

Anti Microbial Activity of Nanosilverferrite Composite

T. Kondala Rao¹, Ch Jagadeeswara Rao², I.V Kasi Viswanath³, Y L N Murthy⁴

Professor of Chemistry, Dept. of Humanities and Basic Sciences, Sri Sivani College of Engineering, Srikakulam, Andhra Pradesh, India¹

Scientist, Corrosion Science and Technology Group, IGCAR, Kalpakkam, Tamilnadu , India²

Associate Professor, Dept. of Chemistry, K.L.University, Vaddeswaram, india³

Professor, Dept. of Organic Chemistry, Andhra University, Visakhapatnam, Andhra Pradesh, India⁴

ABSTRACT: A new silver ferrite nanocomposite, AgFeO₂, was prepared by co-precipitation procedure. The synthesized AgFeO₂ was characterized by X-ray diffraction, Scanning electron microscopy, and vibrating Sample magnetometer. It is paramagnetic. The antibacterial activity of this composite was investigated against some Gram-positive and Gram-negative bacteria and compared with those of silver nanoparticles and some standard antibacterial drugs. The AgFeO₂ nanocomposite shows higher antibacterial activity than those of Ag nano particles and some standard antibacterial drugs.

KEYWORDS: Nano Silver ferrite composite, Antibacterial activity.Target Drug delivery

I. INTRODUCTION

Silver nanoparticles (AgNPs) have attracted considerable attention and have been used as antimicrobial agent for a long time because of their stability, and broad spectrum antibacterial activity and microorganisms, which develop resistance to Antibiotics [1]. Ag nanoparticles are clusters of silver atoms (Ag) that range in diameter from 1to100nm. At the present time, silver nanoparticles are emerging as a new generation of antibacterial agent [2]; which have been used in, medical applications [3-5], and antibacterial water filter [6]. Among metallic nanomaterials like copper, zinc, titanium and gold, silver nanoparticles have higher antibacterial effect [2]. Recent studies have revealed that silver nanoparticles have superior antibacterial activity compared to that of other silver compounds as well as bulk silver. The uses of silver nanoparticles are potential to treat the water which frequently infected with antibiotic resistant bacteria [7]. Treatment of this water usually requires using high concentrated chlorine compounds which may cause a high risk of human cancer due to the formation of halomethanes [8].

The principle characteristic of AgNPs is their ultra small size which leads to high surface area per mass as is the case with all nanomaterials. Unique interactions with bacteria and virus have been demonstrated of AgNPs of certain size ranges and shapes. Usually, smaller Ag nanoparticles are used due to the higher bactericidal ability than larger ones [3,9]. To prevent the aggregation of silvernanoparticles a wide range of materials such as TiO₂ [10], SiO₂ [11], zeolites [12], and activated carbon fibers [13] have been employed to support AgNPs.

It has been reported that the mode of antibacterial action of silver ions is probably similar to that of silver nanoparticles [14]. Some reports proposed that AgNPs form depositions on the microbial cell wall and exert toxic effect by inactivating their essential enzymes by forming complexes with the catalytic sulphur of thiol groups in cysteine residues and through the production of reactive oxygen species such as superoxide anions, hydrogen peroxide, and hydroxyl radicals [15]. In addition to their direct bactericidal activity, AgNPs are also known to disrupt the biofilm formation [16].

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

Another problem encountering the application of argentiferous based antibacterial materials is the recovery of the disinfectants. The argyria and clinical toxicity of AgNPs to mammiferous cells and other aquatic organism has been confirmed by many researchers [17]. Therefore, it is necessary to separate the Ag based disinfectants from water solution after treatment. It would be desirable to support the Ag nanoparticles on a specific matrix, with their positions controlled using methods such as an external magnetic field. Magnetic nanoparticles can be manipulated by an external magnetic field, and therefore magnetic nanoparticles coated with AgNPs could be readily separated from the bulk solution. The separation of magnetic composite by a magnetic field is more effective than filtration or centrifugation [18].

Among the materials available to create magnetic nanosphere, Fe_3O_4 is widely used because it is non-toxic and easily prepared [19]. Ag/ Fe_3O_4 magnetic composites have been successfully synthesized by many groups and the antibacterial performance is also investigated [20–26]. Generally, two-step reactions are designed for the synthesis of Ag/ Fe_3O_4 composite, namely nanostructured Fe_3O_4 is synthesized first, and then Ag particles reduced by suitable agents grow on the Fe_3O_4 sample [27–32].

Generally, metal nanoparticles can be prepared and stabilized by physical and chemical methods; the chemical approach, such as chemical reduction, electrochemical techniques, and photo-chemical reduction is most widely used [33]. Studies have shown that the size, morphology, stability and properties (chemical and physical) of the metal nanoparticles are strongly influenced by the experimental conditions, the kinetics of interaction of metal ions with reducing agents, and adsorption processes of stabilizing agent with metal nanoparticles. Hence, the design of a synthesis method in which the size, morphology, stability and properties are controlled has become a major field of interest [33].

An impressive range of extremely novel and ingenious methods for nanosilver synthesis have been reported in the literature, although only a few have been adopted in main stream production. Chemical reduction is the most frequently applied method for the preparation of silver nanoparticles as stable, colloidal dispersions in water or organic solvents [34,35]. Commonly used reductants are borohydride, citrate, ascorbate, and elemental hydrogen [36-43]. The reduction of silver ions (Ag^+) in aqueous solution generally yields colloidal silver with particle diameters of several nanometers. Initially, the reduction of various complexes having Ag^+ ions leads to the formation of silver atoms (Ag^0), which is followed by agglomeration into oligomeric clusters [44,45,46]. and nanosilver ferrite nanocomposite, AgFeO_2 [47]. and it is used for antimicrobial activity on various gram negative and gram positive bacteria.

GRAM-NEGATIVE bacteria normally found in the gastrointestinal tract that can be responsible for disease in man (sepsis). Bacteria are considered gram-negative because of their characteristic staining properties under the microscope, where they either do not stain Crystal violet or are decolorized by alcohol during Gram's method of staining. This is a primary characteristic of bacteria that have a cell wall composed of a thin layer of peptidoglycan covered by an outer membrane of lipoprotein and lipopolysaccharide containing endotoxin. *E.coli* cause severe stomach cramps, diarrhoea (often bloody), and vomiting and perhaps slight fever. They produce a toxin that can attack the body in several areas: the gut (causing bloody diarrhoea), the kidneys (causing kidney failure), and sometimes the nervous system. *Pseudomonas aeruginosa* may cause infections in the body including premature and newly-born babies. These infections commonly involve the pulmonary tract, urinary tract infections, burns, wounds, and other blood infections[48].

GRAM-POSITIVE bacteria are those which retain the crystal violet stain or that are resistant to decolorization by alcohol during Gram's method of staining. This is a primary characteristic of bacteria whose cell wall is composed of a thick layer of peptidoglycan containing teichoic and lipoteichoic acid complexed to the peptidoglycan. If *staphylococcus aureus* enters the blood it can cause a number of problems in the body: bacteremia and sepsis, toxic shock syndrome (TSS), pneumonia meningitis osteomyelitis, endocarditis. *Bacillus*

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

subtilis bacteria can contaminate food, however, they seldom result in food poisoning. Some *Bacillus* organisms can cause more severe illnesses. *Bacillus anthracis*, for example, causes Anthrax[48].

II. EXPERIMENTAL

Materials and methods

All the chemicals used in this study are of analytical reagent grade. Silver nitrate, ferric nitrate, and sodium hydroxide procured from M/s. Merck and BDH [Analar] have been used as received. X-ray diffraction pattern of the composite was recorded using a Philips 1011 X-ray diffractometer (operating with 40 KV and 45 mA) with Cu K α (1.5406 Å) radiation. A Philips field effect (model XL 30) scanning electron microscope (SEM) with energy dispersive spectrometer (EDS) working at 30 kV was used to examine the surface morphology and elemental composition of the powders. The magnetization measurements of the samples were carried out at room temperature using a Lakeshore-7400 vibrating sample magnetometer (VSM) with the applied magnetic field in the range of -15 to 15 kG.

Synthesis of silver and AgFeO₂ nanoparticles

Silver nanoparticles were prepared according to the procedure reported by Lu and Chou [46]. Silver Ferrite nanoparticles were prepared according to the procedure reported by Murthy et al [47].

Antimicrobial disc method

100 micro liters of 10⁻³ dilute soil sample in nutrient agar media (3grams/100ml) is taken and Antimicrobial disc method is used. The microorganisms used in this work include *Bacillus subtilis* and *Staphylococcus aureus* (as Gram positive bacteria) and *Escherichia coli* and *Pseudomonas aeruginosa* (as Gram negative bacteria).

III. RESULTS AND DISCUSSION

The sizes of the nano silver and nanosilver ferrite particles annealed at 400°C calculated using the Scherer formula as 30nm, 4.5 nm [46],[47] respectively. The bactericidal activities of AgNPs and AgFeO₂ nanocomposite against the above mentioned bacteria were evaluated by determining the presence of inhibition zones(photo.1).

It is generally accepted that an inhibition zone diameter over 7 mm indicates that the tested compounds are active against the bacteria under investigation. It is observed that The antibacterial activity of AgFeO₂ composite against almost all tested bacteria is slightly higher than that of AgNPs (Table 2). Moreover, on comparing the biological activity of the AgFeO₂ nanocomposite with the standard drugs, the following results are obtained (Table 2& Fig.6).

Table 2. Antimicrobial activity of silver nanoparticles and nano silver ferrite particles

Compound	Concentration (mg/mL)	Inhibition Zone (mm)			
		<i>E. Coli</i>	<i>P. aeruginosa</i>	<i>S.aureus</i>	<i>B.subtilis</i>
AgNPs	10	10	9	12	14
	20	11	11	14	16
	40	12	12	15	18
Nano AgFeO ₂	10	12	10	15	18
	20	14	11	17	20
	40	16	13	18	23
Pencillin	10	12	NA	26	13
Streptomycin	10	16	NA	12	22
Cefixime	5	18	NA	NA	9
Amoxicillin	25	9	NA	28	23
Erythromycin	15	NA	NA	25	27

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

Note: Pencilline(10mg/disc), Streptomycin(10mg/disc), Cefixime(5mg/disc), Amoxicillin (25mg/disc), Erythromycin(10mg/disc), NA means no activity.

While all the five screened drugs are not effective against *P. Aeruginosa*, but $AgFeO_2$ found to be effective, (Fig.6). The antibacterial activity of $AgFeO_2$ against *E. coli* is higher than Amoxicillin, Erythromycin and Penicillin but less than Erythromycin and Cefixime drugs. The inhibitory effect of $AgFeO_2$ composite against *S. aureus*, is higher than Cefixime and Streptomycin but less than the other three examined drugs. The biological activity of this new synthesized nanocomposite against *B. subtilis* is also higher than Penicillin and Cefixime drugs. Apparently, the examined $AgFeO_2$ nanocomposite seems to be more effective against Gram-negative (*E. coli* and *P. aeruginosa*) bacteria. Although researchers have debated the mechanisms by which AgNPs exert toxicity to bacteria and other organisms for more than a decade, the very recent study by Alvarez et al. demonstrated that the antimicrobial activity of AgNPs is solely due to Ag^+ release. Therefore, the observation of higher antibacterial activity of the novel $AgFeO_2$ composite compared to AgNPs in our study can be attributed to the faster Ag^+ release rate from this composite.

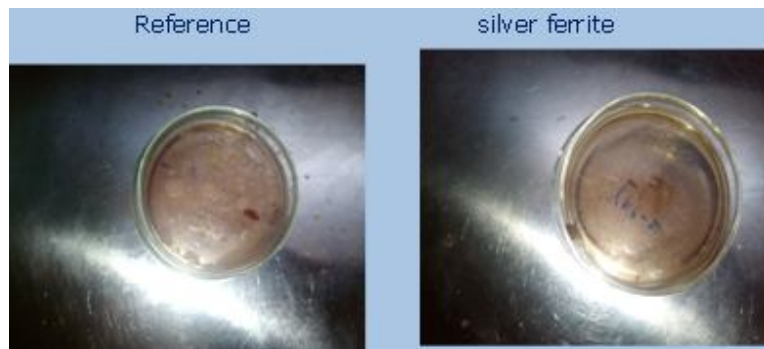


Photo 1. Photograph of the Reference and Silver ferrite during the experimental conditions

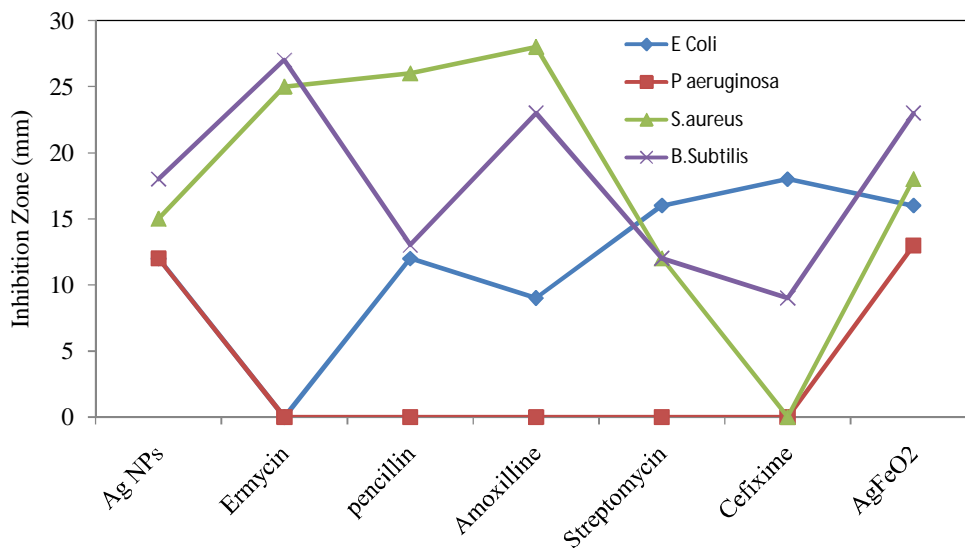


Fig.6. Effect of nanosilverferrite on E.Coli, P.aeruginosa B.Subtilis, S.aureus.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

IV.CONCLUSION

Now, The antibacterial activity of nano silver and AgFeO₂ composite is studied and reported that the AgFeO₂ nanocomposite shows higher antibacterial activity not only than AgNPs but also than some standard antibacterial drugs. In addition to the higher inhibitory effects of nanosilver ferrite composite compared with AgNPs, The nanosilver ferrite possess magnetic nature. So it can be easily removed from water by using a magnetic field after its anti microbial action on water. Due to more Antibacterial,ferro/superparamagnetic and biocompatibility of nanosilverferrite. Its usage for Target drug delivery is also more commendable.

V.ACKNOWLEDGEMENTS

Authors are grateful to The Management, Sri Sivani College of Engineering, Srikakulam for providing the facilities. We are thankful to Mr. Ch. Sudhakar and Smt. Indira Priyadarshini, Faculty of microbiology, Govt. Degree & PG college, Srikakulam for their help in Antimicrobial studies. I am grateful to Department of Chemistry, Andhra University for support and knowledge sharing.

REFERENCES

- [1] Mahendra Q.Li.S., Lyon D.Y., Brunet L., Liga M.V., Li D., Alvarez P.J.J, "Antimicrobial nanomaterials for water disinfection and microbial control: potential applications and implications", *Water Research* Vol 42, PP 4591, 2008.
- [2] Rai M., Yadav A., Gade A., "Silvern nanoparticles as a new generation of antibacterials", *Biotechnology Advances* Vol 27,PP 76, 2009.
- [3] Lok C.N., Ho C.M., R.Chen R., He Q.Y., Yu W.Y., Sun H., Tam P.K.H., Chiu J.F., Che C.M., "Proteomic analysis of the mode of antibacterial action of silver nanoparticles", *Journal of Proteome Research* Vol 5 ,PP 916, 2006.
- [4] Atyeh B.S., Costagliola M., Hayek S.N., Dibo S.A., "Effect of silver on burn wound infection control and healing", *Burns* Vol 33 ,PP139,2007.
- [5] Roe D., Karandikar B., Bonn-Savage N., Gibbins B., Rouillet J.B., "Antimicrobial surface functionalization of plastic catheters by silvern nanoparticles", *Journal of Antimicrobial Chemotherapy*Vol 61, PP869, 2008.
- [6] Jain P., Pradeep T., "Potential of silvern nanoparticle-coated polyurethane foam as an anti bacterial water filter", *Biotechnology and Bioengineering* Vol 90 ,PP 59, 2005.
- [7] Salvatorelli G., Medici S., Finzi G., DeLorenzi S., Quarti C., "Effectiveness of installing an antibacterial filter at water taps to prevent Legionella infections", *Journal of Hospital Infection* vol 61 ,PP 270, 2005.
- [8] Chang S.L., "The safety of water disinfection", *Annual Review of Public Health* Vol 3 ,PP 393, 1982.
- [9] Morones J.R., Elechiguerra J.L., Camacho A., Holt K., Kouri J.B., Ramirez J.T, Yacaman M.J., "The bactericidal effect of silver nanoparticles", *Nanotechnology* Vol 16, PP2346, 2005.
- [10] Akhavan O., "Lasting antibacterial activities of Ag-TiO₂/Ag-a-TiO₂ nanocomposite thin film photocatalysts under solar light irradiation", *Journal of Colloid and Interface Science* Vol 336,PP117, 2009.
- [11] Oh S. D., Lee S., Choi S.-H., Lee I.-S., Lee Y.-M., Chun J.-H., Park H.-J., "Synthesis of Ag and Ag-SiO₂ nanoparticles by g-irradiation and their antibacterial and antifungal efficiency against Salmonella enterica serovar Typhimurium and Botrytis cinerea, *Colloids and Surfaces A: Physicochemical and Engineering Aspects* Vol 275,PP 228, 2006.
- [12] Inoue Y., Hoshino M., Takahashi H., Noguchi T., Murata T., Kanzaki Y., Hamashima H., Sasatsu M., "Bactericidal activity of Ag-zeolite mediated by reactive oxygen species under aerated conditions", *Journal of Inorganic Biochemistry* Vol 92 ,PP 37, 2002 .
- [13] Chen S., Liu J., Zeng H., "Structure and antibacterial activity of silver-supporting activated carbonfibers, *Journal of MaterialsScience* Vol 40, PP 6223,2005.
- [14] Kong H., Jang J., " Antibacterial properties of novel poly(methyl methacrylate) nanofiber containing silver nanoparticles", *Langmuir* Vol 24, PP 2051,2008.
- [15] Feng Q.L., Wu J., Chen G.Q., Cui F.Z., Kim T.N., Kim J.O., "A mechanistic study of the antibacterial effect of silver ions on Escherichia coli and Staphylococcus aureus", *Journal of Biomedical Materials Research* Vol 52,PP 660,2000.
- [16] Kalishwaralal K., Barath Mani Kanth S., Pandian S.R.K., Deepak V., Gurunathan S., "Silvern nanoparticles impede the biofilm formation by Pseudomonas aeruginosa and Staphylococcus epidermidis", *Colloids and Surfaces B:Biointerfaces* Vol 79 ,PP 340,2010.
- [17] Chudasama B., Vala A.K., Andhariya N., Upadhyay R.V., Mehta R.V., "Enhanced antibacterial activity of bifunctional Fe₃O₄-Ag core-shell nanostructures", *Nano Research*Vol 2, PP 955,2009.
- [18] Kooti M., Saiahi S., Motamedi H. "Fabrication of silver-coated cobalt ferrite nanocomposite and the study of its antibacterial activity", *Journal of Magnetism and Magnetic Materials* Vol 333, PP 138, 2013.
- [19] Tomitaka A., Hirukawa A., Yamada T., Morishita S., Takemura Y., "Biocompatibility of various ferrite nanoparticles evaluated by in vitro cytotoxicity assays using HeLa cells", *Journal of Magnetism and Magnetic Materials* Vol 321, PP 1482,2009.
- [20] Xing G., Jiang J., Ying J.Y., Ji W., "Fe₃O₄-Ag nanocomposites for optical limiting—broad temporal response and low threshold", *Optics Express* Vol 18 ,PP 6183,2010.
- [21] Quang D.V., Sarawade P.B., Hilonga A., Kim J.-K., Chai Y.G., Kim S.H., Ryu J.-Y., Kim H.T., "Preparation of silver nanoparticle containing silica micro beads and investigation of their antibacterial activity", *Applied Surface Science* Vol 257 ,PP 6963, 2011.
- [22] Liu C.H., Zhou Z.D., Yu X., Lv B.Q., Mao J.F., Xiao D., Preparation and characterization of Fe₃O₄/Ag composite magnetic nanoparticles, *Inorganic Materials* Vol 44 ,PP291,2008.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

- [23] Iglesias-Silva E., Rivas J., Isidro L.M.L., Lopez-Quintela M.A., "Synthesis of silver-coated magnetite nanoparticles", Journal of Non-Crystalline Solids Vol 353 ,PP 829,2007.
- [24] Xia H., Cui B., Zhou J., Zhang L., Zhang J., Guo X., Guo H., "Synthesis and characterization of Fe₃O₄@C@Ag nanocomposites and their antibacterial performance", Applied Surface Science Vol 257,PP 9397,2011.
- [25] Chudasama B., Vala A.K., Andhariya N., Upadhyay R.V., Mehta R.V., "Antifungal activity of multifunctional Fe₃O₄-Ag nanocolloids", Journal of Magnetism and Magnetic Materials Vol 323 ,PP 1233,2011.
- [26] Gong P., Li H., He X., Wang K., Hu J., Tan W., Zhang S., Yang X., "Preparation and antibacterial activity of Fe₃O₄@Ag nanoparticles", Nanotechnology Vol 18 ,PP 285604, 2007.
- [27] Zheng B., Zhang M., Xiao D., Jin Y., Choi M.M.F, "Fast micro wave synthesis of Fe₃O₄ and Fe₃O₄/Ag magnetic nanoparticles using Fe²⁺ as precursor", Inorganic Materials Vol 46 ,PP 1106,2010.
- [28] Pan L., Li L., Xu M., Zhang Z., "Synthesis and electrocatalytic property of mono- dispersed Ag/Fe₃O₄ composite micro-sphere", Materials Science and Engineering Vol B176 PP 1123,2011.
- [29] Lee B., Koo S., "Silver reduction on the surface of magnetite nanoparticles using a coupling agent", Journal of Industrial and Engineering Chemistry, Vol 18, PP 1191,2012.
- [30] Jiang J., Gu H., Shao H., Devlin E., Papaefthymiou G.C., Ying J.Y., "Bifunctional, Fe₃O₄-Ag hetero dimer nanoparticles for two-photon fluorescence imaging and magnetic manipulation", Advanced Materials Vol 20, PP 4403,2008.
- [31] Liu J., Zhao Z., Feng H., Cui F., "One-pot synthesis of Ag-Fe₃O₄ nanocomposites in the absence of additional reductant and its potent antibacterial properties", Journal of Materials Chemistry Vol 22 ,PP 13891,2012.
- [32] Pucek R., Tucek J., Kilianova M., Panacek A., Kvitek L., Filip J., Kolar M., Tomaňkova K., Zboril R., "The targeted antibacterial and antifungal properties of magnetic nanocomposite of iron oxide and silver nanoparticles", Biomaterials Vol 32 ,PP 4704, 2011.
- [33] Wiley B., Sun Y., Xia Y., "Synthesis of silver nanostructures with controlled shapes and properties", Accounts of Chemical Research Vol 40 ,PP 1067,2007.
- [34] Tao A., Sinsermsuksakul P., Yang P., "Polyhedral silver nanocrystals with distinct scattering signatures", Angewandte Chemie International Edition Vol 45 ,PP 4597,2006.
- [35] Wiley B., Sun Y., Mayers B., Xia Y., "Shape-controlled synthesis of metal nanostructures: the case of silver", Chemistry A European Journal Vol 11,PP 454, 2005.
- [36] Shirtcliffe N., Nickel U., Schneider S., "Reproducible preparation of silver sols with small particlesize using borohydride reduction: for use as nuclei for preparation of larger particles", Journal of Colloid and Interface Science Vol 211,PP 122,1999.
- [37] Nickel U., Castell A., Poppl K., Schneider S., "A silver colloid produced by reduction with hydrazine as support for highly sensitive surface-enhanced Raman spectroscopy", Langmuir Vol 16 ,PP9087,2000.
- [38] Chou K.-S., Ren C.-Y., "Synthesis of nanosized silverparticles by chemical reduction method", Materials Chemistry and Physics Vol 64 ,PP241,2000.
- [39] Evanoff Jr D.D., Chumanov G., "Size-controlled synthesis of nanoparticles Silver-only aqueous suspensions via hydrogen reduction", The Journal of Physical Chemistry Vol B108, PP13948,2004.
- [40] Amato E., Diaz-Fernandez Y.A., Taglietti A., Pallavicini P., Pasotti L., Cucca L., Milanese C., Grisoli P., Dacarro C., Fernandez-Hechavarría J.M., Necchi V. "Synthesis characterization and antibacterial activity against Gram positive and Gram negative bacteria of biomimetically coated silvernanoparticles", Langmuir Vol 27,PP 9165,2011.
- [41] Merga G., Wilson R., Lynn G., Milosavljevic B.H., Meisel D., "Redox catalysis on naked silvernanoparticles", The Journal of Physical Chemistry Vol C111 ,PP 12220, 2007.
- [42] Ahmadi T.S., Wang Z.L., Green T.C., Henglein A., El-Sayed M.A., "Shape-controlled synthesis of colloidal platinum nanoparticles", Science Vol 272 ,PP 1924,1996.
- [43] Le A.-T., Tam L.T., Tam P.D., Huy P.T., Huy T.Q., Hieu N.V., Kudrinskiy A.A., Krutyakov Y.A., "Synthesis of oleic acid-stabilized silver nanoparticles and analysis of their antibacterial activity", Materials Science and Engineering Vol C30 ,PP 910, 2010.
- [44] Guzman M., Dille J., Godet S., "Synthesis and antibacterial activity of silver nanoparticles against Gram-positive and Gram-negative bacteria", Nanomedicine: Nanotechnology, Biology and Medicine Vol 8 ,PP 37,2012.
- [45] Ghaseminezhad S.M., Hamed S., Shojaosadati S.A., "Green synthesis of silver nanoparticles by a novel method: comparative study of their properties", Carbohydrate Polymers Vol 89 ,PP 467,2012.
- [46] Lu Y.C., Chou K.S., "A simple and effective route for the synthesis of nano-silver colloidal dispersions", Journal of the Chinese Institute of Chemical Engineers Vol 39 ,PP 673,2008.
- [47] Murthy Y.L.N., Kondala Rao T., Kasi Viswanath I.V., Rajendra Singh, "Synthesis and characterization of nano silver ferrite composite", Journal of Magnetism and Magnetic Materials Vol 322 ,PP 2071,2010.
- [48] web pages on bacteria: en.wikipedia.org/wiki.

BIOGRAPHY

Dr. Kondala Rao Tata (corresponding Author) is Presently working as a professor of chemistry in Sri Sivani College of Engineering, Srikakulam, Andhra Pradesh, India. He has 36 years of Teaching Experience, did his Ph.D on Nanomaterials. He has 9 years of research experience, His research interests are synthesis of New active nanomaterials. He published 8 research papers in international Journals and also presented research papers on nano technology in 36 National/international conferences, Dr. Tata wrote 3 books on Chemistry, also acting as Reviewer and Editorial Board Member to Several International Journals, He got Best teacher Award from Govt. of Andhra Pradesh, (India) and Chemical Society of India. Bharat jyothi award from India international friendship Society. He organized several National Seminars.