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# Antibacterial effects of titanium embedded with silver nanoparticles based on electron-transfer-induced reactive oxygen species

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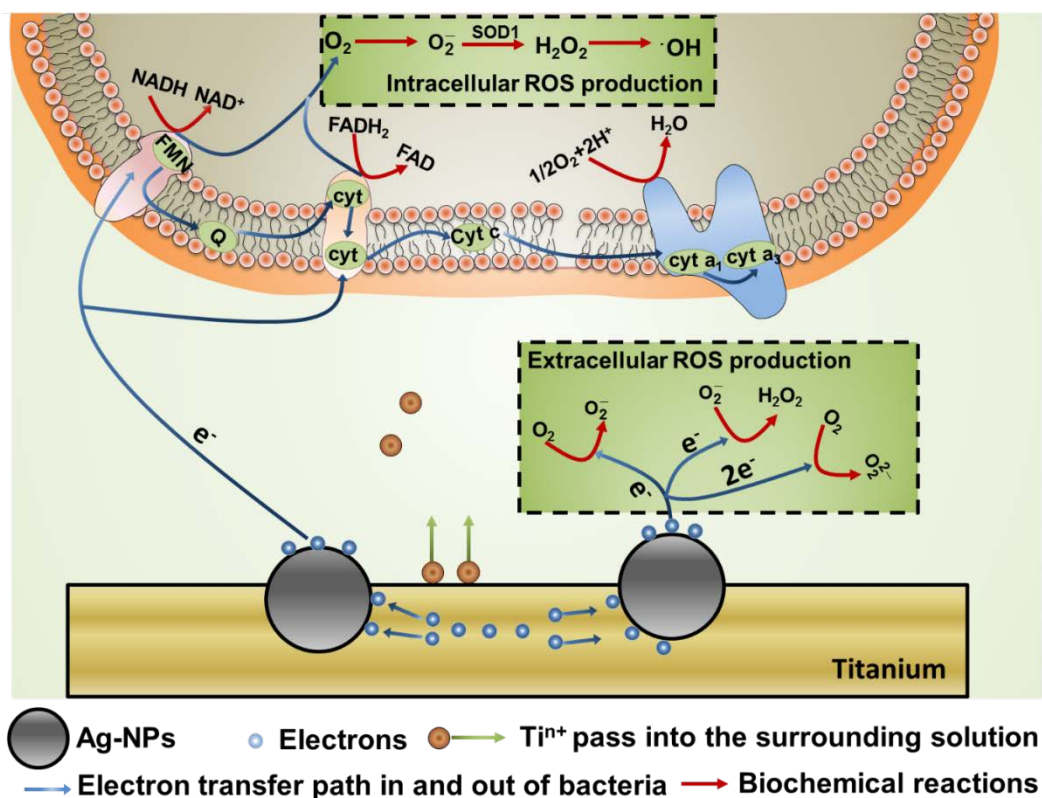
**Keywords:** Antibacterial mechanism; titanium; silver nanoparticles; reactive oxygen species; electron transfer

**Introduction:** Although titanium embedded with silver nanoparticles (Ag-NPs@Ti) are suitable for biomedical implants because of the good cytocompatibility and antibacterial characteristic [1-3], the exact antibacterial mechanism is not well understood. Previous study indicated that the micro-galvanic effect between Ag and titanium evokes electron transfer in the surrounding medium [4] and in fact, electron transfer is a universal behavior in bacteria and cell respiration. However, there have been few studies on the antibacterial effects by considering both the materials and biological aspects and concomitant interactions between the biomaterial and biological system.

**Materials and Methods:** In the present work, the antibacterial mechanisms of Ag-NPs@Ti prepared by plasma immersion ion implantation (PIII) are explored in details. The antibacterial effect of Ag-NPs on different substrates is determined to monitor the electrical interaction between materials and microorganism. We evaluate the intracellular oxidative stress and the physiochemical property of culture medium before and after treatment to explain the antibacterial process in details. Besides, the cytocompatibility of Ag-NPs@Ti is tested.

**Results and Discussion:** The antibacterial effects of the Ag-NPs depend on the conductivity of the substrate revealing the importance of electron transfer in the antibacterial process. In addition, electron transfer between the Ag-NPs and titanium substrate produces bursts of reactive oxygen species (ROS) in both the bacteria cells and culture medium (Fig. 1). ROS leads to bacteria death by inducing intracellular oxidation, membrane potential variation, and cellular contents release and the antibacterial ability of Ag-NPs@Ti is inhibited appreciably after adding ROS scavengers. Even though ROS signals are detected from osteoblasts cultured on Ag-NPs@Ti, the cell compatibility is not impaired

**Conclusion:** This electron-transfer-based antibacterial process which produces ROS provides insights into the design of biomaterials with both antibacterial properties and cytocompatibility.



**Figure 1.** Generation of oxidative stress in the surrounding solution and within the bacteria cell of *S. aureus*.

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