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Research on partially and fully bioresorbable metals

Two biometallic composites produced by powder metallurgy developed at IMMM SAS are presented.

1) Ti-Mg metal-metal composites selectively exploit the advantages of both biometals. While a permanent Ti serves as the matrix material providing the implant with requested mechanical properties, a bioresorbable Mg component acts as a beneficiary modulator for generating an osseoconductive surface via spontaneous dilution in the body environment, as well as bone formation stimulant. In addition to its very good biodegradation potential, Mg has Young's modulus much lower than that of Ti and it gives rise to a reduction of the stress-shielding effect upon loading of Ti-Mg implant. Owing to the porosity, which forms with time as a result of the selective Mg dilution from the surface and the volume of the implant, Young's modulus of Ti-Mg is further decreased and the osseointegration and bonding strength at the bone–implant's interface improves further. The development of a novel permanent dental implant manufactured from the optimized partially bioresorbable Ti-Mg composite, which reduces the drawbacks of the established Ti-based materials i.e., insufficient surface activity and stress-shielding effect, is presented.

2) The issue of intrinsic microstructural and mechanical instability of Zn-based metals limits their expansion in potential applications of bioresorbable stents and orthopedic fixators. A new concept of stabilization of Zn microstructure by a small fraction of nontoxic nanometric ZnO dispersoids is proposed and demonstrated for the first time. The effect of the ZnO dispersoids on post-processing microstructural stability, deformation and strengthening mechanisms, creep resistance, corrosion, and in-vitro biological behavior are pursued. The ZnO dispersoids arise in situ within deformed Zn structure during the consolidation of fine atomized Zn 99.99wt.% powder by extrusion, while ZnO nanodispersoids form from passivating films present on Zn powder. They allow formation of ultrafine-grained Zn structure and its retention by Zener pinning action during subsequent annealing. The Zn+ZnO composite with the finest grain size of 0.6 µm, ever reported for unalloyed Zn, shows the superior mechanical properties than those reported for pure Zn materials. A relationship between the tensile yield stress and grain size i.e., Hall-Petch law, for an ultrafine-grained Zn was experimentally evaluated for the first time. The utilized stabilization concept doesn`t compromise corrosion and biological responses. In-vitro cyto/genotoxicity assays performed using DMEM diluted extracts of the Zn+ZnO and cast Zn incubated with L929 cells yield in comparable and non-toxic responses. The presence of ZnO dispersoids induces a small but still significant bacteriostatic activity.