Short Communication

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Engineered nanoparticles eluding bacteria to obliteration

Abstract

This concise report briefs about engineered inorganic nanoparticles. The principle of operation as well as reaction kinetics is also highlighted here.

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Introduction

Metal nanoparticles possess unique properties which make them potential candidates for various applications. They include sensing in various dimensions. Sometimes, they also show antibacterial properties when they are bioengineered with specific functionalities. As such, both theranostics and therapeutics are the newer dimensions of bioengineered nanoparticles. Spanning from drug delivery to diagnostics, hybrid nanoparticles have come a long way leading to eradication of bacteria. There exists a considerable span of bacterial strains which can easily elude antibiotic treatment by hiding inside cells.[1–5] This way, they prevent themselves from getting detected; thereby their removal from host immune system gets obstructed. One can cite the example of Staphylococci commonly infecting human tissues, especially skin, bone, and other organs. Although considered as harmless, their impacts cannot be totally ignored.[2–6] Sometimes, their invasion into blood streams can cause severe inflammations. In certain cases, it ends as toxic shock or sepsis. As such, the aforementioned bacteria could cause single pathogen fatalities. This makes Staphylococci one of the main causes of death from single-pathogen infections. It is worth to mention here that methicillin-resistant Staphylococcus aureus (MRSA) poses as one of the dangerous ones owing to its intrinsic resistance towards conventional antibiotics; thereby causing more deaths.[3–8] On looking deeper, experts cite inadequate access to the intracellular position as one of the main limitations towards treating MRSA infections. Accordingly, usual antimicrobial agents no longer enable themselves to go inside the infected mammalian cells which eventually lead to eradication of these pathogens. Although promising aspects of nanoparticles in delivering antibiotics have been established, however, prior release ahead of target and eventual toxicity concerns cripple the efficacy of load-carrier systems. In such cases, inorganic nanoparticles being endowed with antibiotic activity could utilize their twin activity, i.e., load and carrier entailing antibacterial agents. Although prior studies use silver nanoparticles; however, they prove to be detrimental to mammalian cells.[5–11]

As per insights by Herrmann group,[1] the inorganic nanoparticle shows some intrinsic behaviours which make them more effective towards these pathogens—as they are less likely to build resistance against these nanoparticles as compared to traditional antibiotics. Some unspecific modus operandi of these inorganic nanoparticle includes induction of oxidative stress, binding to proteins, and interruption of transport processes related to electron. Bioglass is widely acclaimed for its multifunctional attributes which make them usable in reconstruction of bones and soft tissues. Particularly known as cerium oxide nanoparticles, strong antibacterial properties are attributed to the reversible conversion between its valence states. As per,[1] the inorganic hybrid cerium oxide nanoparticles exhibit excellent antibacterial activity. These inorganic nanoparticles have inherent antimicrobial properties and can target pesky bacteria that hides inside cells. Notably, they are less toxic to mammalian cells. Using a highly scalable production method known as liquid-flame pyrolysis, they tailored several hybrids entailing bioglass, cerium, composite of bioglass and cerium etc. Through scanning electron microscopy, it was revealed that these nanoparticles become functional unleashing their activity in the immediate neighbourhood of the pathogens as they directly elude by the identical size and surface charge. Additionally, it was found that these hybrids are quite efficient against MRSA. As compared to silver-based nanoparticles, they are more effective because of their high compatibility with human macrophages. Most importantly, MRSA counts were also reduced due to their injection. Surprisingly, these kinds of efficacies were not reported in case of silver-based nanoparticles. Precisely, these inorganic hybrids are found to have regenerative capacity which shows their lasting impact so far as the oxidative effect of nanoparticles over bacteria is concerned. Apart from this, it is worth mentioning that there was no impact over mammalian cell membranes during the interaction of nanoparticles and bacteria. This comes as a validation that they can selectively disrupt bacterial membranes within the same cellular compartment. Indeed, this comes as a good achievement. However, more in-depth analysis about the reaction mechanism is required. Equally important is the morphology of the nanoparticles which require further analysis as well as optimization. It is expected that these engineered nanoparticles eluding pathogens is going to become a part and parcel of the healthcare system which will be a great boon for therapeutics.

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None.

Conflicts of interest

The authors declare that there is no conflict of interest.

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