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Development and modification of the natural polymers by converting them into nanobiocomposite

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***Abstract*---**The main target ofTthis study is to develop an antibacterial chitosan nanocomposite fabric among in situ crated silver nanoparticles utilizing Vitex leafTextract, which i s amedicinal herb. The CNCFs were evaluated using scanning electron microscopy (SEM), Fourier transform infrared (FT-IR) spectroscopy,Xray diffraction (XRD), and antimicrobial testing. Additionally, these CNCFs have excellent antibacterial characteristics. These CNCFs could be used in medical applic ations like surgical aprons, wound cleansing, wound dressing, and hospital bed mat erials, as they were manufactured utilising a simple and environmentally acceptable approach.

***Keywords*---**natural polymer, chitosan textile, silver nanoparticles, nanobiocomposite.

Introduction

Nanobiocomposite (NBC) materials hav e evolved as an alternative to standar d materials, among probable attribute and success during a several applicatio ns in a variety of industries (aeronaut cal, automotive, furniture, packaging,tra nsportation, medical,and defense). Nano biocomposite materials are made up of two, three or more components, one of which is in the form of matrix an d the others in the form of particles or biofibres. When a load is applied to nanobiocomposite materials, it is distributed evenly throughout all parts. The most significant advantages of pol ymerbased nanobiocomposite materials are enhanced industrial productivity, ea se of processing technology and lower manufacturingprices [1-3].

The development of an infiltration net work enclosed by the matrix is the m ost crucial property in the formulation of nanocomposites utilizing several cla sses of nanoparticles like nano clays,c arbon nanotubes, or cellulose nanocryst als, CNCs) [4]. Numerous investigations on the creatio n of advanced organic/inorganic hybrid substances and nanocomposites have b een conducted [5]. "Nanocomposite" is a term that is frequently used for nanofiller filled polymers with distributed n anofillers. Particle sizes lower than 100 nanometers on average [6]. Polymers are a type of material that is made u p of metal [6to9] and semimetal as a good host material [10to14] conductor na noparticles, at the same time, optical and electrical qualities are outstanding. A valiant effort polymericinorganic na nocomposites are a typeof polymerinor ganic nanocomposites that have a vari ety of properties. Electrical, optical, a nd magnetic qualities that are fascinati ng aresteadily superior to the center p olymeror inorganic family has been de scribedin the literature [15-18].

Metallic nanoparticlespolymer nanocom posites can be made by adding the m etal precursor to a polymer solution a nd then reducing it with a reducing a gent or by thermolysis, or by polymer izing a colloid of metallic nanoparticle s in a monomer solution and then re ducing it, or by polymerizing a colloi d of metallic nanoparticles in a mono mer solution and then reducing it. sta bilizers are important in the creation of metal nanoparticles because they in fluence both the formation and dispers ion stability of the particles[19-21].

Chitosan is a deacetylated polysacchari de derived from natural chitin, which is found in crustacean shells and many fungi's cell walls. Chitosan has rece ntly sparked alot of attention as a po ssible polysaccharide resource because of its beneficial capabilities, like studi es on mix films including chitosan ba sed upon its biocompatibility, biodegra dability, nontoxicity and adsorption pro perties [22-25]. Metal nanoparticles can be made from metal salts in a variety of ways, incl udingchemical and biological approache s [26]. Many leaf extracts are currently being usedto convert metal salts into t heir respectivenanoparticles. To make s ilver nanoparticlesand copper nanoparti cles, reducing agents such as tea leafa nd coffee powder, planttea, Ocimum s anctum, and Gymnema sylvestre wereu tilised.

Several researchers disseminated the pr oduced metal nanoparticles in polymer matrices to create polymer nanocompo sites. Although, nanoparticle dispersion in polymer matrices frequently results in agglomeration [27]. To solve this pr oblem, several researchers used several leaf extracts as reductant to make silv er nanoparticles and copper nanoparticl es in chitosan matrix in situ. The sci entists attempted to generate silver na noparticles in situ in chitosan textiles utilizing Vitex leaf extract as a reduci ng agent in this investigation.

The chitosan nanocomposite fabrics we re examined using Fourier transform infrared(FTIR) spectroscopy, scanning e lectron microscopy (SEM), Xray diffra ction (XRD), and antibacterial action t esting. The main goal of this research was to develop antibacterial chitosan f abrics among in situ generated silver nanoparticles during medical applicatio ns likesurgical aprons, wound healing and wound cleaning materials and hos pital bed spreads utilizing an easy an d lowcost process that used medicinal leaf extract as a reductant.

Material and Methods Materials

Silver nitrate was purchased as an off ering sample from Loba Chem, Mumb ai, India, and rinsed twice among dou ble distilled water before air drying. Vitex leaves were sourced from the s urrounding region.

Methods

The Vitex leaves were cleaned and cu t towards little pieces prior to being appendto distilled water at 80°C for 20 minutes.The empty was segregate, fi ltered, and stored until the next time it was needed. To manufacture CNCF s containing in situproduce silver nano particles, aqueous AgNO3 solutions wi th concentrations of 1, 2,3, 4, and 5 mmol/L were first created independently. The Vitex leaf extract was soaked in the cleaned chitosan, allowing the leaf extract to diffuse into the textile fibres. the leaf extractinfused textile fibrewas then stored in various concen trationsof aq. AgNO3 solutions. When these fibres were immersed in yellow brown, theirhues gradually shifted and intensified. Behind 24 hours the CNC Fs were properly cleansed among disti lled water.

Characterization

The FTIR spectra of chitosan and CN CFswith in situ generated silver nanop articleswere recorded on a smart iTR ATR Nicolet using 10 FTIR spectroph otometers in the range of 4000to500 cm1 with 32 scans in each case at a resolution of 4 cm1. To investigate th e presence of silver nitrite and its par ticle size distribution in the CNCFs, SEM pictures were acquired with a Z eiss EVO 18 scanning electron micros cope at a 10 kV accelerating voltage The Xray diffraction spectra of the sa mples were recorded using the same instrument. The samples were gold sp utter coated before being photographed. The XRD of the matrix and CNCFs containing in situ generated silver nitri te was recorded using aBruker Eco D8 XRD

diffractometer in the 2 range of 10°to90°, a voltage of 40 kV, and a current of 25 mA. The disc method was used totest the matrix's antibacteri al activity, andCNCFs with in situ pr oduced silver nitrite were found to be effective against twogramme negative (Pseudomonas and E. coli) and two gr amme positive (Bassilus subtils and St aphylococcus areus) bacteria. The inhi bitory zones that were seen werephoto graphed, and the diameter of each zo ne was measured.

Result and Discussion

Figure 1 shows digital images of the chitosan fabric, matrix, and CNCFs ge neratedwith 15 mmol/L aq. silver nitri te solutions. As illustrated in Fig. 1, the chitosan fabric was yellow, where as the Vitex leaf extract saturate textile fabric (matrix) was light brown. Instead , when the concentration of the source solution grew, the CNCFs' color shift ed from medium brown to dark brown. Preliminarily, the insitu initiation of th e silver nanoparticles in the matrix ca n be seen as a colour shift. The CN CFs' SEM images were documented in order to visualize the silver nanopa rticles that were created. Figure 2 dis plays SEM images of CNCFs using aq. silver nitrite solutions with concen trations of 1 mmol/L (minimum) and 5 mmol/L (highest). The same graphic also includes theEDX spectra that wer e described at the same time as the paralleling SEM images. Micrographs w ere used to examine the particle size distribution in both of these occurrenc es, and the results are shown in the same image. In the SEM images in f igs. 2a and 2b, the spherical shape of the generated silver nanoparticles is cl earlyvisible. The EDX spectra in figur es 2c and 2d verified the presence of silver particles. The intensity of the E DX apex paralleling the silver element was also foundto be higher when CN CF was made witha 5 mmol/L origin solution than when CNCF was formed with a 1 mmol/L origin solution. When a more concentrated origin solu tionwas used, it appeared that a large number of silver nanoparticles were pr oduced. Figures 2e and 2f show the particle size distribution of CNCFs ge nerated using 1 mmol/L and 5 mmol/ L origin solutions, respectively. The la rgest amount of cratedsilver nanopartic les was in the particle range of 94–100 nm in both occurrences, as shown by the distribution curves. Although, in theCNCFs generated with 1 mmol/ L and 5 mmol/L origin solutions, the average sizeof the formed silver nanop articles was 89nm and 104 nm, respe ctively. This couldbe due to the agglo meration of a few nanoparticles that o ccurred when highly concentrated origi n solutions were employed. The avera ge particle size of CNCFs generated using extra concentrated origin solution s (2, 3 and 4 mmol/L) was considere d to be in the middle of these two values.

a.  **b.**  **c.** 

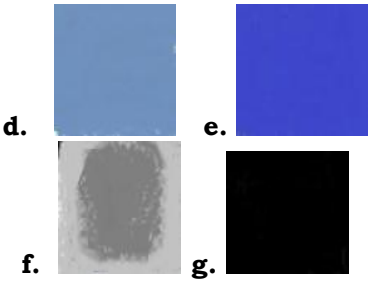


Fig. 1: CNCFs among in situ gener ated silver nanoparticles using 1 m mol/L (a); digital pictures of chitos an fabric (b); matrix (c) CNCFs a mong in situ generated silver nano particles using 1 mmol/L (c) (d) 2 mmol/L a concentration of 3 mmol/ L (e) (f) 4 mmol/L and mmol/L (g) sources of information

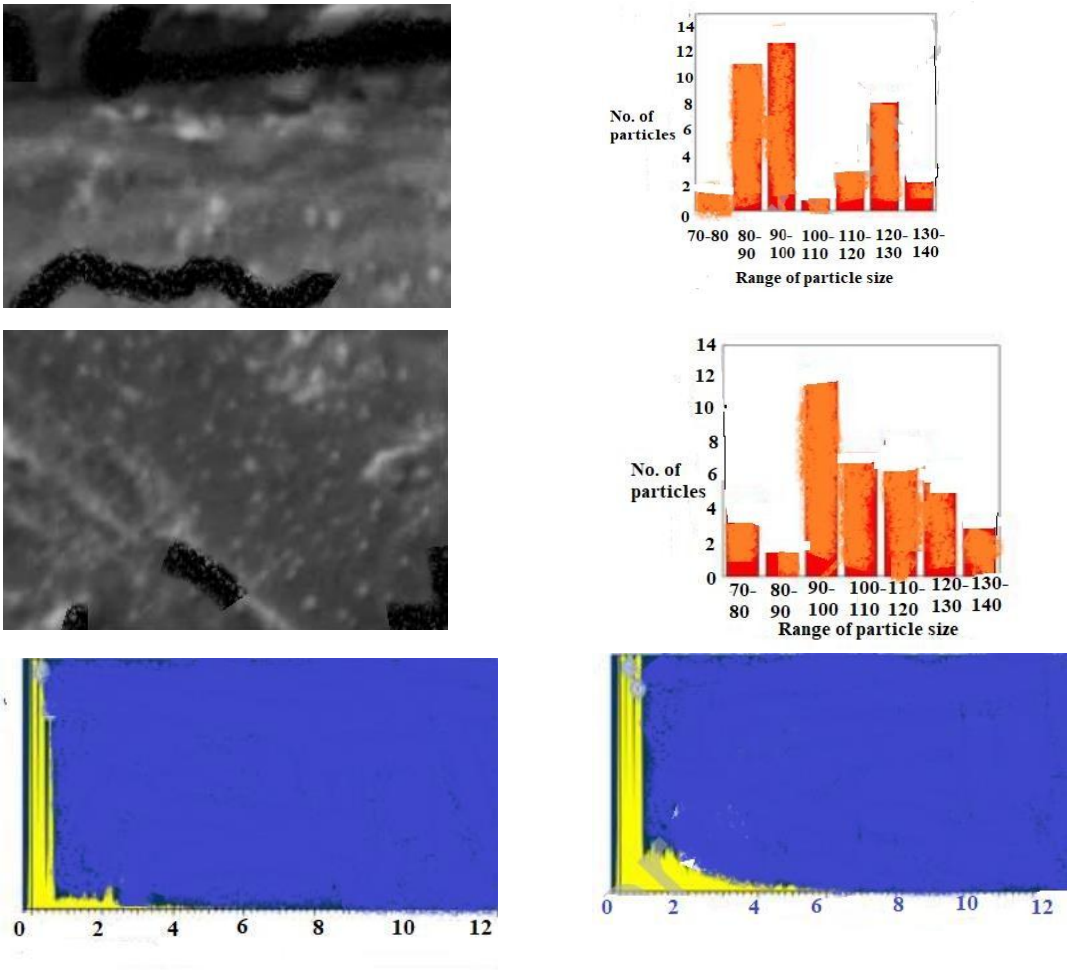
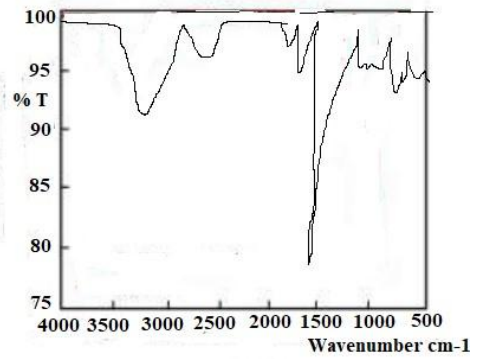
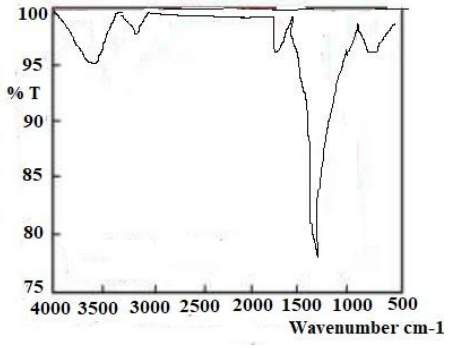


Fig. 2. a and b are two examples of examples of examples of example s of examples of examples of Ener gy-dispersive Xray (EDX) spectra are

visible in scanning electron microscope (SEM) d) micrographs C and d.Particle size distribution of chitosan nanocomposite fabrics (CNCFs) with in situ produced silver nanoparticles (AgNPs) using 1 mmol/L and 5 m mol/L aq.silver nitrite solutions, res pectively, is shown in E and f

To examine their interaction, the FT- IR spectra of the chitosan fabric and theVitex leaf extract are shown in Fig.3a. In Fig. 3a, both spectra had the same apex, indicating that they belong ed to the same chemical class. The a pex of the matrix had a higher intens ity than the chitosan textile at 3298 cm1 (OH stretching vibration) and 10 12 cm–1 (C–O-C stretching vibration), indicating that theleaf extract belonged to the OH an d C–O-C categories. In order to investigate t he effect of in situ generated silver n anoparticles on the chemical structure of the matrix, the FTIR spectra of th e matrix and CNCFs using 15 mmol/ L source solutions are shown in Fig. 3b. For coherence, the matrix and CN CF spectra using a 5 mmol/L origin solution are shown separately in Fig. 3c. With the exception of the overcas ting of intensity of the bands correspo nding to the O–H and C–O groups in the case of nano compos itefabrics, no significant changes were seen in Figures 3b and 3c. The O–H and C-O classes of the matrix are definitely involved in converting silver salts to silver nanoparticles. Additional typical bands can be seen at 2898 cm–
1 (CH stretching.), 1633 cm–
1 (CH stretching.), and 1633 cm–
1 (CH stretching.). (CH stretching). (water crystallisation) At 1421 cm–
1 (CH2 b.), 1352 and 1317 cm–
1 (CH2 wagging), and 867 cm–
1 (CH2 wagging), the chitosan structu re is apparent in both the matrix and the CNCFs (-glucosidic linkage).





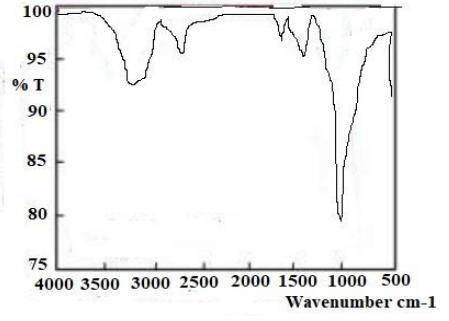


Fig.3: a) Chitosan fabric and matri x FTIR spectra; b) matrix and CN CFs with in situ produced Silver n anoparticles using 1–5 mmol/L aq. silver nitrite source solutions employing a 5 mmol/L source so lution, a matrix and chitosan nanoc omposite fabric with in situ produc ed silver nanoparticles

To investigate the effect of silver nan oparticles on the crystallinity of the n anocomposite fabrics, the X-ray diffractograms of the chitosan fibr e, matrix, and nanocomposite chitosan fabricsamong in situ generated silver n anoparticles using 1to5 mmol/L aq. sil ver nitrite solutions weredescribed and shown in Fig. 4a. Because the overlapped diffractograms did not provide substantial information, the dif fractograms communicate with the mat rix and the CNCF utilising 5 mmol/L aq. Figure 4b depicts the various for ms of silver nitrite solution. As seen in Fig. 4b, the CNCF intensity was somewhat greater than the matrix, indi cating a minor increase in the crystall inity of the CNCFs due to thepresenc e of silver nanoparticles.

Because the presence of silver nanopa rticles in overlapped diffractograms is difficultto detect, the CNCF diffractogr am using 5 mmol/L aq. silver nitrite was enlarged in 2 = 30°to67° and is displayed in Fig. 4c. Figure 4c shows that the diffractograms of the peaks at 2 = 39.1°, 46.1°, and 64.2° correspon d to reflections from the (111), (200), and (220) planes of silver nanoparticle s, respectively. Further prominent peak s can be found at 2 = 33.0°, 37.5°, 57.2°, and66.2°, which correspond to r eflections from the Ag-O nanoparticles planes (121), (209), (224), and (309), respectively. As a res ult, both silver nanoparticles and AgO nanoparticles were initiated in the CN CFs created. The insitu production of silver nanoparticles andAgO nanoparticl es in the matrix is demonstrated by these results.

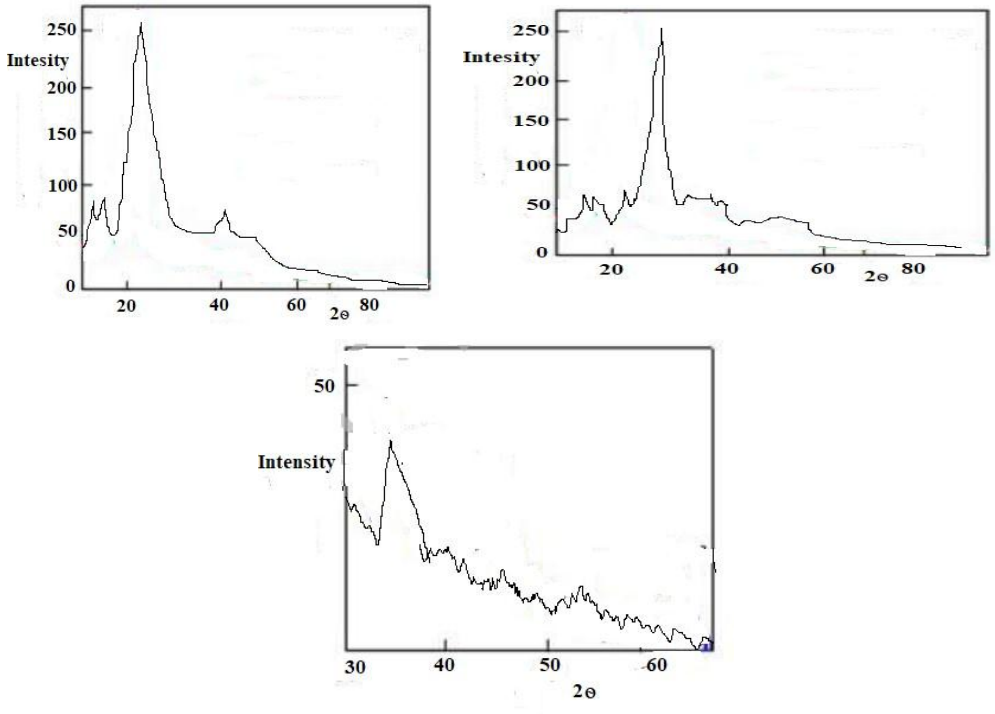


Fig.4. a) X-ray diffractograms (XRD) of chitosa n fabric, matrix, and CNCFs produ ced with 1–5 mmol/L aq. Silver nitrite source solutions a) matrix and CNCF with a 5 mmol/L source solution b) and CNCF with a 5 mmol/L solution e nlarged in the 2 = 32°–68° temperature range

The disc technique was used to test t he antibacterial activity of the CNCFs produced using different concentrated source solutions against two gramme negative (Pseudomonas and Escherichia coli) and two gramme positive (Bassil us subtils and Staphylococcus areus) b acteria. A chitosan fabric and matrix comparative test was also performed. I mages of the petri plates used in the experiment are shown in Fig. 5.Since the chitosan cloth and matrix were identified as A and B, the CNCFs us ing1, 2, 3, 4, and 5 mmol/L were de legatedas H, I, J, K, and L in the i mages. Table 1 shows the diameter of the intelligible zones, which was com puted using the Image J programme. As indicated in Fig.5 and Table 1, ne ither the chitosan clothnor the matrix appears to have an antibacterial activity. Despite this, CN CFsbetween in situ started silver nano particlesand Vitex leaf extract as a re ducing agent demonstrated higher antib acterial activityagainst both gramme ne gative and gramme positive bacteria. I n most cases, the comprehensible zone diameters ranged from 12.0 to 17.3 m m, and the concentration of the sourc e solutions increased in all cases. CN CFs could be used as antibacterial ma terials in medicinal applications, according to these findings.

Table 1
Using 1–5 mmol/L aq. silver nitrite solutions a gainst gramme negative (Pseudomonas and Escherichia coli) and gramme positive Pseudomonas and Escherichia coli) bacteria, the diameter of the coher ent zones was measured for chitosan fabric, matrix, and CNCFs (Bassilus s ubtils and Staphylococcus areus)

Conc. Of aq. AgNO3 solution used	**Diameter (mm)**			
	E. coli	**Pseudomonas**	**Staphylococcus aureus**	**Bassilus subtils**
Chitosan textile(A)	-	-	-	-
Matrix (B)	-	-	-	-
1 mmol/L (H)	12	13.3	12.6	13.7
2 mmol/L (I)	12.4	13.1	12.8	15.3
3 mmol/L (J)	14.7	14.8	14.4	16.1
4 mmol/L (K)	15.6	14.8	15.6	15.7
5 mmol/L (L)	15	15.9	17.9	14.2

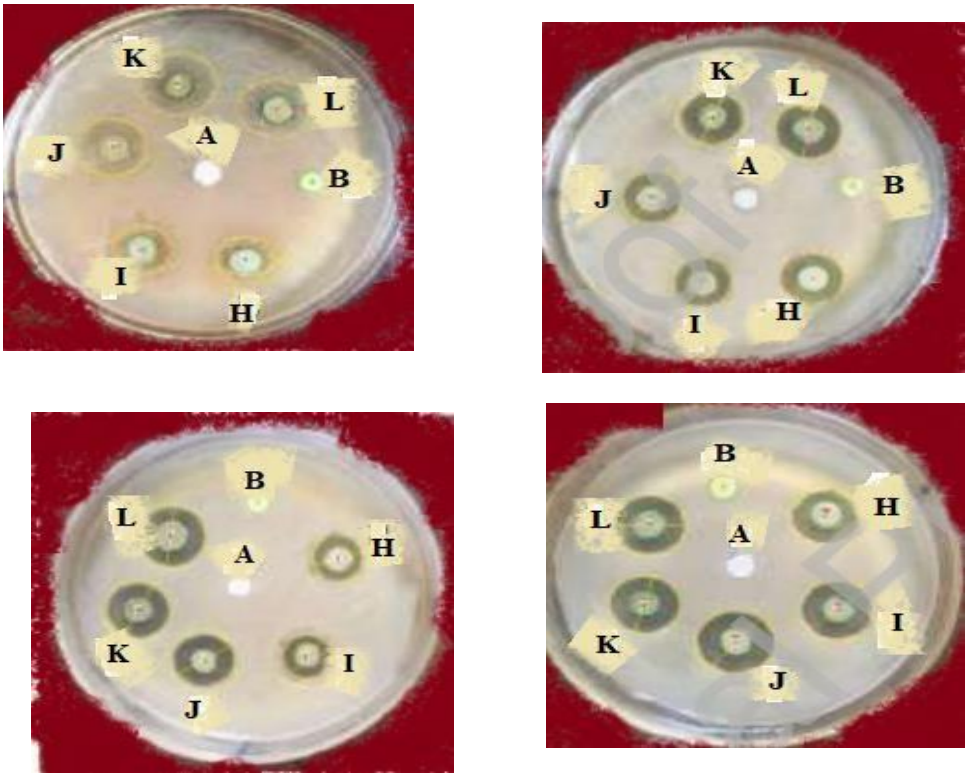


Fig. 5. CNCFs with in situ generat ed AgNPs using 1 mmol/L (H), 2 mmol/L (I), 3 mmol/L (J), 4 mmol/ L (K), and 5 mmol/L (L) aq; anti bacterial activity of chitosan fabric (A); matrix (B); CNCFs with in sit u generated AgNPs using 1 mmol/L (I), 3 mmol/L (J), 4 mmol/L Pseud omonas aeruginosa (a), Escherichia coli (b), Bassilus subtilis (c), and S taphylococcus areus (d) bacteria we re tested using AgNO3 source solut ions and Vitex leaf extract as a re ducing agent.

References

1. Zagho M., Hussein E.A., Elzatahry A. Recent Overviews in Functional Po lymer Composites for Biomedical Appl ications. Polymers. 2018; 10: 739.
2. Sherif G., Chukov D.I., Tcherdynts ev V., Torokhov V. Effect of Formati on Route on the Mechanical Propertie s of the Polyethersulfone Composites
3. Mustafa A., Bin Abdollah M.F., S huhimi F.F., Ismail N., Amiruddin, H. Umehara N. selection and verificatio n of kenaf fibres as an alternative fri ction material using Weighted Decision Matrix method. Mater. Des. 2015; 67:577–582.
4. Capadona J. R., Van Den Berg O., Capadona L. A., Schroeter M., Rowan S. J., Tyler D. J., & Weder C. A versatile approach for the processing of polymer nanocomposites with self- assembled nanofibre templates. Nature Nanotechnology. 2007; 2: 765-769.
5. Mark JE. Ceramic-reinforced polym ers and polymer-modified ceramics. Po lymer Engineering & Science. 1996;36 (24):2905-20.

6. Huang H., Yuan Q., Yang X. Prep aration and characterization of metal–chitosan nanocomposites. Colloids and surfaces B: Biointerfaces. 2004;39(1- 2):31-7.
7. Akamatsu K., Takei S., Mizuhata M., Kajinami A., Deki S., Takeoka S., Fujii M., Hayashi S., Yamamoto K. Preparation and characterization of pol ymer thin films containing silver and silver sulfide nanoparticles. Thin Solid Films. 2000 ;359(1):55-60.
8. Zeng R., Rong MZ., Zhang MQ., Liang HC., Zeng HM. Laser ablation of polymer-based silver nanocomposites. Applied Surface Science. 2002;187:(3-4):239-47.
9. Cole DH., Shull KR., Baldo P., R ehn L. Dynamic properties of a mode l polymer/metal nanocomposite: gold p articles in poly (tert-butyl acrylate). Macromolecules. 1999;32(3):771-9.
10. Hussain I., Brust M., Papworth A J., Cooper AI. Preparation of acrylate-stabilized gold and silver hydrosols an d gold− polymer composite films. Lan gmuir. 2003;19(11):4831-5.
11. Vijaya Kumar R., Elgamiel R., Di amant Y., Gedanken A., Norwig J. S onochemical preparation and characteriz ation of nanocrystalline copper oxide embedded in poly (vinyl alcohol) and its effect on crystal growth of copper oxide. Langmuir.. 2001;17(5):1406-10.
12. Sajinovic D, Saponjic ZV, Cvjetic anin N, Marinovic-Cincovic M, Nedeljkovic JM. Synthesi s and characterization of CdS quantumdotspolystyrene composite. Chemical P hysics Letters. 2000;329(1-2):168-72.
13. Djokovic V, Nedeljkovic JM. Stre ss relaxation in hematite nanoparticles· polystyrene composites. Macromolecular rapid communications. 2000 ;21(14):99 4-7.
14. Kumar RV., Koltypin Y., Cohen YS., Cohen Y., Aurbach D., Palchik O., Felner I., Gedanken A. Preparation of amorphous magnetite nanoparticles embedded in polyvinyl alcohol using ultrasound radiation. Journal of Materi als Chemistry. 2000;10(5):1125-9.
15. Yu SH., Yoshimura M., Calderon Moreno JM., Fujiwara T., Fujino T., Teranishi R. In situ fabrication and o ptical properties of a novel polystyren e/semiconductor nanocomposite embedd ed with CdS nanowires by a soft sol ution processing route. Langmuir. 2001;17(5):1700-7.
16. Croce F., Appetecchi GB., Persi L, Scrosati B. Nanocomposite polymer electrolytes for lithium batteries. Natur e. 1998 ;394(6692):456-8.
17. Huynh WU., Peng X., Alivisatos AP. CdSe nanocrystal rods/poly (3-hex ylthiophene) composite photovoltaic devices. Advanced materials. 1999 ;11(11):923-7.
18. Guo L., Yang S., Yang C., Yu P., Wang J., Ge W., Wong GK. Synth esis and characterization of poly (viny lpyrrolidone)-modified zinc oxide nanoparticles. Che mistry of Materials. 2000 ;12(8):2268-74.
19. Zhao M., Sun L., Crooks RM. Pr eparation of Cu nanoclusters within de ndrimer templates. Texas A and M u niv college station dept of chemistry.1 998.
20. Esumi K., Suzuki A., Yamahira A., Torigoe K. Role of poly (amidoa mine) dendrimers for preparing nanopa rticles of gold, platinum, and silver. L angmuir. 2000;16(6):2604-8.

21. Zheng J., Stevenson MS., Hikida RS., Van Patten PG. Influence of pH on dendrimer-protected nanoparticles. The Journal of Physical Chemistry B. 2002;106(6):125 2-5.
22. Huang H., Yuan Q., Yang X. Pre paration and characterization of metal–chitosan nanocomposites. Colloids andsurfaces B: Biointerfaces. 2004;39(1- 2):31-7.
23. Fuentes S., Retuert PJ., Ubilla A., Fernandez J., Gonzalez G. Relationship between composition and structure in chitosan-based hybrid films. Biomacromolecules. 2000 ;1(2):239-43.
24. Tanabe T., Okitsu N., Tachibana A., Yamauchi K. Preparation and char acterization of keratin–chitosan composite film. Biomaterials. 2002;23(3):817-25.
25. Zhang M., Li XH., Gong YD., Z hao NM., Zhang XF. Properties and b iocompatibility of chitosan films modif ied by blending with PEG. Biomateria ls. 2002 ;23(13):2641-8.
26. Sadanand V., Rajini N., Varada R ajulu A., Satyanarayana B. Preparation of cellulose composites with in situ g enerated copper nanoparticles using lea f extract and their properties. Carbohy dr. Polym. 2016; 150:32–39.
27. Jamshidi A., Jahangiri M. Synthes is of copper nanoparticles and its anti bacterial activity against Escherichia co li. Asian J. Biol. Sci. 2014; 7:183– 186