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Investigation into microdefects and corrosion resistance of nickel-titanium shape memory alloy using electrical discharge coating process

Abstract

Nickel-titanium shape memory alloy is a novel material with outstanding properties suitable for biomedical applications such as implantation devices. Unfortunately, the high composition of nickel in this alloy can be harmful to the human body, if its exposure exceeds a threshold value. Therefore, an innovative electrical discharge coating technique was investigated and proposed in this study to develop minimal microdefect formation with high corrosion resistance through fractional factorial design of experiment. The results showed that discharge duration mostly dominated the material deposition, microcracks, and porosity fraction up to 72%, due to the impact of the intensity of discharge energy. There was also a pronounced effect of titanium powder concentration in the deionized water on the percentage of titanium and nickel elements and microcrack formation. The powder suspension enhanced the recast layer formation through the increment of layer density, which covered up the Ni-rich region and diminished the microcrack formation. An optimized substrate recorded the lowest corrosion current, I_{corr}, and highest corrosion voltage, E_{corr}, at 3.43×10^{-6} μA/cm^2 and –0.07 V respectively, thus exhibiting an outstanding corrosion resistance rate at only 8.57 μm/year in phosphate-buffered saline solution, due to the low nickel concentration, low microcracks, and low porosity fraction in the recast layer. Therefore, the results obtained within this styud presented an initial step towards assessing the feasibility of applying the electrodischarge process to biomaterials, including nickel-titanium shape memory alloy. Further exploration, involving both in-vitro and/ or in-vivo studies, is essential to thoroughly evaluate the performance of the coating obtained from the process.

Keywords

Corrosion resistance; Electrical discharge coating; Microcrack; NiTi SMA; Porosity