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Antimicrobial titanium/silver PVD coatings on titanium

Biofilm formation is a recurrent complication in surgery. Implanted devices are ideal substrates for biofilm forming microorganisms. Such implanted devices in which biofilm colonize include catheters both urinary and venous, heart valves, dialysis units as well as implanted prostheses. Microorganisms adhere to the surface of the implant and divide to form microcolonies. This microcolony is often referred to as biofilm, or the biofilm layer. Antibiotics do aid in the process to cease cell division on the dividing microorganisms but have little to no affect on the already existing colony not dividing. As a result, the residing colony acts as a diffusion barrier for any further antibiotic affect.

Device surfaces should prevent microorganisms from adhering in order to promote host tissue interaction with the implant. Antimicrobial properties of the implant surface can be achieved in two ways. One way includes doping the implant surface with antibiotics and the other modifying the implant surface with a contribution of silver. Silver is already known to be an affective antimicrobial and is currently used in several applications within the body. In addition, silver based antimicrobials are known to be non-toxic to human cells in low concentrations. The underlying issue using silver in load bearing applications such as artificial joint replacements is that the metal is relatively soft. As a result, a need to produce a titanium implant with a durable coated surface arose.

The coat on the load bearing implant contains a metallic alloy composed of titanium and silver. The coat is produced using a process know as physical vapor deposition (PVD). "During this process, a defined mixture of silver and titanium is deposited onto the implant surface by simultaneous vaporization of metallic targets in a vacuum" (Ewald, Gluckermann, Thull Gbureck). Different ratio sample coatings were produced, alloys ranging from 0.7% silver to 9% silver. Criteria used in the coating evaluation included surface roughness, hardness, biocompatibility, and bactericide action.

Surface roughness was tested using a profilometer in which measurements were taken at various locations on the surface. The average and standard deviation were calculated. The hardness of the coatings was determined by measuring the Vicker's hardness HV10 (Zwick, Ulm, Germany). Most importantly, biocompatibility and antimicrobial properties were tested. To examine antimicrobial properties, two bacterial strains (Staphylococcus epidermis and Klebsiella pneumoniae) were individually placed in cultures with the various compositions of the alloy. Pure titanium with the individual bacteria's was used as a control for the experiment. It was found that the optimum bactericide action occurred on the 3% silver alloy. Klebsilla pneumoniae adhesion was reduced by 64% and Staphylococcus epidermis adhesion was reduced by about 50% for all silver surfaces. At the same time, the surface showed no cytotoxicity for eukaryotic cells such as epithelial or osteoblast cells. This was determined by measuring cell activity and total protein content of the human cells.

Ewald, Andrea, Gluckermann, Susanne, Thull, Roger, and Gbureck, Uwe. "Antimicrobial titanium/silver PVD coatings on titanium." <u>BioMedical Engineering OnLine</u> 5:22 24 Mar 2006. 20, April. 2006 <http://www.biomedical-engineering online.com/content/5/1/22>.