SURFACE MODIFICATION OF NiTi WIRES FOR ENDOSCOPIC GUIDE WIRES USED IN UROLOGY

TOMASZ GORYCZKA[1]*, TOMASZ BORYCKI[2], ANDRZEJ BORYCKI[2]

[1] INSTITUTE OF MATERIALS ENGINEERING, UNIVERSITY OF SILESIA IN KATOWICE, POLAND
[2] ENDOX-POLSKA SP. Z O.O., BIELSKO-BIAŁA, POLAND
*E-MAIL: TOMASZ.GORYCZKA@US.EDU.PL

[ENGINEERING OF BIOMATERIALS 158 (2020) 62]

Introduction

The use of NiTi shape memory alloys increases every year [1]. One of the examples of applications are elements of endoscopic devices in the form of guide wires [2]. The core of the guide wire is made of a superelastic NiTi wire coated with a polyurethane polymer. The hydrophilic coverage plays a protective role and makes it easier to overcome tight constrictions in blood vessels or urinary tract.
The problem is the adhesion of polyurethane to the NiTi wire, especially at the tip of the guide wire. Therefore, the aim of the paper was to increase the adhesion of the polymer by increasing the roughness of the wire surface.

Materials and Methods

The subject of the research was guide-wire produced by Endox-Polska Sp. z o. o. The surface of the NiTi wire was etched following conditions shown in TABLE 1. Depending on the effects of etching, the temperature was adjusted from the room temperature (RT) up to 50 °C. The etching time was adjusted in a similar way: from 60 seconds to 15 minutes.

TABLE 1. Composition of etching solutions and etching conditions.

Sample	Solution	Temperature	Time
S1	$HCl+HNO_3$+ethanol	50 ºC	10 min
S2	$HCl+CuCl_2$+ethanol	RT	120 s
S3	$HCl+CuSO_4+H_2O$	RT	120 s
S4		RT	180 s
S5		40 ºC	60 s
S6		50 ºC	120 s

The surface of the wires was observed with use of light microscope OLYMPUS GX-51. The roughness of the NiTi wires was characterized by the parameters: Ra, Rz, Rz measured on profilometer Mitutoyo Surftest sj-500. Finally, the adhesion of polyurethane to the NiTi surface was determined by the force from the static bursting test using Zwick/Roell testing machine. The maximal force was determined as an average one from 5 measurements.

Results and Discussion

The etching of the wire at room temperature for even 15 minutes in the mixture consisted of HCl + HNO_3 + ethanol did not bring any positive changes in the surface roughness. Raising the temperature of the solution and extending the etching time to 10 minutes resulted in a slightly twofold increase in the Ra parameter in comparison to the initial state (FIG. 1). Changing the etching solution to HCl + $CuCl_2$ + ethanol and carrying out the etching at room temperature for a relatively short time - 120 s resulted in an increase of roughness of 10 times. In consequence of that the increase in the breaking load from 209 N (initial state) to 224 N was observed (FIG. 2).

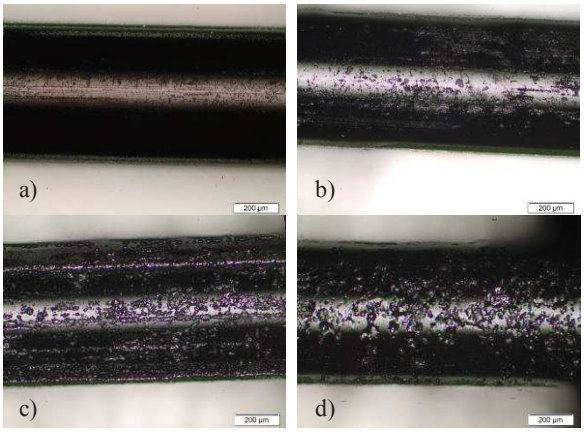

FIG. 1. Images of surface of the NiTi wire at initial state (a), and after etching for sample S1 (b), S2 (c) and S5.

The use of HCl + $CuSO_4$ + H_2O solution and etching at room temperature for 180 s gave a result similar to the previous solution. However, a significant increase in roughness (30 times) and the breaking force (229N) was measured for etching carried out at 40ºC with a relatively short time of 60 s. Raising the process temperature to 50ºC and extending time to 120 s resulted in an increase of roughness up to 4,5 um. However, the pitting produced on the surface of the NiTi wire lowered the adhesion and the breaking strength was comparable to one received at the initial state.

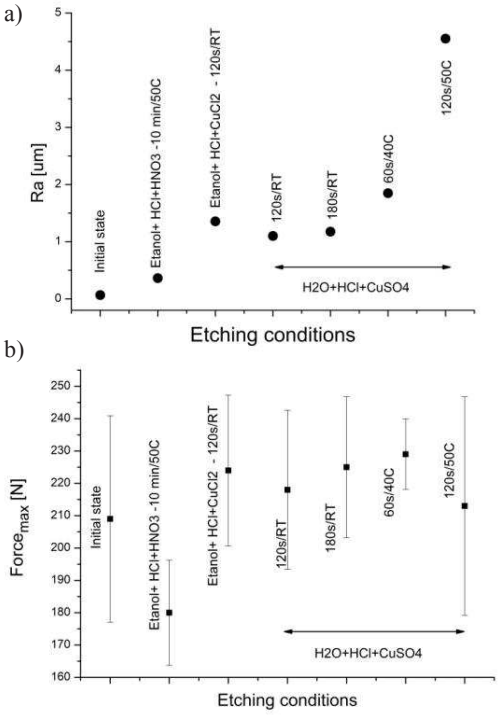

FIG. 2. Arithmetic mean of the roughness profile R_a (a) and maximal force F_{max} (b) versus etching conditions.

Conclusions

The etching conditions carried out in the $HCl+CuSO_4+H_2O$ (40ºC/60s) or $HCl+CuCl_2$+ethanol (RT/120s) solution significantly increase the adhesion of polyurethane to the NiTi wire surface.

References

[1] T. Yoneyama, S. Miyazaki, Shape memory alloys for biomedical applications, Woodhead Publishing Limited, Cambridge (2009).
[2] L. Yahia, Shape memory implants, Springer-Verlag Berlin Heidelberg (2000).