Development of High Strength Biodegradable Metals for Regenerative Medicine

Y. Zheng[1]

[1] *Peking University, School of Materials Science and Engineering, Beijing, China*

After two decades of research and development of biodegradable metallic materials, Mg-based, Fe-based and Zn-based biodegradable metals (BMs) had been widely studied by in vitro and in vivo biocompatibility testing. There were WE43 Mg alloy and Mg-Ca-Zn alloy bone screws being clinically used in Europe and China, Nitride Fe bioresorbable vascular scaffold being CE marked and clinically trailed in China, Zn-Mg-Fe alloy Maxillo facial bone screw being clinically trailed in China. For the mechanical strength viewpoint, the current Mg-based biodegradable metals is in generally below 350MPa and it can only be suitable for low load-bearing application in regenerative medicine, whereas the Zn-based biodegradable metals had been explored, with the Zn-Li-Mg alloys exhibiting the tensile strength around 600MPa, close to that of the pure Ti and stainless steel, and is applicable for the medium load-bearing application in regenerative medicine. The Fe-based biodegradable metals had shown higher mechanical strength, but the majority of biometal society believe that Fe-based BMs is unsuitable for orthopaedic applications since element iron doesnot exist in the bone. So there is the requirement to development of higher strength biodegradable metals with the mechanical property comparable to CoCr alloys, to meet the high load-bearing applications in regenerative medicine. In the present work, we tried to solve this problem from two aspects. One is to develop Zn-based BMs with higher strength by the addition of more alloying elements into Zn-Li alloys. And we found that rare earth elements are helpful to further enhance the mechanical strength of Zn-Li alloys to the level of around 800MPa. On the other hand, we screened the metal elements on the periodic table by our proposed "biodegradability & biocompatibility" dual criteria, and proposed the development of a high-performance molybdenum based biodegradable metals system with mechanical properties comparable to CoCr alloys. We had explored the impact of simulated inflammation on the corrosion behavior of pure Mo, a potential biodegradable metal for biomedical applications for the first time. Under simulated inflammatory conditions, Mo exhibits altered electrochemical properties, such as increased open circuit potential, higher corrosion rates, and reduced impedance as H_2O_2 concentration rises. Immersion test confirm the higher corrosion rates with increases in H_2O_2 concentration. Interestingly, pure Mo exhibit uniform corrosion behavior under aggressive simulated inflammation which is beneficial to maintain biomedical devices’ mechanical integrity. Our recent further works indicate the Mo-based biodegradable alloys can be fabricated by the addition of some alloying elements into Mo, and exhibit the mechanical strength higher than 800MPa. We also demonstrated that the additive manufacture technology is feasible to produce 3D printing Mo-based BM sca

Acknowledgment
I acknowledge the invitation of CESB 2024 to be a keynote speaker.