In situ construction and antibacterial performance study of ultraviolet/near-infrared dual light responsive coatings on titanium

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Abstract Implant associated infection is the major challenge that orthopedic devices need to address[1]. Phototherapy has gradually attracted researchers' attention due to its unique advantages of controllability, non-invasiveness, broad-spectrum antibacterial activity, and low probability to induce drug resistance[2]. Titanium dioxide, the most mature ultraviolet light photocatalyst, is also widely used as biofunctional coating on titanium implants due to its complex topology and excellent biocompatibility[3]. However, its limited near-infrared (NIR) light absorption capacity restricts its application in photodynamic therapy for deep tissue infections. In this study, we introduced a upconversion nanoparticles (UCNPs)[4] into TiO_2 coating which was in situ grown on the surface of titanium alloy by anodizing method, thus endowing the coating with dual UV/near-infrared light responsive antibacterial properties. No markable differences were found in the microstructure and corrosion resistance between the coating with and without UCNPs, while the Si, Y, Tm elements contained in UCNPs were detected by XPS. Under 360 nm ultraviolet (UV) light irradiation, the coatings exhibit certain photocatalytic and photothermal activity. Moreover, with the addition of UCNPs, the reactive oxygen species (ROS) release can be also observed from the coatings under 980 nm NIR light irradiation. More importantly, the synergistic effects of the generated hyperthermia and ROS kills Staphylococcus aureus with an efficiency from 95.8% to 99.5% in vitro within 5 min NIR irradiation, depending on UCNPs concentration. In addition, the anodization coatings can also eliminate the weak toxicity of UCNPs. The coaings with a certain concentration range of UCNPs did not exhibit cytotoxicity to MC3T3-E1 cells in 14 days. In conclusion, the UCNPs doped TiO_2 coating prepared by anodizing method exhibited UV/NIR dual light responsive antibacterial properties, good corrosion properties and biosafety, confirming its potential as a new surface modification strategy for the prevention and treatment of infectious bone defects.

Keywords TiO_2 coating, anodization, near-infrared light response, antibacterial activity

Reference

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