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Antimicrobial mechanism of ZnO nanoparticles under dark condition

Ara Joe and Eue Soon Jang
Kumoh National Institute of Technology, South Korea

Zinc oxide (ZnO) with a direct wide band gap (ΔEg=3.37 eV) is one of the most promising antibacterial materials owing to its biocompatibility and broad antimicrobial activity against both gram-negative and gram-positive bacteria. For light irradiation above band gap energy, studies have reached universal consensus that the antibacterial activity of ZnO results from the generation of reactive oxygen species (ROS) via photo catalytic water splitting. However, the antibacterial activity in the absence of light is poorly understood and is still under debate. In this study, the bactericidal activity of three different ZnO nanoparticles including nanoplates (NPs), nano-assemblies (NAs) and conventional nanoparticles was systematically analyzed under dark conditions against gram-positive Staphylococcus aureus and gram-negative Klebsiella pneumoniae. We highlight the major findings of the work: Antibacterial activity of the ZnO nanoparticles under dark conditions was different from that of zinc salts with respect to the ionization rate at the antimicrobial stage. The dissolved Zn^{2+} ion concentration in ZnO dispersed media was too low to reduce bacterial viability. Antibacterial activity does not result from transfection but from the attachment of ZnO nanoparticles to the bacterial cell wall. Local dissolution of the attached ZnO nanoparticles can lead to increased Zn^{2+} ions in the bacterial cytoplasm without causing cell lysis by occupancy competition for influx metalloprotein channels between Ca^{2+}, Mg^{2+} and Mn^{2+} ions.

jar@kumoh.ac.kr

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