Recent Advances in Enhancing Antibacterial Property by Nanoparticles

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ABSTRACT

Antibacterial activity is related to compounds that locally kill bacteria or slow down their growth, without being in general toxic to surrounding tissue. In this review, we mentioned the antibacterial property of different nanoparticles and their effects. Antibacterial agents are significant in the textile industry, medicine, food packaging, and water disinfection. In this study, we compared the antibacterial property of silver nanoparticles; silver coated gold nanoparticles, zinc oxide nanoparticle and iron nanoparticles. Silver nanoparticles can also be produced by biological methods because of the abundance of renewable, cost-effective and biodegradable materials while comparing the properties Au nanoparticles are biocompatible and relatively simple to prepare. The Zn nanoparticles did not require the protection layer to prevent the degradation of the performance of the antibacterial effect. The study of iron nanoparticles pattern with bacteria interface which affects the antibacterial property of IO NP. Ag NP-GT can be employed as a cytotoxic bactericidal agent, whereas Ag NP-OB (7.5 nm) as a biocompatible bactericidal agent. Au-Ag NPs immobilization on cellulose paper could be a valuable antibacterial technology for applications such as food packaging, clothing, wound dressings, and other personal care products. The chitosan coating of IONP result in an interface that enhances ROS production, hence the antimicrobial activity.

Keywords: Antibacterial property, Silver nanoparticle, Zinc oxide nanoparticles, Gold nanoparticles, Iron oxide nanoparticles.

I. INTRODUCTION :

For the metallic nanoparticle synthesis, the chemical methods required are organic solvents and reactive reducing agents, which compromise environmental and biological risks [1,2]. Similarly, for the physical method includes sophisticated equipment and the conditions which are limited low production rate, high energy consumption and high cost[3]. Mostly chemogenic silver nanoparticles are cytotoxic and no biocompatible[4]. This is due to the contamination from chemical precursors, solvent toxicity and generation of hazardous by-products, etc.[5]. A study of biogenic and protein capped silver nanoparticles, and chemically synthesized silver nanoparticle came as a result that biogenic nanoparticle was more bactericidal than the chemically synthesized nanoparticles[6]. The present study compares the antibacterial activity of two biogenic; protein capped silver nanoparticle obtained from natural plant gums against gram negative and gram positive planktonic and biofilm bacteria.

Gold nanoparticles have proven to have high biocompatibility without cytotoxicity. Moreover, gold nanoparticles have been usedin the development of new drug delivery and other therapeutic methods[7,8]. The gold nanoparticles biocompatibility is not particularly antibacterial[9-11]. In this, they have studied the silver and gold nanoparticles combined in cellulose paper to create a safer of the active antibacterial material that is suitable for biomedical and food packaging purposes. The aim was to coat gold nanoparticles of varying size with silver by using a suitable procedure “silver

enhancement" which has been used in immune chromatography to provide signal amplification and thus enhance the sensitivity of detection[12,13]. The formed thin silver shell can provide effective antibacterial properties. This happens by releasing silver ions like silver and gold-silver nanoparticles, which is suitable for biomedical purposes[14].This antibacterial concept by varying the amount of silver and gold reagents, we were able to control the gold nanoparticle size as well as the thickness of the silver coating. To investigate the antibacterial effects of the silver and silver-coated gold nanoparticles, using a more practical approach, these silver-coated gold nanoparticles have excellent antibacterial activity against *E.coli* JM 109.

We can use zinc nanoparticles instead of silver for their antibacterial function and influence of the transmitters which was studied by using samples which are deposited by optimal conditions for the better mechanical endurance of the zinc nanoparticles on a glass substrate the Ti nanoparticles were used as the adhesion between zinc and glass[15-17]. Morphologically transmittance, antibacterial effects and mechanical endurance of the zinc /glass were investigated for different structures such as zinc /glass /titanium nanoparticles. The main aim was to evaluate the antimicrobial property of Chitosan coated IO NP, and it showed insignificant antimicrobial activity when it is not coated with Chitosan. Then it continued with the IONP which was synthesized and coated with positively charged Chitosan bimolecular and their antimicrobial activity against a gram positive and gramnegative kinetics. Finally, the data resulted that the interaction pattern at the interface plays a critical role in determining the antimicrobial activity of IONP [18-20].

2. ANTIBACTERIAL PROPERTIES OF NANOPARTICLES :

2.1. Antibacterial Property of Silver Nanoparticles

By adjusting the turbidity to 0.5 Mc Farland and growing a single colony overnight in the nutrient broth, the bacterial suspension was prepared Mueller Hinton Agar plate were introduced with this suspension. To this suspension, 5 mg of silver nanoparticles added. The plates with negative control were maintained with autoclaved gum-loaded wells. Erythromycin loaded culture plates were considered as a positive control [21]. Plates were kept bacteriological incubator at 37°C for 24 hours, and the zone of inhibition was calculated. To know the impact of free radicals on the bacterial activity silver nanoparticles MHA plates were supplemented with Ag nanoparticles at 5mg. The N-acetyl cysteine antioxidant was added to these plates at 10mm concentration. These plates were introduced with known CFU of bacteria by spreading plates, and then the bacteria were counted after 24 hours of incubation at 37°C.Then the nanosilver free control plates were maintained with NAC[22, 23].

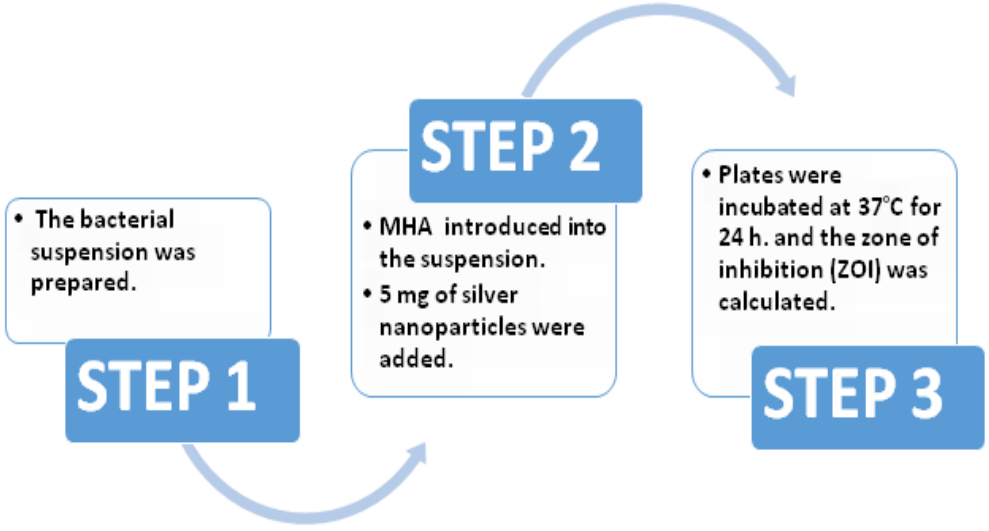

Fig. 1: Flowchart representing the synthesis of antibacterial body

2.2. The Impact of Free Radicals on the Bactericidal Activity of Silver Nanoparticles

The flowchart representing the free radicals impact on the antibacterial bodyis represented in figure 2.

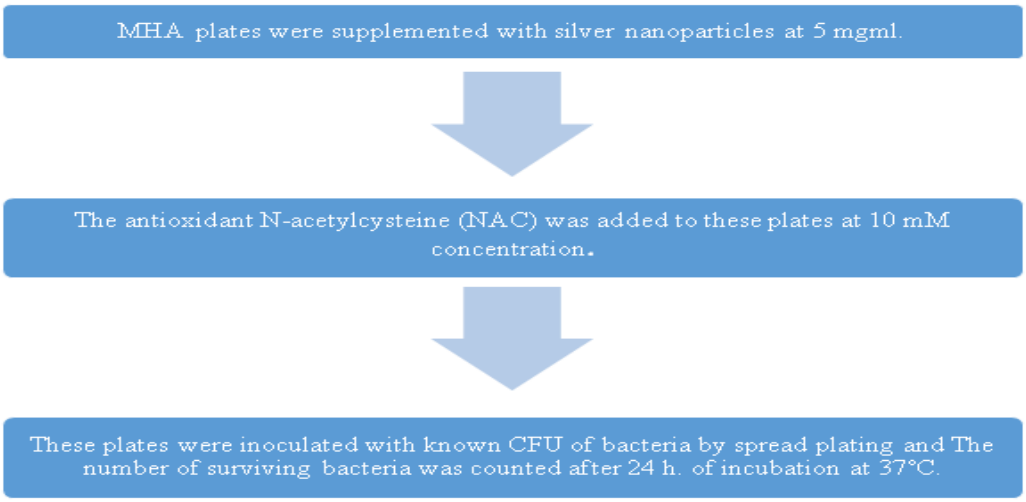

Fig. 2: Flowchart representing the free radicals impact on the antibacterial body

2.3. Antibacterial Property of Silver Coated Gold Nanoparticles

A flowchart representing the synthesis of silver-coated gold nanoparticles antibacterial propertyis given in figure 3. A single colony of *E.coli* JM109 from LB agar plates and introduced it in 5mL LB broth. The bacterial culture was grown overnight, and later it was centrifuged at 2500 for 10minutes diluted 1.0*104/mol in isotonic sodium chloride. The percolated 6mm BD Taxo blank paper discs with 20 µL of the six different NP solutions which was just enough solution to wet the disc. Then drying the sample at 37°C for 1 hour before soaking each in bacterial suspension by shaking at 37°C and 150rpm in an incubator, then at the different hour the solution from the different sample was taken, then measured the number of bacterial colonies on the plate[24-26]. Then the plate was undergone for the quantitative analysis of the antibacterial effects of the different nanoparticles.

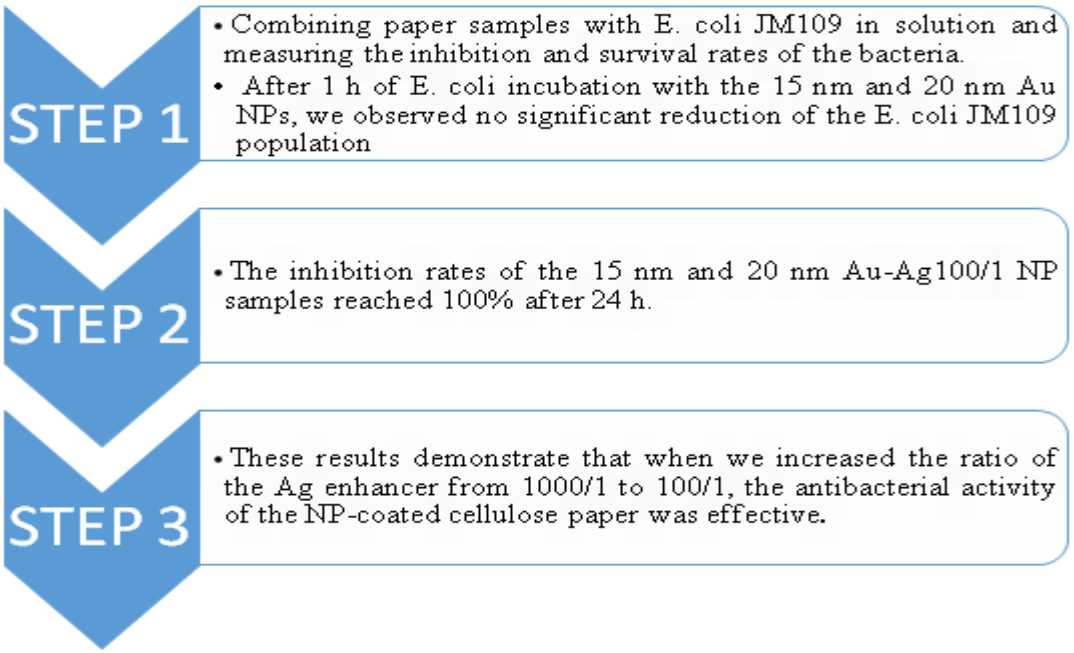

Fig. 3: Representing the synthesis of silver-coated gold nanoparticles and antibacterial property.

2.4. Antibacterial Property of Zinc Oxide Nanoparticles

The antibacterial test was zinc nanoparticles were done using the 'film–attachment' method[27,28]. They used the following microorganisms such as Staphylococcus aureus strain, American type culture collection no.6538 which is gram-positive Escherichia coli, and American type culture collection

number 8739. The test was performed by counting the number of bacteria after incubation at 35°C for 24 hours by using an RH 90% solution[29-40]. A flowchart representing the antibacterial property of zinc oxideis given in figure 4.

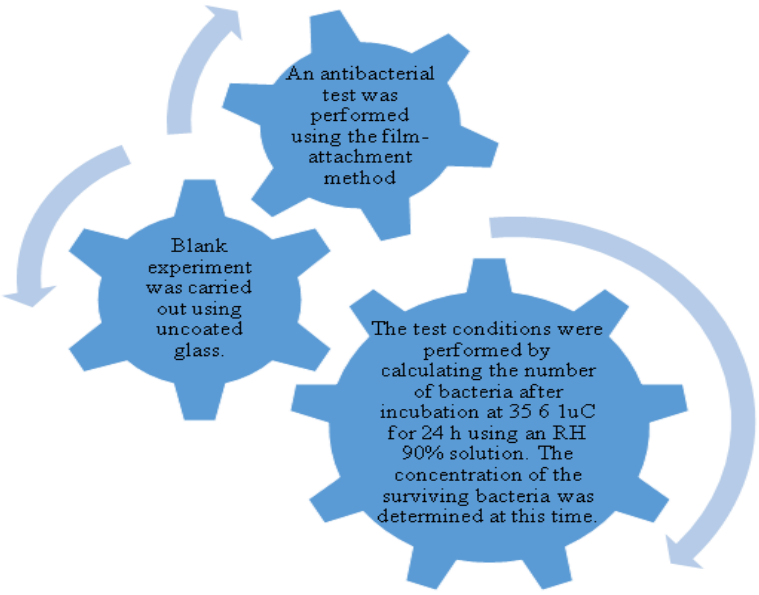

Fig.4: Flowchart representing the antibacterial property of zinc oxide

2.5. Antibacterial Property of Iron Oxide Nanoparticles

Effects of interaction pattern at IO NP bacteria interface is studied by using some bacteria such as *E Coli* and *E.subtilis* in presence and absence of different IO NP (both negative and positive) concentrations. The test organisms were prepared in nutrient broth by taking the loop of bacteria from the different slant culture, and it is culture overnight at 37°C and 150 rpm agitation [41-44]. The different concentration was taken. The IO NP solution prepared by dispersing IONP in sterilized broth. The nutrient broth is solicited for 10 minutes followed by UV radiation sterilization [45-54]. The mixtures without nanoparticles were taken, then slowly 20 µL of bacteria mother cultures were added to the different mixtures prepared in 96-well plate. The volumes were adjusted by adding nutrient broth to a final volume of 300 µL with nanoparticles. At the approximatelymid-log phase of bacterial growth, respective concentrations of nanoparticleswere added to the mixture [55-60].

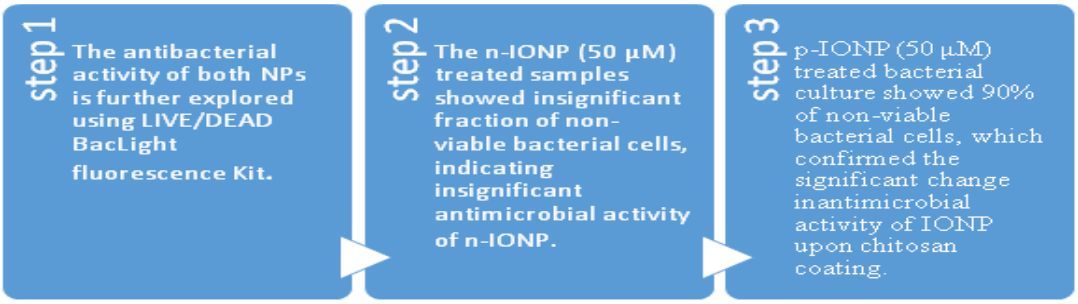

Fig. 5: Flowchart representing a synthesis of iron oxide nanoparticles antibacterial property

3. ANTIBACTERIAL EFFECTS OF NANOPARTICLES :

3.1. Antibacterial Effects of Silver Nanoparticles

The antibacterial effect of silver nanoparticles was studied with the involvement of ROS using NAC as an antioxidant. With the control of Petri plates with NAC alone, the bacterial colonies were seen with no growth. Due to the complete inhibition of growth no bacteria colonies were observed. However, in the plates supplemented with both NAC and silver nanoparticles, the bacterial colonies

were observed. From this, we can confirm that ROS are involved in the activity of bacterial and NAC can act as the scavenger. The percentage survival of bacteria in the presence of NAC and silver nanoparticle is depicted. For the Gram-positive *S. aureus*, NAC was able to protect the bacterial cells almost entirely from the toxicity of Ag NP-GT and Ag NP-OB.

3.2. Antibacterial Effects of Silver Coated Gold Nanoparticles

After the immobilization of Au and Ag nanoparticles on the cellulose paper, we can undergo for an investigation that the composite materials antibacterial study can be studied by combining the paper samples with *E.coli* JM 109 in solution and can determine the surgical rates of the bacteria. We can also determine the antibacterial activity of both Au and Ag nanoparticles by adapting the AATCC 100 activity test which is the usual antibacterial test for fabrics. After 1 hour of incubation of *E.coli* with the 15nm and 20nm NPs were observed and no significant reduction of the *E.coli*JM109. After 8-hour inhibition rate for the 15nm and 20nm Au-Ag1000/1 NP samples plateau at approximately 40%. With contrast, the inhibition rates of the 15 nm and 20 nm Au-Ag100/1 NP samples reached 100% after 24 hours. This result demonstrates that when we increase the ratio of the Ag enhancer from 1000/1 to 100/1, the antibacterial activity of the nanoparticle coated cellulose paper was more effective. This would result that the Ag shell is responsible for the antibacterial action.

3.3. Antibacterial Effects of Zinc Oxide Nanoparticles

It was observed that the antibacterial activity of the Ti NPs /glass was below 2for both *E-coli* and *S. aureus* bacteria. However, the result concluded that the Ti NPs did not exhibit the antibacterial effect. However, the Zn NPs/SiO_2/glass, Zn NPs/Ti NPs/glass, and Zn NPs/Ti NPs/glass after maintaining for 3 months came into a result that the active antibacterial activity of 6.1 and 4.3 for both bacteria's. The result shows greater bacterial activity against E.coli than that of *S.aureus* which indicates that the *S.aureus* has thinner cell wall when we compare to *E.coli*, based on this we can conclude that the zinc nanoparticles exhibit a strong antibacterial effect.

3.4. Antibacterial Effects of Iron Oxide Nanoparticles

The antibacterial activity of both SNPs resulting from the interaction pattern is explained by using LIVE/DEAD Backlight fluorescence Kit. In principle, the kit gives green fluorescence in the presence of viable cells. One of the components of the kit stains the intact membrane of viable cells which has emission in the green region. Another component of the kit is praesidium iodide which stains dead cells having deformed membrane, and the emission wavelength is in the red region of the visible spectrum and lasts the untreated bacterial cells showed green fluorescence inferring the presence of 100% viable cells. Then-IONP treated samples showed an insignificant fraction of non-viable bacterial cells, indicating insignificant antimicrobial activity of-IONP against *B. subtilis*and *E. coli*. On the other hand, p-IONP treated bacterial culture showed 90% of non-viable bacterial cells, which confirmed that the significant change in antimicrobial activity of IONP is upon chitosan coating.

4. CONCLUSION :

In this paper, we are concluding that all nanoparticles have their different antibacterial property, which depends on nature and surroundings. The stable biogenic silver nanoparticles have a significant role in antibacterial action on planktonic as well as in biofilm modes of bacterial growth which is against gram negative and positive bacteria. Then it concluded that Ag NP-GT is a more potent bactericidal and cytotoxic agent than Ag NP-OB. The antibacterial activity of Ag NP-GT has an active bactericidal agent, but the non-cytotoxic nature makes it as a candidate for bactericidal activity. Further studies are going on the molecules which are responsible for the different activity of these silver nanoparticles. NPs have been used against many diseases that are caused by bacteria and viruses. Herein, we present different sizes and compositions of Au and Au-Ag NPs deposited on cellulose paper to examine the antibacterial activity of the resulting composites. Based on the results, we demonstrated that Au-Ag100/1 and Au-Ag1000/1 NP-coated cellulose paper could reduce the growth of *E. coli*, with 15 nm Au-Ag100/1 NPs showing the most substantial inhibitory effects. To date, there are only a few studies done on the activity of NP-coated cellulose paper toward bacterial pathogens. Our results indicate that cellulose paper deposited with Au-Ag NPs have the potential to serve as useful antimicrobial products shortly. The zinc nanoparticles are grown on the Ti nanoparticles shown a high transmittance and a potent antibacterial activity. The buffered titanium

nanoparticles are attractive for the enhanced transport and high antibacterial zinc nanoparticles with a mechanical endurance. The zinc nanoparticles do not require any protection layer to prevent the degradation of both the antibacterial effect and for the transmittance. The iron oxide nanoparticle has antimicrobial activity at relatively very high concentrations the activity can further modify or moderated by changing the surface potential and by accessible surface functional groups this change cause the interaction pattern at the interface. Hence it plays a crucial role in determining the antimicrobial property of iron nanoparticle. The enhanced production of the ROS is because of the interaction potential at the interface. This is the principal cause for the antimicrobial property of the nanoparticles. As a result, the interaction pattern at the nano-bio interface plays a vital role in determining the antimicrobial activity of metal oxide nanoparticles.

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