Chitosan/glycerol gel films for the accurate in vitro evaluation of the corrosion of biodegradable medical magnesium alloys

Medical magnesium-based metals are widely used in clinical applications, such as bone fixation devices, dental implants, and cardiovascular stents, thanks to their excellent biocompatibility and absorbability, as well as their ability to promote bone regeneration. However, when their degradation rate in the body exceeds expectations, excessive accumulation of magnesium ions may lead to hemolysis or osteolysis, while if the rate is too slow, there is a risk of inflammation from residual material. Therefore, it is essential to accurately quantify the degradation process in order to prevent these complications.

Biodegradable implants interact not only with bodily fluids and blood, but also with tissues and organs such as bones, muscles, and the extracellular matrix. Therefore, traditional electrochemical corrosion evaluation methods that rely on liquid electrolytes fail to accurately assess the degradation of these materials.

To address this issue, we used a chitosan hydrogel, which simulates the elemental composition and microstructure of biological tissues, as the background electrolyte. For example, the 3D porous network of the hydrogel mimics the extracellular matrix and intramuscular connective tissue, allowing for a more accurate assessment of the degradation process.

In this study, we compared the degradation of the magnesium alloy AZ91D in liquid and gel-based electrolytes through electrochemical analysis and observation of changes in the alloy's microstructure. Our results show that, unlike in solution, where the degradation is rapid and uniform, the alloy degrades more slowly when in contact with gel, accompanied by pitting corrosion on the surface and the formation of a mixed layer between the gel and alloy corrosion products.

We also investigated the influence of chitosan deacetylation degree, film thickness, and electrolyte composition on the corrosion properties of the alloy. These findings can provide a basis for customizing corrosion tests to specific implant sites or individual patient variations in the future.