Antibacterial and photoluminescence activity of synthesized Ag NPs

E.Nirmala Devi [a*] ,T.Subba Rao [b],

[a]*Research scholar in physics, Rayalaseema University, Kurnool – 518007 (AP, India)*

[b] *Dept of Physics ,S.K.University Ananthapurma-515003(AP, India)*

***Correspinding Author :** *nirmalajakki@gmail.com*

Abstract

Silver nanoparticles (Ag NPs) were synthesized through sol-gel method. The prepared Ag NPs were characterized from various techniques such as X-ray diffractometer (XRD), Fourier Transform Infra Red (FTIR) Spectroscopy for structural property investigations and high resolution transmission electron spectroscopy (HR-TEM). It was observed that the Ag NPs were crystallized in face centered cubic crystal structure with an average crystalline average size of 25.4 nm as confirmed from XRD. Also HR-TEM studies reveal the formation of Ag NPs with face centered cubic nano structure. FTIR spectra exhibits the occurrence of different functional groups and their stretching / bending vibrations in the formation of Ag NPs. Further studied on antibacterial activity were done by the prepared Ag NPs on Klebsiella pneumoniae and Staphylococcus aureus organisms for the group of gram negative and gram positive bacteria by well diffusion method on enrichment media. The end of result found exhibit the zone of inhibition confirming the antibacterial activity. Finally the investigated outcome confirms the Ag NPs are potential candidates for antimicrobial activity applications as well as photoluminescence activity.

Key words: Ag NPs, characterization, antibacterial activity, photoluminescence

Introduction

The antibacterial and photoluminescence activity of silver has been known since earliest times, and the metal compound has been generally used for containers for liquid, coins, shavings, foils, sutures etc. Commonly, Ag NPs prepared and stabilized using physical, chemical and green methods. Now days, numerous methods have been reported to prepared metal nanoparticles. Virous forms of silver compound such as in the form of salts, metals and nanoparticles have been useful to medical products to prevent microbial infections. In the recent days, silver nanoparticle has more attention in healthcare associated fields, due to their unique properties and broad spectrum antimicrobial properties. Therefore, Ag NPs are used in biomedical applications, cosmetics, food industry, clothing and water purification [1-4]. AgNPs have already been reported to be effective in various microbes, including Gram-negative bacteria (Escherichia coli,

Pseudomonas aeruginosa, and Salmonella typhimurium), Grampositive bacteria (Staphylococcus aureus, Enterococcus faecium. Nanotechnology has attracted much interest in the scientific community around the globe since it acts as a effective intermediary between bulk and atomic scale structures [5]. The physical properties of the bulk materials remains constant regardless of the size whereas at nanoscale, the properties of the materials varies with size and also much significance is given to the percentage of the atoms at the surface of the materials. Nanotechnology has set out prominent applications in the field of energy storage, chemical sensors, electrochromic and photochromic modulation devices, photocatalytic paints, medicinal and pharmaceutical applications [6]. A substantial volume of new materials such as ceramics, polymers and graphene are making their way into the market with vast number of applications. Silver nanoparticles occupied a prominent place in our day to day life due to their antimicrobial properties [7]. Silver is the least toxic and silver nanoparticles has a potential in wound healing and ulcers, biotechnology water treatment and textile engineering. Since silver nanoparticles are less reactive, they can be used in antibacterial and anticancer activities. Silver nanoparticles exhibit surface plasmon resonance due to the absorption and scattering of light in visible region [8-9]. Silver nanoparticles are extensively used in catalysis, electronics and optical fields due to their unique size dependent properties.

Synthesis method

Analytical grade $AgNO_3$, CH_3COOH, NaOH and $N_2H_4.H_2O$ were used for the synthesis of Ag NPs. All glass wares were washed carefully and rinsed with deionized water. Silver nanoparticles (Ag NPs) were synthesized by chemical reduction method using $N_2H_4.H_2O$ as reducing agent. 1mM of $AgNO_3$ in 100 ml dionisezed stirring for 30minutes after that 0.1M of citric acid, 0.1M of sodium hydroxide was added drop wise and stirred constantly. In the above solution 20ml of $N_2H_4.H_2O$ was added and stirred vigorously. The solution turned black after addition of $N_2H_4.H_2O$ solution which confirms the silver ions was reduced. The solution was then stirred for 3 hours at room temperature. After that the solution was transparent and silver particles shining inside the flask. The particles were collected using filter paper [10].

Results and discussion

XRD Analysis:

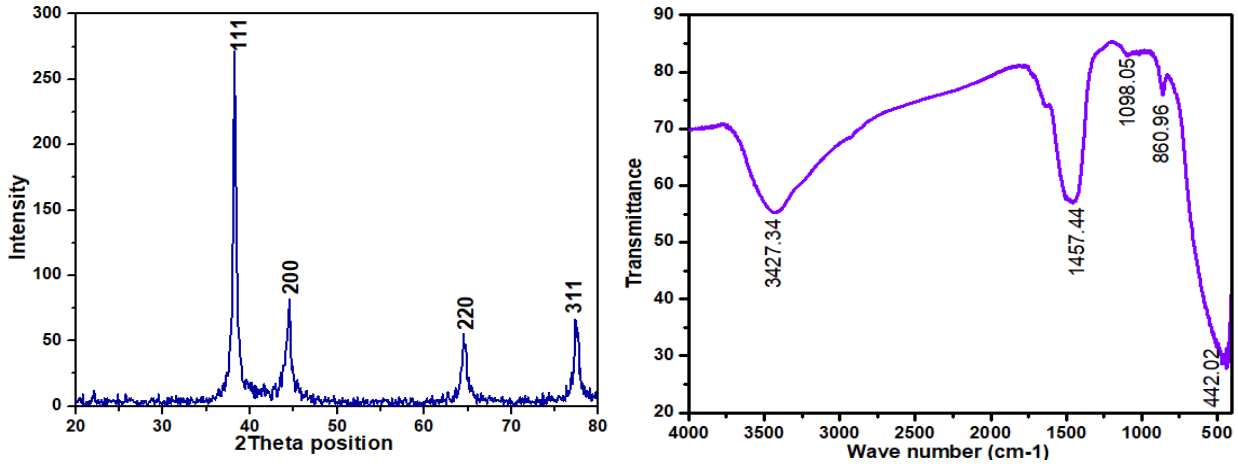


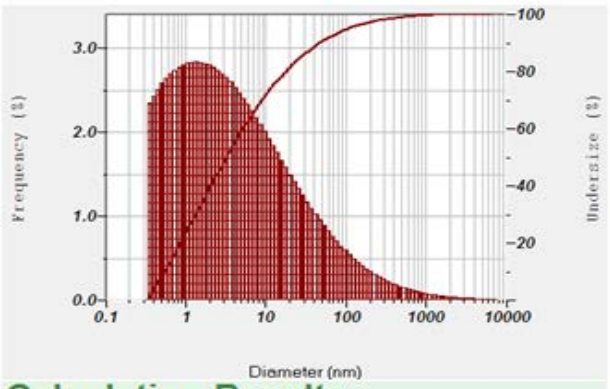
Fig. 1 XRD pattern and FTIR spectra of Ag NPs

XRD analysis

To study the crystallographic structure of the Ag NPs, XRD analysis has been carried out. The crystalline nature of the sol-gel synthesized AgNPs was determined by X-ray diffraction (XRD). The XRD peaks revealed that crystalline AgNPs were formed by the reduction of the Ag+ ions using the hydrazine hydrate [11]. The Bragg reflections with 2θ position of 38.6º, 44.35º, 64.6º and 78.98 corresponded to the (111), (200), (220) and (311) sets of the lattice planes, respectively, and matched well with JCPDS Data Card No: 04-0783. These sol-gel synthesized AgNPs have a cubic crystal system. The average size of the sol-gel synthesized AgNPs was assessed using the Debye–Scherrer equation.

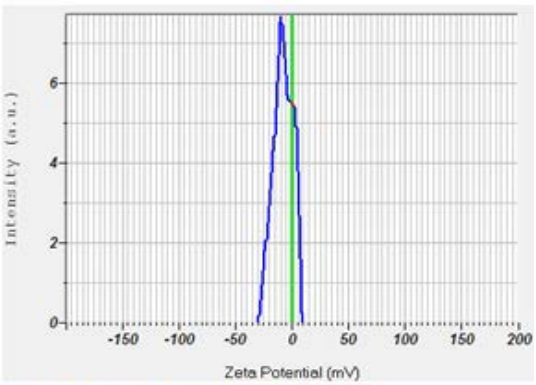
FTIR spectra analysis

The results of FTIR spectra of this study display different stretches of bond at different peaks. Ag NPs were dried at 80^{o}C and crushed with anhydrous Potassium Bromide (KBr) to form a pellet and characterized in FTIR at the absorption frequency from 4000 cm-1 to 400 cm-1 [12]. The stretching vibration bond from 500-700 cm^{-1} correlated to the metal oxide bond of Ag Nps. A sharp peak at 800-1600 cm^{-1} confirms the presence of (C=O), C-C, C-N and C-OH. The small band at 3000 - 3500 cm^{-1} is due to the presence of OH group.



Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	32.8 nm	189.1 nm	1.4 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	32.8 nm	189.1 nm	1.4 nm



Calculation Results

Peak No.	Zeta Potential	Electrophoretic Mobility
1	-9.6 mV	-0.000074 cm2/Vs
2	--- mV	--- cm2/Vs
3	--- mV	--- cm2/Vs

Fig.2 the DLS and Zeta potential analysis of Ag NPs

The Ag NPs was dissolved in aqueous solution to DLS analysis of particles size and zeta potentials. Ag NPs showed mean particle size of 32.8nm. The Ag NPs revealed PDI value of 0.01, indicating that they are polydispersed as shown in Fig. 2. The zeta potential Ag NPs exhibited mean surface charge of -9.6mV as shown in Fig. 2. NPs size in nano range scale affects both in-vivo performance and physical stability of the drug delivery systems. Ag NPs were found to be well in nano size when studied through zetasizer.

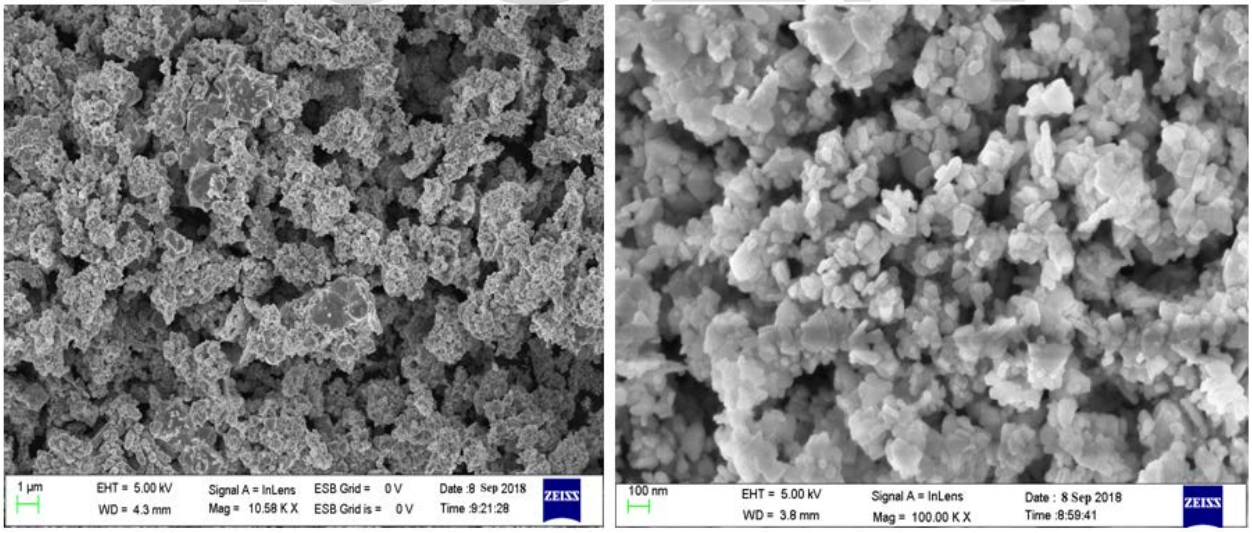


Fig . 3 FE-SEM images of Ag NPs

The surface morphology of the Ag NPs was analyzed by FE-SEM fig.3 showed the presence of partially spherical shape and some of the particles rod like structure with agglomeration. This

result strongly confirms that hydrazine hydrate might act as a reducing agent in the production of silver nanoparticles (13).

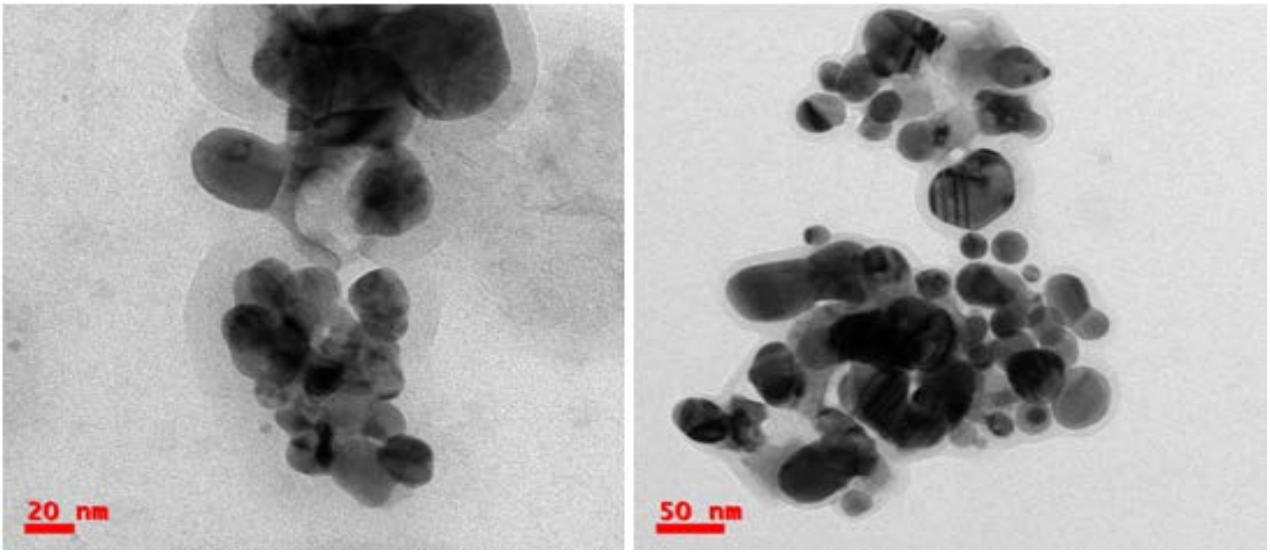


Fig. 4 HR-TEM images of Ag NPs

The carried out high-resolution transmission electron microscopy (HR-TEM) to obtain information on the size and morphology of the sol-gel synthesized Ag NPs. The typical HR-TEM images of sol-gel synthesized Ag NPs are shown in Fig.4, with different magnifications. The HR-TEM images of sol-gel synthesized Ag NPs at different magnifications clearly revealed that the Ag NPs were spherical in shape and nearly monodisperse in nature. The images show that the diameter of the sol-gel synthesized Ag NPs nearly 20nm to 50nm, which was in good agreement with the XRD results.

Antibacterial activity of Ag NPs

Silver nanoparticles are considered to be a powerful antimicrobial, anti-fungal and antiviral agent. In particular, antimicrobial effects of Ag NPs have been utilized since Antique times due to their alluring chemical, physical and biological properties [14-15]. In this study, antimicrobial activity of Ag NPs was estimate against K. pneumonia a Gram-negative bacterium. Klebsiella infections commonly appear amid the sick patients who are acquiring treatments for other health problems and in now days this microorganism is becoming a multidrug resistance. As examined earlier, the antibacterial activity of Ag NPs was massive in obstruct the growth of bacteria. The results obtained from agar well diffusion bioassay method inferring a decrease in bacterial

colonies growth upon increasing concentration [16]. However, the exact mechanism involved in the killing effect of bacterial cells by Ag NPs is still unknown. However, a number of mechanisms have been deliberately explained to elucidate the bacterial activity of Ag NPs. It is reported that, Ag NPs due to their size (below 100 nm) may attach the surface of the bacterial cell membrane followed by interrupting the growth signaling pathway by modulating tyrosine phosphorylation of putative peptide substrates, critical for cell viability and division. It is known that nano-materials have strong inhibiting effects against a large spectrum of bacteria and other organisms, mainly Ag NPs exhibits strong activity against all the pathogenic organisms, which shows the potential large spectrum antibacterial activity [17]. The remarkable gain in the antibacterial functionality is ascribed to the interaction of the negatively charged cell walls of the pathogens with the positively charged cationic sites of the antimicrobial agent, which changes its chemical and physical properties. This action interrupts cell membrane functions and protein activity as well as the ability to multiply. In addition, the Ag NPs released silver ions, which produced more biocidal effect on the pathogenic organisms [18].

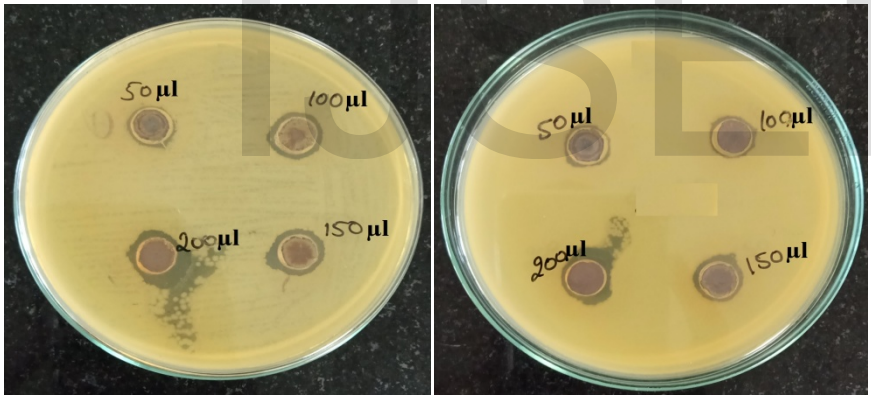


Fig. 5 Antibacterial activity of Ag NPs against *Klebsiella pneumoniae* (-ve) and *Staphylococcus aureus* (+ve)

Table.1 antibacterial activity of Ag NPs

S.No.	Compound	Zone of inhibition (Diameter in mm at conc. 3mg/mL)	
		Ag NPs	
		Klebsiella pneumoniae (-ve)	*Staphylococcus aureus* (+ve)

		50 µl	100µl	150µl	200µl	50µl	100µl	150µl	200µl
1.	**Ag NPs**	7± 0.5	9± 0.29	13± 0.31	15 ± 0.19	6± 0.15	8± 0.13	13 ± 0.21	16± 0.25

Photoluminescence activity of Ag Nps

The photoluminescence spectra from Ag Nps are shown in fig.6 PL emission spectra have been recorded at room temp at 320 nm excitation wavelength .The PL spectra are between 300 to 650nm refers to electron-hole recombination .The PL spectrum showed symmetric broad band with max intensity at 436nm and belongs to blue emission band and well defined sharp intensity speak with max intensity at 626 nm and belong to red emission band. These peaks correspond to SP intraband transition. When the of particle size decreased, the intensity of the PL increased indicating strong influence, So due to this shifts from blue to red (19, 20). The position and sharp of the PL speak is almost independent of the excitation wavelength.

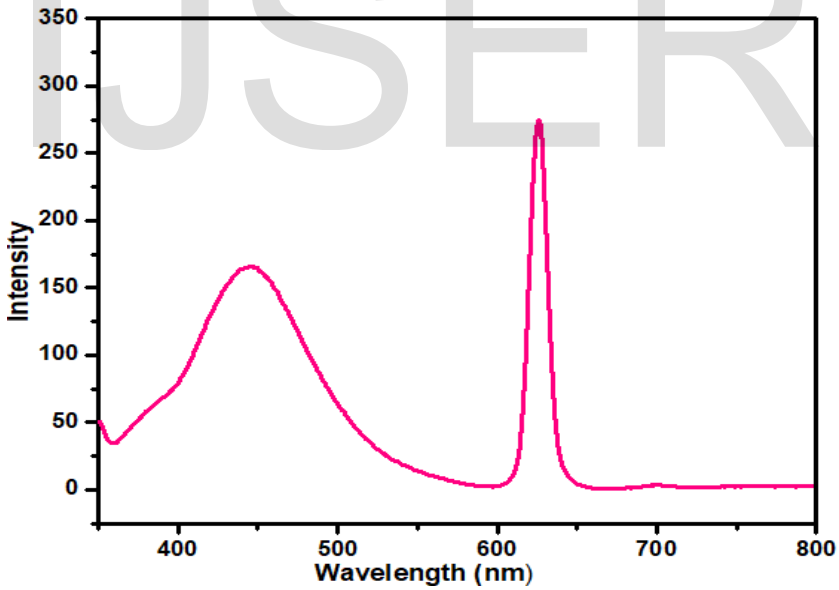


Fig. 6 photoluminescence spectra of Ag NPs

Conclusion

In the present study, Ag NPs was successfully synthesized using sol-gel method with the size of 25 to 40 nm in spherical. The synthesized Ag NPs shows the strong antibacterial activity against

the K. pneumonia. These results provide valuable knowledge for further investigations on the bactericidal activity of AgNPs on pathogenic bacteria. This study provides a strong base for future research in the development of new drug and supports the pharmaceutical industry.

Acknowledgement

I, E.Nirmala Devi, one of the co-authors of this research paper would like to convey my gratitude to Rayalaseema University for providing infrastructure and lab facilities for my research. I am indebted to them for their cooperation.

Reference:

1. M. Latha, M. Priyanka, P. Rajasekar, R. Manikandan, N.M. Prabhu, Biocompatibility and antibacterial activity of the *Adathoda vasica* Linn extract mediated silver nanoparticles, Microbial Pathogenesis 93 (2016) 88-94.
2. C. Contado, R. Argazzi, V. Amendola, Sedimentation field flow fractionation and optical absorption spectroscopy for a quantitative size characterization of silver nanoparticles, Journal of Chromatography A 1471 (2016) 178-185.
3. H. Zhang, D. Ning, L. Ma, J. Zheng, Silver deposition directed by self-assembled gold nanorods for amplified electrochemical immunoassay, Analytica chimica acta 902 (2016) 82-88.
4. M. Saravanan, S.K. Barik, D. MubarakAli, P. Prakash, A. Pugazhendhi, Synthesis of silver nanoparticles from *Bacillus brevis* (NCIM 2533) and their antibacterial activity against pathogenic bacteria, Microb Pathog 116 (2018) 221-226.
5. H. Wang, X.D. Gao, G.C. Zhou, L. Cai, W.B. Yao, In vitro and in vivo antioxidant activity of aqueous extract from Choerospondias axillaris fruit, Food Chemistry, 106 (2008) 888-895.
6. G.M. Sangaonkar, K.D. Pawar, Garcinia indica mediated biogenic synthesis of silver nanoparticles with antibacterial and antioxidant activities, Colloids and Surfaces B: Biointerfaces, 164 (2018) 210-217.
7. A.K. Mittal, J. Bhaumik, S. Kumar, U.C. Banerjee, Biosynthesis of silver nanoparticles: Elucidation of prospective mechanism and therapeutic potential, Journal of Colloid and Interface Science, 415 (2014)39-47.
8. C. Rajkuberan, S. Prabukumar, G. Sathishkumar, A. Wilson, K. Ravindran, S. Sivaramakrishnan, Facile synthesis of silver nanoparticles using Euphorbia antiquorum L. latex extract and evaluation of their biomedical perspectives as anticancer agents, Journal of Saudi Chemical Society, 21 (2017) 911-919.
9. M. Ott, V. Gogvadze, S. Orrenius, B. Zhivotovsky, Mitochondria, oxidative stress and cell death, Apoptosis, 12 (2007) 913-922.
10. S.J. Jang, I.J. Yang, C.O. Tettey, K.M. Kim, H.M. Shin, In-vitro anticancer activity of green synthesized silver nanoparticles on MCF-7 human breast cancer cells, Materials Science and Engineering: C, 68 (2016) 430-435.

11. C. Krishnaraj, P. Muthukumaran, R. Ramachandran, M.D. Balakumaran, P.T. Kalaichelvan, Acalypha indica Linn: Biogenic synthesis of silver and gold nanoparticles and their cytotoxic effects against MDAMB- 231, human breast cancer cells, Biotechnology Reports, 4 (2014) 42-49.
12. P.C. Nagajyothi, T.V.M. Sreekanth, J.-i. Lee, K.D. Lee, Mycosynthesis: Antibacterial, antioxidant and antiproliferative activities of silver nanoparticles synthesized from Inonotus obliquus (Chaga mushroom) extract, Journal of Photochemistry and Photobiology B: Biology, 130 (2014) 299-304.
13. M. Ovais, A.T. Khalil, A.Raza, M.A.Khan, I. Ahmad, N.U.Islam, M. Saravanan,M.F. Ubaid, M. Ali, Z.K. Shinwari, Green synthesis of silver nanoparticles via plant extracts: beginning a new era in cancer theranostics, Nanomedicine (Lond) 11 (2016)3157-3177.
14. G. Enkhtaivan, K.M.M. John, M. Pandurangan, J.H. Hur, A.S. Leutou, D.H. Kim,Extreme effects of Seabuckthorn extracts on influenza viruses and human cancer cellsand correlation between flavonol glycosides and biological activities of extracts, Saudi J. Biol. Sci. 24 (2017) 1646-1656.
15. G. Enkhtaivan, P. Muthuraman, D.H. Kim, B. Mistry, Discovery of berberine based derivatives as the anti-influenza agent through blocking of neuraminidase, Bioorg.Med. Chem. 25 (2017) 5185-5193.
16. A. Shakeel, A. Mudasir, L.S. Babu, I. Saiqa, A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise, J Adv. Res. 7 (2016) 17-28.
17. F. Faedmaleki, F.H. Shirazi, A.-A. Salarian, H.A. Ashtiani, H. Rastegar, Toxicity effect of silver nanoparticles on mice liver primary cell culture and HepG2 cell line, Iranian journal of pharmaceutical research: IJPR, 13 (2014) 235.
18. J.K. Patra, K.-H. Baek, Antibacterial activity and synergistic antibacterial potential of biosynthesized silver nanoparticles against foodborne pathogenic bacteria along with its anticandidal and antioxidant effects, Frontiers in microbiology, 8 (2017) 167.
19. Mozhdeh sharif,Davoud Dorranian,Effect of Nacl concentration of silver nanoparticles produced by 1024nm laser ablation in Nacl solution.In:Molecular crystal and liquid crystal,Volume.606(2015),36-46.
20. D.Gaspar & A.C Pimentel ,Ag and Sn Nanoparticles to enhance the Near –Infrared Absorption of a-Si:H thin films.In:Plasmonics.9(2014),1015-1023.