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Short Review

Application of Innovative Nano materials to Resolve Imminent Antimicrobial Resistance.

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Abstract

The foremost world-wide community issue of the health is due to virulent bacteria and successively increase antimicrobial resistant against these microorganisms. The renowned disease control center stated that the world entered in post antibiotic horizon, where the death rate from the microorganism will be more from cancer disease. In the ongoing period new techniques such as nanoparticles emerging and used against the virulent strains of microorganism. Those difficulties which face by common antimicrobial such as antibiotic resistant can overcome by the advancement of nanotechnology. The nanomaterial (selenium, cobalt, silver, cadmium, zinc oxide and magnesium) plays a vital role in the delivery vehicle and surface therapeutic

agents for cargo of antimicrobial drugs. In this review, we presented the use of nanoparticles as an efficient system for antibacterial applications.

Keywords: antibacterial, antimicrobial resistance, antibiotics, nanomaterials

Introduction

Antimicrobial resistance (AMR) is the wider term for resistance in different kinds of microorganisms and involves struggle to antibacterial, antiviral, anti-parasitic and antifungal drugs. AMR occurs when bacteria change in response to the usage of antibiotics in the treatment of bacterial infections and making them ineffective. Low-quality medicines, wrong prescriptions and poor infection prevention and control also encourage the development and spread of drug resistance (WHO, 2017) (1).

The major obstacle face in the human health is the new drug resistance in pathogenic bacteria. When the microorganisms become resistant to most antimicrobials they are often referred to as "superbugs". According to predictable assessment that approximate two million cases of severe illness caused by bacterial antibiotic resistant and also in United State many deaths annually occurred. It is estimated that in future the annual death will be in million due to bacterial infections, which is more than caused by disease of cancer in present (2). In persistent antibiotic treatment of multi drug resistant, most of the cases but in tissue debridement is having less number of cases, the cost of health care boosted and patient compliance declined. In United Sate it was noted that the health and societal cost by these infections are 55 billon US dollar yearly increased (3).

Action of nanomaterial and antibiotic

The mechanism of antibiotic directly target on the synthesis of bacterial cell wall inhibition, which is necessary for bacterial genetic material (RNA & DNA). The intrinsic activity of the bacterial cell quickly emerges by mutation and transfer of DNA by action of antibacterial (4). In multiple drug resistant, genetic material from different organism can acquire by these antibiotic which have antibacterial characteristic. The infection caused by the planktonic and biofilms, are minimized by especially designed nanomaterials based on antimicrobial which having high efficacy against biofilms and planktonic infections (5, 6). In this review, we have focussed on different kind of nanomaterial having the property of antimicrobial by combating multidrug resistance caused by the planktonic bacterial infection. Furthermore, this review is mostly emphasized on the nanomaterial efficacy against bacterial infections, as well as on therapeutic agent and delivery vehicle of antimicrobial agents.

In the initial study of microbe and nanoparticles interaction by Metch and its co-worker (7) designed those bacteria *bacillus cereus* was homogenously distributed in cetyl trimethyl ammonium bromide (CTAB) coated gold nano-spheres or nano-rods. This is possible because of electrostatic interaction between the negative charge present on bacterial cell wall teichoic acid moieties (8) and positive charge present on nanomaterial surface. In other experiment, the pili of gram-negative bacteria *E. coli* bind on mannose substituted gold nanoparticles (NPs). This process was effective because of pili hair like morphology present on the bacterial surface, which contain lectin in rich quantity due to that mannose coated nanoparticles NPs (9) are perfectly bonded. On the basis of these observations, Wang and its companion demonstrated about the cation NPs isolate the toxicity against bacteria (10). In other similar studies, the bacterial membrane coated with nanoparticles indicated that positively charged gold nanoparticles, which are hydrophobic in nature formed strong aggregation on the bacterial membrane. It is noted by researchers that the effect of 2mm core diameter gold nanoparticles on gram positive bacteria (*bacillus subtilis*) lysed rapidly but less toxicity against gram negative bacteria (e.g. *E. coli*) (11). The strong interaction between bacterial membrane and specific nanoparticles function can lead to modify the functionality as well as influence on the membrane structure.

The antimicrobial silver-based nanoparticles utilize free silver ions acting as an active agent. The characteristic feature of silver ions is to damage the genetic material, (12) electron transport and membrane of the bacterial cell. While in case of copper, the nano particles have free copper ions that can produce reactive oxygen species, which damage the genetic material and amino acid in bacterial cell. Likewise, the bacterial lysed by the titanium dioxide and zinc oxide nanomaterial (13). Many nanomaterials antibacterial mechanism is to combat superbug drug resistant. In biotechnological research the main focus on interaction between bacteria and metal nanoparticles.

Gupta and co-worker (14) formulated nanoparticles of mixed charged that have antimicrobial activity against grams bacteria. Such type of nanoparticles design by different concentration of negatively (MUA) and positively (TMA)charged ligands. Specific nanoparticles ligands concentration (MUA: TMA) in ratio of 48:50

and80:20, respectively, have the ability of selectively kill the bacteria. The further research work indicate that cation ligands help in the attachment of nanoparticles to the bacterial surface, on other hand the anionic ligand with headgroup (carboxylate) by formation of hydrogen bonding in the bacterial cell wall components that cause the cell death by breakdown the structural integrity.

Additionally, another study indicate that researcher designing of zwitterionic ligand with nanoparticles with different charge representation, one positive charged inside the ligand termini and other positive charge at the outermost layer [15]. It is concluded that the antimicrobial activity of the nanoparticles which are outer side was higher as compared to inner side as being positive charged as well as more effective, depending on the particle size. Nanomaterial helpful in designing of organic Nano systems (16) (micelles, liposome, polymeric and lipid base nanoparticles) and inorganic nanosystems (selenium, cobalt, silver, cobalt, cadmium, zinc oxide and magnesium) to combat with antibiotic and act as powerful tool against bacteria.

Conclusion

Utilization of nanomaterials in the area of antimicrobial therapy, offer best and long term solution in antimicrobial resistance formation. The vast diverse potential effect of nanomaterial with antibiotic and to understand the exact mechanism of bacterial cell death by different targets actions. The main advantages of nanomaterial fabrication of organic and inorganic nano-systems have profound ability to combine with antibiotic, which can effectively work against antibiotic resistant bacteria safely.

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