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Synergistic Effect of Ag-ZnO-HA Nanocomposite Laser Cladding on Ti6Al4V Implant in Antibacterial and Osteogenic Abilities

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Keywords: Ti6Al4V, implant, laser cladding, nanocomposite, Ag-ZnO-HA, antibacterial, osteogenic

Introduction: The requirements of orthopedic implants become more and more tremendous in surgery because of the developing of orthomorphia and the raising rate of fracture or joint degeneration. Implants materials bacterial infections may occur in orthopedic operation. What's more, the implant and the host often have immune rejection, and is not conducive to recovery in postoperative. Herein, we used the chemical reduction method to prepare silver nanoparticles, and fabricated the Ag-ZnO-HA (silver- zinc oxide- hydroxyapatite) nanocomposite on the Ti6Al4V by laser cladding means. Ag nanoparticles and ZnO nanoparticles possess the excellent broad spectrum antibacterial effect, due to the oxidative stress is induced when the generation of ROS exceeds the cell's antioxidant capacity, which resulted in rupturing of the bacterial wall [1-3]. HA has the biocompatibility and osteoinductivity due to its similarity with natural bone in component, HA and ZnO play a synergistic role to promote osteogenesis during the healing processes [4, 5].

Materials and Methods: Our preparation preplaced coating is containing AgNPs, ZnO nanoparticles and HA nanoparticles compound (Ag-ZnO-HA) with different ratios. Ag nanoparticles were synthesized by using hydrazine hydrate (N_2H_4) to reduction, and the $AgNO_3$ crystals as the silver source. The Ag-ZnO-HA nanocomposite was coated on the Ti6Al4V by laser cladding means. The Ag-ZnO-HA preplaced coating was characterized by transmission electron microscope (TEM; Tecnai G20, FEI, USA). The surface morphology of the Ag-ZnO-HA nanocomposite coating was examined by field emission scanning electron microscopy (FESEM, JSM7100F) and energy dispersive X-ray spectroscopy (EDS). In vitro tests, the antibacterial of the Ag-ZnO-HA nanocomposite coatings were evaluated to against *E. coli* and *S. aureus*, besides, the MTT and ALP were measured through MC3T3-E1. In vivo, responses of Bone and its surrounding muscle tissue were revealed by Bone defect and inflammation model in rabbits.

Results and Discussion: The results demonstrated that the Ag nanoparticles was successfully prepared by using N_2H_4 (Figure 1). Ag-ZnO-HA coating exhibited the spherical nanostructures of surface morphology and evenly distributed of elements (Figure 2). Due to the Ag-ZnO-HA nanocomposite coating possess firmly nanostructures, excellent long-term antibacterial and osteogenesis properties were evidenced by Ag-ZnO-HA nanocomposite coating.

Conclusion: With the development of implant materials in the fight against antibacterial and induce the osteogenic aspects, we prepared Ag-ZnO-HA nanocomposite coating exhibited the excellent antibacterial properties against the *E. coli* and *S. aureus*. In addition, HA and Zinc element can induce the osteogenic to accelerate bone healing. The Ag-ZnO-HA nanocomposite coating plays a good balance of the antibacterial and osteogenic properties of the implant.

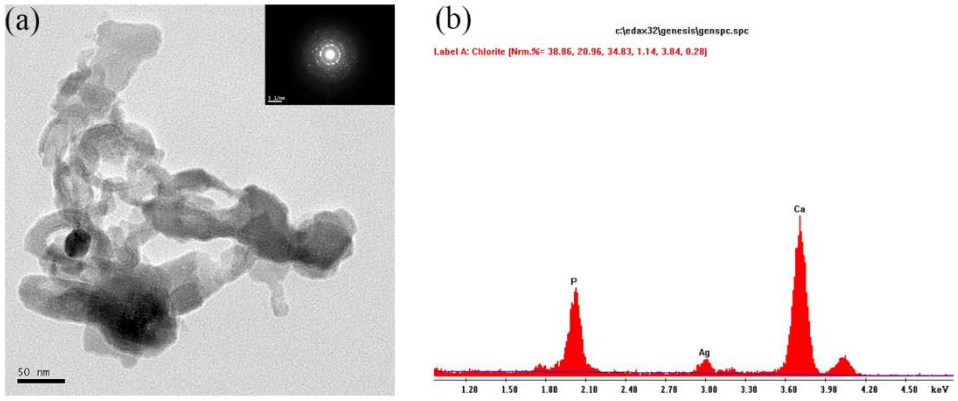

Figure 1 structure of Ag-HA preplaced coating was analyzed by: TEM/SAED (a) and EDS (b).

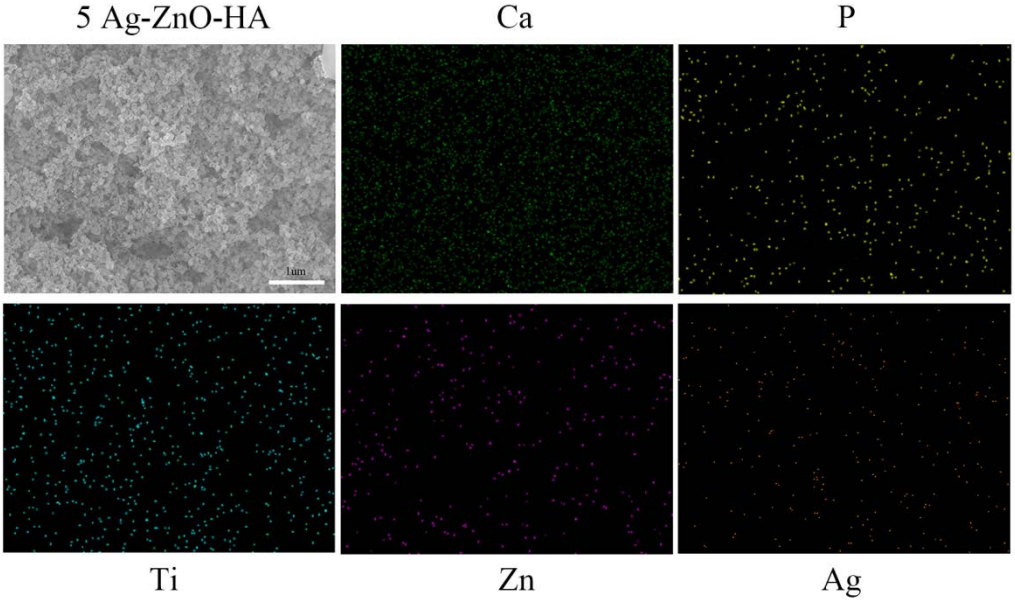

Figure 2 The surface morphology of the 5 Ag-ZnO-HA (Ag: ZnO: HA equal to 5:5:90 on mass ratio) was examined by FESEM and distributed of elements was examined by EDS.

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