

Iron-based biodegradable alloys: effect of composition and experimental parameters on the corrosion rate

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This work investigates the degradation behaviour of iron-based alloys in pseudo physiological conditions. The goal is to identify the best composition leading to a corrosion rate adapted to biodegradable stent applications. In this context, TWIP steels (Fe-Mn-C alloys) with excellent mechanical properties are compared to pure iron, known for its too slow degradation rate. To assess the corrosion properties, two main kinds of tests were conducted, immersion and electrochemical tests. To reach reproducible and relevant results, the suitable experimental parameters were identified.

The immersion tests in a pseudo physiological solution had two purposes, to estimate the corrosion rate by measuring the mass loss or concentration of ions released in the solution, and to scrutinise the corrosion mechanism owing to the characterisation of the corroded samples. SEM-EDS, XPS, ToF-SIMS and in situ AFM were used to look at the corroded surfaces. In this last case, the samples were immersed in a cell in the AFM while scans were conducted after different times, giving an insight into the formation of the different layers. Indeed, these analyses showed that different layers form on the surface. The bare metal is covered by oxides and hydroxides and then by calcium phosphates precipitating from the pseudo physiological solution. These layers actually protect the metal from corrosion. The results also show that many factors influence the corrosion rate such as the roughness or pre-oxidation of the surface, the composition of the solution, the solution stirring, the sample positioning, and the solution volume to sample surface ratio. This means that the test protocol has to be carefully chosen to reach reproducible results and to mimic the actual physiological conditions.

Electrochemical tests such as potentiodynamic polarisation tests in a pseudo physiological medium aimed at comparing different materials. They also gave information about the tendency of the materials to passivate and the degree of protection offered by the passive layers. It is shown that TWIP steels corrode faster than commercial iron and that the degree of deformation of the TWIP samples does not seem to change noticeably their degradation rate.