International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.05, May 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Antimicrobial investigation of silver doped titanium dioxide nanoparticle

Mini Mishra[1], *Pratima Chauhan[2]

[1]*Center of Environmental Science, University of Allahabad, Allahabad, India.*

[2]*Depatment of Physics, University of Allahabad, Allahabad, India.*

.

ABSTRACT

Silver doped titanium dioxide nanoparticles were synthesized by chemical reduction method. The prepared sample was characterized by UV-vis spectroscopy, Fourier transform infrared spectroscopy (FTIR), Transmission electron microscopy (TEM), X-ray diffraction (XRD). UV-visible absorption spectra of Ag doped TiO_2 a nanoparticle has been observed at 435nm. FTIR spectra of silver doped titanium dioxide nanoparticles have absorption band at 1550cm^{-1} corresponding to C=C and C-H group, band at 1678 cm^{-1}, 2262 cm^{-1}, 2402 cm^{-1}, 3702 cm^{-1} shows stretching of C-H, C=C, C=N, O-H, N-H groups respectively. The antibacterial activity of the sample was studied against bacterial strain: Pseudomonas aeruginosa by indicating Zone of inhibition by performing disc diffusion method. Pseudomonas aeruginosa is a gram negative bacterium and is multidrug resistant as well as antibiotic resistant that causes severe infection in human body and soft rot disease in plants. The results showed significant antibacterial activity against bacterial strain

Keywords: *Doping, TiO_2, Silver, FTIR*

1. INTRODUCTION

Silver as a metal nanoparticles have been extensively used as an antipathogens. The antimicrobial property of silver in its ionized state has been explored since time immemorial. But the nanosized of silver enhance its biological properties and make it more effective [1]. Not only as metal nanoparticles, silver along with some metal oxide as well as other materials have been tremendously used in various fields.[2-5]. Silver silica nanocomposites show effective antimicrobial properties against *E.coli* and *S.aureus* [6]. As we are very much aware of polymers and their excellent properties, they can be easily being incorporated in the matrix of polymer to form nanocomposites [7]. Besides others Titanium dioxide nanoparticles is one of the most widely studied semi-conducting photocatalysts for the degradation of organic contaminants from water and air, because of its physical and chemical stability, high catalytic activity, high oxidative power, low cost and ease of production [8–11]. In recent years TiO 2 has been used widely for the preparation of different types of nanomaterials, including nanoparticles, nanorods, nanowires, nanotubes, and mesoporous and nanoporous TiO 2 – containing materials [12]. Doping of TiO2 nanoparticles with silver is usualy done to create heterojuntion which ranges from 10 to 100 nm in size in between the surface of silver in metallic form and that of TiO2 nanoparticles [13-15].

Titanium dioxide (TiO2), particularly in its nanoscale range, has evolved a great deal of interest over decades, as it has plentiful potential applications. TiO_2 nanomaterials are of interesting in a broade range of applications such as photocatalysis, dye sensititized solar cells, gas sensors, photochromic devices, photo degradation of organic compounds, deactivation of microorganisms, organic synthesis and cells culture [16]. A number of researches have observed it to be an effective light activated photocatalyst, with strong bactericidal activity. However, its main disadvantage is its wide band-gap, meaning it is only really bactericidal when it absorbs UV light [17].

Silver modification of TiO2 reduces the band gap energy, allowing visible light to activate the material's photocatalytic activity [18]. Even small quantities of Ag–TiO2 nanoparticles (>2%wt) are able to produce a significant bactericidal effect when in contact with S. mutans under visible light [19].

TiO_2 NPs combined with silver (Ag) in the presence of UV light have been showing greater effect against the growth of E. coli compared with TiO_2 NPs without silver [20].

Here in this work we have synthesized Titanium dioxide nanoparticles and doped it with silver to enhance its physical and biological properties. Titanium dioxide nanoparticles itself has significant antimicrobial activity, but silver doping has much enhanced antibacterial activity against many pathogenic bacteria.

2. MATERIAL AND METHOD

2.1 Selection of pathogen

Pseudomonas aeruginosa MTCC number 10235 was purchased from MTCC Chandigarh in freeze dried condition and revived the culture in nutrient agar plates.

2.2 Synthesis of silver doped titanium dioxide nanoparticle

Synthesis of silver doped titanium dioxide nanoparticles can be done by several methods, here we have synthesized by using sodium borohydride as reducing agent at low temperature.

0.2gm of TiO_2 nanoparticles was added in 100ml of distilled water and was thoroughly homogenized in an ultra sonicator bath for 30 minutes. 30 ml 0.2mM silver nitrate solution was added in the above Chilled 30 ml of 0.2 mM sodium borohydride solution was added drop wise in the above solution with continuous stirring on magnetic stirrer. The pH was maintained at 10 adding NH_4OH.

3. Characterization

3.1 UV-Vis Spectroscopy

International Journal of Advance Research in Science and Engineering
Volume No.07, Issue No.05, May 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

The Ag doped TiO_2 nanoparticles were characterized by UV- Vis spectroscopy which revealed that the UV Vis exhibiting the typical surface Plasmon absorption maxima at the formation of silver nanoparticles by wavelength in the range of 400-450nm as observe. The highest peak observed is at 435nm in fig 1.

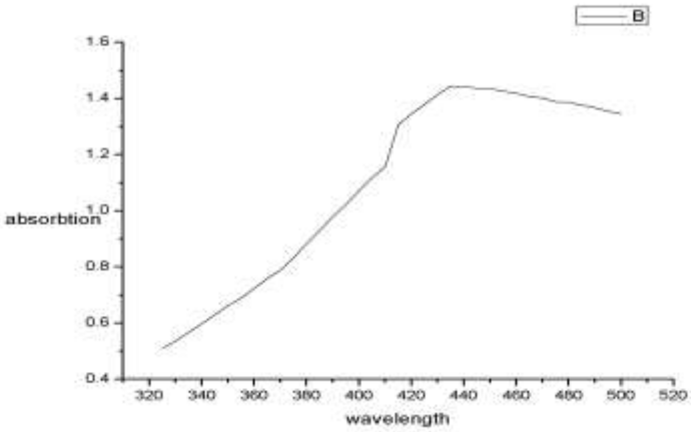


Fig.1. Absorption spectra of silver doped titanium dioxide nanoparticles

3.2 X ray Diffraction

The crystallite size D can be calculated by using Debye-Scherrer formula.

$$D = 0.94\, \lambda / \beta \cos \theta$$

where D is the average crystallite domain size perpendicular to the reflecting planes, λ is the X-ray wavelength, β is the full width at half maximum (FWHM), and θ is the diffraction angle. The crystallite size of the synthesized silver doped titanium dioxide nanoparticles obtained by Debye-Scherrer formula is 22 nm and the peakes were matched with the JCPDS file no. 88-1175 as shown in fig. 2.

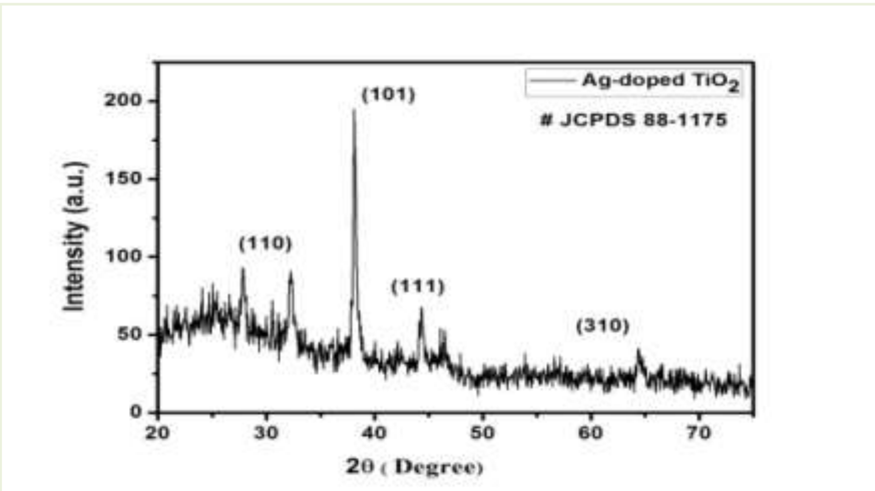


Fig. 2: X-ray diffraction pattern of silver doped titanium dioxide nanoparticles

3.3 Fourier transforms infrared spectroscopy

The common used region for infrared absorption spectroscopy is 4000 ~ 400 cm^{1} because the absorption radiation of most organic compounds and inorganic ions is within this region.FTIR spectra of silver doped titanium dioxide nanoparticles have absorption band at 1550cm^{-1} corresponding to C=C and C-H group, band at 1678 cm^{-1}, 2262 cm^{-1}, 2402 cm^{-1}, 3702 cm^{-1} shows stretching of C-H, C=C, C=N, O-H, N-H groups respectively as shown in fig 3.

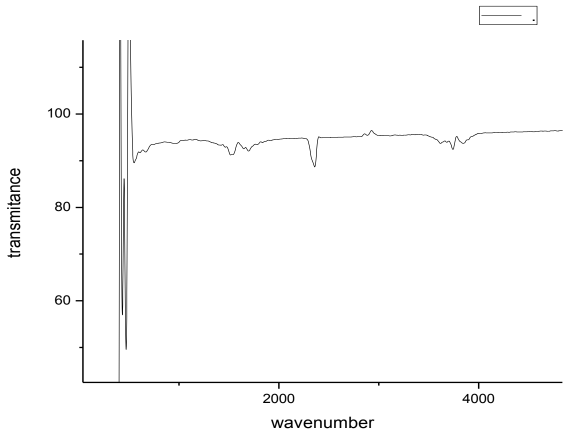
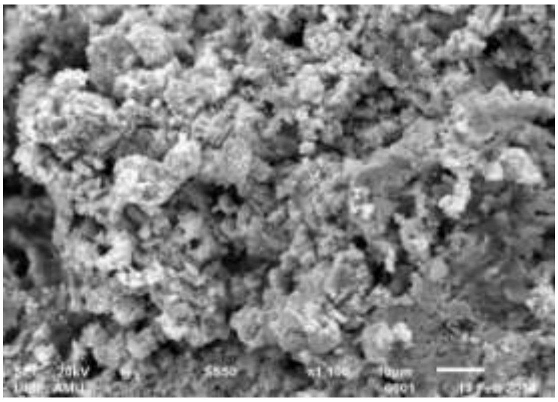


Fig.3. I.R. spectra of silver doped titanium dioxide nanoparticle

3.4 SEM Imaging

SEM analysis was performed by JEOL-JAPAN scanning machine from Aligarh Muslim University. The image shows silver doped titanium nanoparticles. Surface morphology of the particle reveals that the particles are not of equal size rather it is showing clusters of Particle as in fig.4. Edax image shows the Peakes of silver, titanium and oxygen which confirms the Presence of silver doped Titanium dioxide nanoparticle in fig.5.



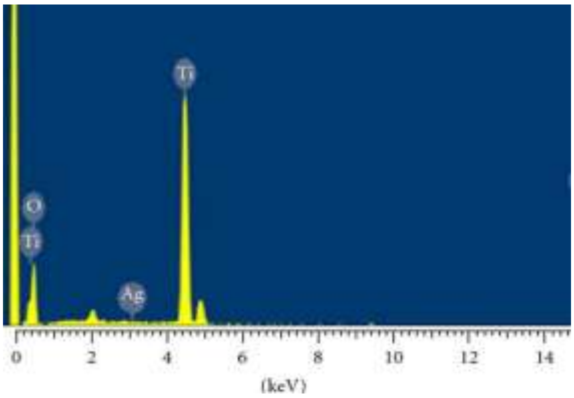


Fig: 4: SEM image of silver doped titanium dioxide nanoparticle

Fig.5: Energy dispersive X-ray analysis of silver doped nanoparticle

4. ANTIBACTERIAL ACTIVITY OF AG/TIO_2.

4.1 Disc diffusion method

The antibacterial activity of the synthesized silver doped titanium dioxide Nanoparticles was tested using the standard disc Diffusion method, leading to the inhibition of bacterial growth. We have used lower concentrations (10, 30, 50, 70 and 90 µg/ml) of Ag/TiO2 Nps to determine zone of inhibition. We have ciprofloxacin an antibiotic as positive control.

5. Results and Discussion

The quantitative evaluation of Silver doped titanium dioxide nanoparticles showed broad spectrum antibacterial property against Pseudomonas aeruginosa as compared to that of conventional antibiotic ciprofloxacin that can be clearly observed by the diameter (in mm) of the zone of growth inhibition of bacteria around the diffused discs. As the concentration of Ag-Tio2 nanoparticles increased the diameter of inhibitory zone get enhanced, as shown in table 1. The antibiotic ciprofloxacin shows resistance against bacterial pathogens to some extent as compared to that of silver doped titanium dioxide nanoparticles.
Here in fig.6 the graphical representation has clearly explained the inhibitory effect of Ag/TiO2 nanoparticles.

TABLE: 1

Comparative study of antibacterial activity of silver doped titanium dioxide nanoparticles and antibiotic ciprofloxacin		
	Diameter of zone of inhibition (mm)	
Concentration in(µg/ml)	Ciprofloxacin (positive control)	Ag/TiO2
10	1	1
30	2	4
50	2.5	5
70	3	6.5
90	5	7

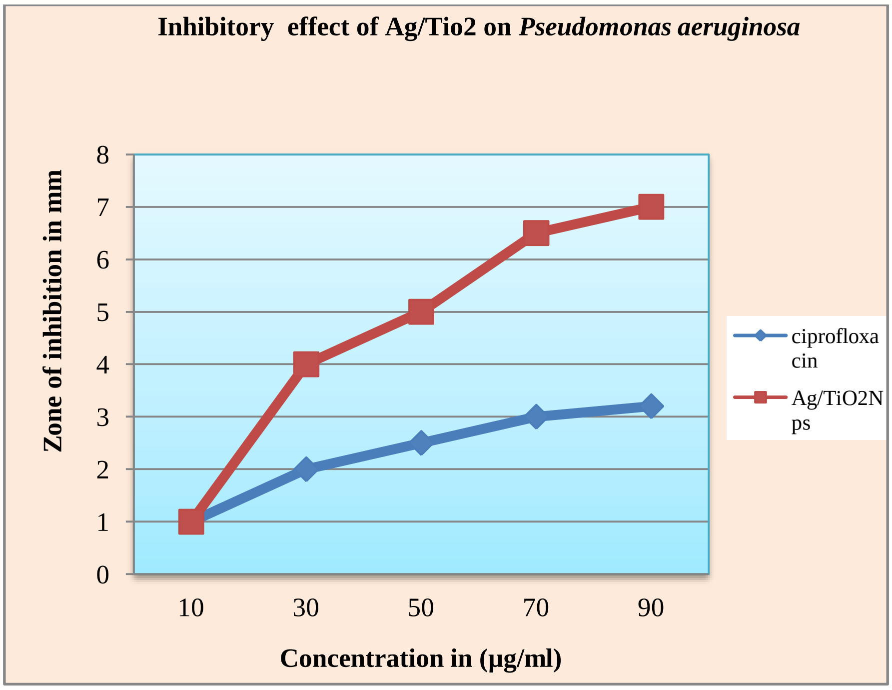


Fig. 6: Graphical represent of growth inhibitory effect of silver doped titanium dioxide nanoparticle

6. CONCLUSION

The importance in medical applications of silver and antibacterial activity of TiO2 together led researchers to think about the manufacture of silver doped titanium dioxide nanoparticles for food preparation surfaces, air conditioning filters, etc. This paper describes the synthesis of TiO2 containing different amounts of silver metal by the sol–gel route. Synthesis of silver doped titanium dioxide nanoparticles was confirmed by UV Vis measurement and presence of titanium, silver and oxygen confirmed by peaks of edax. Crystallite size was obtained to be 22 nm. Ag doped TiO2 nanoparticles show enhanced antibacterial activity rather than as by ciprofloxacin antibiotic. At concentration 90µg/ml the silver doped titanium dioxide nanoparticles show maximum growth inhibition.

7. FUTURE PROSPECTS

Due to mutidrug and antibiotic resistance of pathogenic bacteria silver doped titanium dioxide nanoparticles have proved to be good and convenient alternative. In future Ag/TiO2 nanoparticles can be commercially exploited in pharmaceutical companies, and medicine. Due to antibacterial properties it can be used for water treatment in purifiers. Manufacturing bandages for wound healing.

8. ACKNOWLEDGMENT

We are sincerely thankful to the Department of physics, University of Allahabad for providing UV characterization, FTIR, and XRD facility. We are also grateful to the Department of Botany, University of Allahabad for other required facility for the above research. The authors also thank NCEMP University of Allahabad for SEM facility. Great vote of thanks to all our labmates for giving their valuable and precious time for making this research work worth. Financial support was provided by UGC fellowship and contingency.

REFERENCES

1. Chauhan Pratima, MishraMini and Gupta Deepika: Potential Application of Nanoparticles as Antipathogens.Advanced Materials for Agriculture, Food, and Environmental Safety, *Scrivener Publishing LLC., 2014, 333-368*
2. Salome Egger, Rainer P. Lehmann, Murray J. Height, Martin J. Loessner, and Markus Schuppler, "Antimicrobial Properties of a Novel Silver-Silica Nanocomposite Material", *applied and environmental microbiology, , p. 2973–2976 Vol. 75, No. 9, May 2009*
3. Kanikireddy Vimala, Yallapu Murali Mohan, Kokkarachedu Varaprasad, Nagireddy Narayana Redd, Sakey Ravindra, Neppalli Sudhakar Naidu, Konduru Mohana Raju, "Fabrication of Curcumin Encapsulated Chitosan-PVA Silver Nanocomposite Films for Improved Antimicrobial Activity", *Journal of Biomaterials and Nanobiotechnology, 2011, 2, 55-6*
4. P.K. KhannaNarendra Singh, ShobhitCharan, V.V.V.S. Subbarao, R. Gokhale, U.P. Mulik, "Synthesis and characterization of Ag/PVA nanocomposites by chemical reduction method", *Materials Chemistry and Physics 93 (2005) 117–121*
5. Jun Sung Kim, DVM, phd,aEunyeKuk, MS,bKyeong Nam Yu, MS,a Jong-Ho Kim, MS,g Sung Jin Park, BS,a Hu Jang Lee, DVM, phd,c So Hyun Kim, DVM, phd,dyoung Kyung Park, DVM, MS,d Yong Ho Park, DVM, phd,dCheol-Yong Hwang, DVM, phd,e Yong-Kwon Kim, phd,f Yoon-Sik Lee, phd,gdae Hong Jeong, phd,b,4 Myung-Haing Cho, DVM, phd, "Antimicrobial effects of silver nanoparticles", *Nanomedicine: Nanotechnology, Biology, and Medicine 3 (2007) 95– 101*.
6. J. Loessner and Markus Schuppler Salome Egger, Rainer P. Lehmann, Murray J. Height, Martin, "Silver-Silica Nanocomposite Material Antimicrobial Properties of a Novel Silver-Silica Nanocomposite Material", *applied and environmental microbiology, may 2009, p. 2973–2976*
7. R.A. de Barros,W.M. de Azevedo, "Polyaniline/silver nanocomposites preparation under extreme or non-classical conditions", *Synthetic Metals 158 (2008) 922–926*
8. Anpo, M., Kishiguchi, S., Ichihashi, Y., Takeuchi, M., Yamashita, H., Ikeue, K., Morin, B., Davidson, A., Che, M., 2001. The design and development of second-generation titanium oxide photocatalysts able to operate under visible light irradiation by applying a metal ion-implantation method. *Res. Chem. Intermediates 27 (4–5), 459–467*.

9. Kim, S.H., Kwak, S.Y., Sohn, B.H., Park, T.H., 2003. Design of TiO2 nanoparticle self-assembled aromatic polyamide thin-filmcomposite (TFC) membrane as an approach to solve biofouling problem. J. Membr. Sci. 211, 157–165.
10. Huanjun Zhang And Guohua Chen, "Potent Antibacterial Activities ofAg/TiO2 Nanocomposite Powders Synthesized by a One-Pot Sol-Gel Method", Environ. Sci. Technol. 2009, 43, 2905–2910
11. A. Kedziora, W. Strek, L. Kepinski, G. Bugla-Ploskonska, W. Doroszkiewicz, "Synthesis and antibacterial activity of novel titanium dioxide doped with silver", *J Sol-Gel Sci Technol (2012) 62:79–86.*
12. Magdalena Lungu, S¸ tefaniaGavriliu, Elena Enescu, Ioana Ion, Alexandra Bra˘tulescu, Grigore Miha˘escu • Luminit¸aMa˘rut¸escu, Mariana Carmen Chifiriuc, "Silver titanium dioxide nanocomposites as effective antimicrobial and antibiofilm agents", J *Nanopart Res (2014) 16:2203.*
13. Maria Eugenia Noriega-Trevino, Claudia Cristina Quintera-Gonzalez, Jose Elpidio, Morales-Sanchez, Jesus Maria Guajardo-Patheco, Martia Eugenia Compean- Jasso, Facundo Ruiz, "Aggregation study of Ag TiO_2 Composites", *Material science and applications, 2011. 2. 1719-1723.*
14. Wei-Ping Xu, Le-Cheng Zhang, Jian-Ping Li, Yang Lu, Hui-Hui Li, Yi-Ni Ma, Wei-Di Wang and Shu-Hong Yu, "Facile synthesis of silver@graphene oxide nanocomposites and their enhanced antibacterial properties", *J. Mater. Chem., 2011, 21, 4593.*
15. Banerjee, A.N. The design, fabrication, and photocatalytic utility of nanostructured semiconductors: focus on TiO_2-based nanostructures. (2011) *Nanotechnology Sci Appl 4: 35–65*
16. Ashkarran, A.A., Aghigh, S.M., Farahani, N.J. Visible light photo-and bioactivity of Ag/TiO_2 nanocomposite with various silver contents. (2011) *Current Applied Physics 11(4): 1048-1055.*
17. Chen S, Liu X, Liu Y, Cao G. The preparation of nitrogen-doped TiO2-xNx photocatalyst coated on hollow glass microbeads. *Appl Surf Sci 2007;253:3077–82.*
18. C. Chambers a, S.B. Stewart b, B. Suc , H.F. Jenkinsond, J.R. Sandy a, A.J. Irelanda, Silver doped titanium dioxide nanoparticles as antimicrobial additives to dental polymers, *dental mat e r ial s 3 3 (2 0 1 7) e115–e123.*
19. Zhanga ZL, Wanc M, Ma YL. Enhanced photovoltaic effect of TiO2-based composite ZnFe2O4/TiO2. *J Photochem Photobiol A 2012;233:15–9.*
20. Kisch H, Macyk W. Visible-light photocatalysis by modified titania. *ChemPhysChem 2002;3:399–400*