Effect of surface treatments on localized corrosion behavior of Nitinol alloys

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Nitinol usage for biomedical implant devices has received significant attention due to its corrosion and biocompatibility. The potential problem with Nitinol implant devices is the release of nickel in the human body which stimulated a great deal of research on its surface modifications. Surface treatments are known to effect surface charge, surface chemistry, morphology, wettability and corrosion resistance. Electropolishing (EP) is a standard surface treatment process employed as a final finish in the manufacture of Nitinol devices. Recently, the beneficial effects of magnetoelectropolishing (MEP) have been recognized. In this study, cyclic polarization *in vitro* corrosion tests were conducted on untreated, electropolished and magnetoelectropolished Nitinol alloys in compliance with ASTM F 2129-08. The concentrations of dissolved metal ions in the electrolyte are determined by ICPMS. The surface morphology and surface chemistry were studied using SEM and XPS respectively.

Methods

In this study, Nitinol alloys have been prepared using arc melting (AM) method at the National Institute of Standards and Technology (NIST). Samples were prepared by cutting the cylindrical ingots with a high-speed saw into cylindrical discs of dimension (1cm x 2mm). The discs were electropolished and magnetoelectropolished by Electrobright® (Macungie, PA, USA).

The cyclic polarization tests were performed using a GAMRY® potentiostat at scan rate of 1mV/s over a potential range between -0.5 to 2.2 V_{SCE} at 37 °C. Phosphate buffer saline (PBS) was as an electrolyte.

Results

Cyclic polarization curves for untreated and treated NiTi are shown in fig. 1.

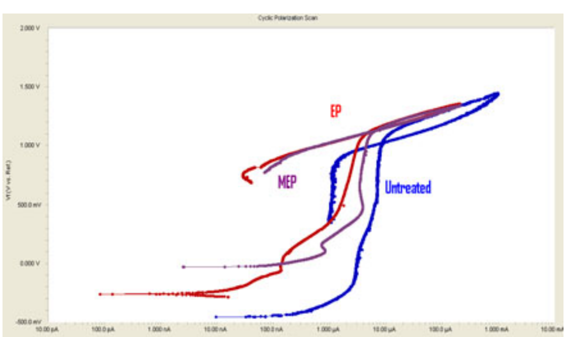

Fig.1 Cyclic polarization curves for NiTi

The resistance to pitting corrosion, which is the breakdown potential (E_b) or the difference between the break down and reference potential (E_r), is higher for treated samples when compared to untreated ones [1]. Similarly, the loop area for untreated sample is higher than treated samples which shows treated samples are more reistant to corrosion.

The ICP-MS (Perkin Elmer Sciex, model ELAN DRC-II) was used to determine the concentration of dissolved metal ions in solution after each corrosion test. EP and MEP NiTi samples did not show any Ni leaching as shown in table. 1.

Table 1. ICPMS Analysis (ppb)

(At. %)	NiTi	NiTi-EP	NiTi-MEP
Ti	ND	ND	ND
Ni	69	ND	ND

The pH and dissolved oxygen were also measured The surface morphology and surface chemistry were studied using SEM and XPS respectively.

Conclusions

- Cyclic polarization corrosion tests revealed that the break down potential (Eb) increased for NiTi alloys after electropolsihing and magnetoelectropolishing.
- ICPMS results releaved that electropolished and magentoelectropolished samples showed no Ni leaching.
- XPS survey spectra showed that low elemental Ni after surface treatments on NiTi and NiTiCr.
- XPS depth profiles showed that Ni oxides are present in materials surface after surface treatments.

Acknowledgement

The project described was supported by Award Number SC3GM084816 from the National Institute of General Medical Sciences. Waseem Haider would also like to acknowledge Dissertation Year Fellowship from the University Graduate School at Florida International University.

Reference

[1] W. Haider, N. Munroe, C. Pulletikurti. P. Gill, S. Amruthaluri, "A comparative biocompatibility of ternary Nitinol alloys", Journal of Materials Engineering and Performance: Volume 18, Issue 5 (2009) pp. 765-767.