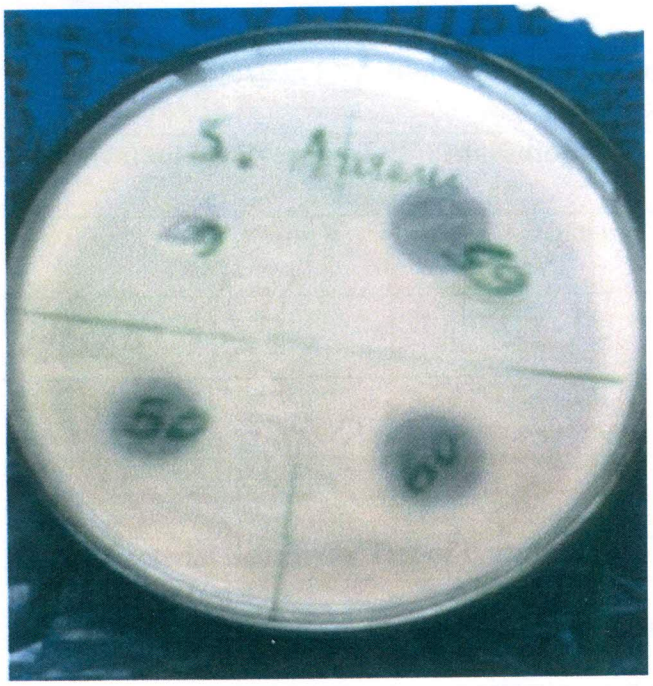


Figure12: Antibacterial sensitivity test of S.aureus on 0.0075 gm Silver loaded film.

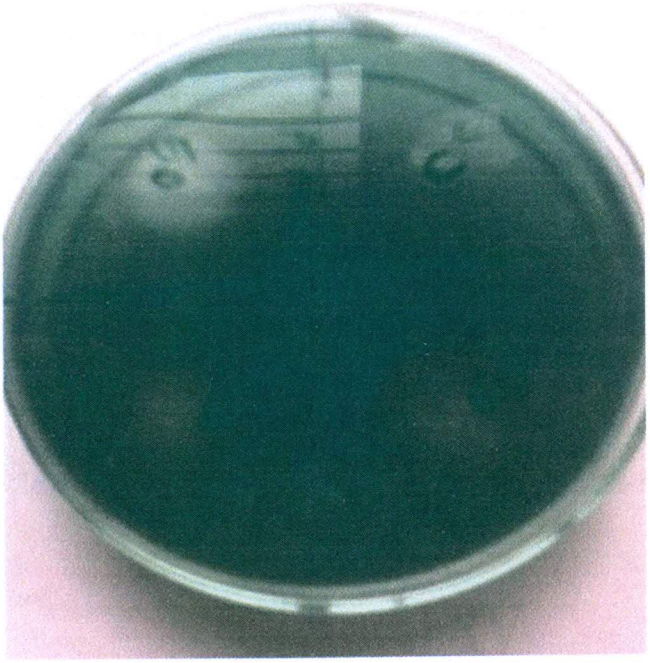


Figure13: Antibacterial sensitivity test of P.aeroginosa on 0.0075 gm Silver loaded film.

The results show the antibacterial sensitivity of nanocomposite films was incrased with increasing the Ag mass loading in PVA film. Table 3and 4 show the inhibition zone with Ag mass loading in PVA film.

Table 3: Concentration of Ag in PVA film and Inhibition zone for S.aureus

Concentration of silver (gm)	**Inhibition zone (mm)**
0.00 gm in PVA film	No zone
0.0054 gm in PVA film	12
0.0054 gm in PVA film	14
0.0075 gm Ag-PVA film	15

Table 4: Concentration of Ag in PVA film and Inhibition zone forP.aeroginosa

Concentration of silver (gm)	**Inhibition zone (mm)**
0.00 gm in PVA film	No zone
0.0054 gm in PVA film	15
0.0054 gm in PVA film	17
0.0075 gm Ag-PVA film	18