CORROSION BEHAVIOUR OF OVERLAPPING CORONARY ARTERY STENTS

Dóra Károly[1], Lilla Asztalos[1], Éva Fazakas[2]

[1] Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Materials Science and Engineering, H-1111 Budapest, Bertalan Lajos u. 7. Hungary. E-mails: kdora@eik.bme.hu, lilla@eik.bme.hu

[2] Bay Zoltán Nonprofit Ltd. for Applied Research, H-1116 Budapest, Kondorfa u. 1. Hungary. E-mail: eva.fazakas@bayzoltan.hu

1. Introduction

We only have one heart. If a larger part dies, the rest cannot take over the work of the fell out part, so that the performance of the organ weakens and cannot supply the body with adequate amount of oxygen. Cardiovascular diseases are leading both morbidity and mortality statistics worldwide. The negative economic and social impacts of these diseases are increasing continually. The high mortality numbers clearly indicate the importance of the development in the field of cardiology research, diagnostic and therapeutic procedures [1].

Coronary artery stents are widely used for the treatment of ischemic heart disease. After implantation the stent remains in the body. Stents are gradually incorporated into the vascular connective tissue – depending on the health and genetics of the patient – until they eventually become a part of the vessel wall. Due to the differences in coronary flow, shear stress and turbulences bifurcation lesions (stenosis at the division of an artery into two branches) are common anatomy features of the human coronary tree. In the case of bifurcation lesions or severe stenosis, several stents are implanted in the same vessel segment, dilating them into each other, overlapping. The blood flow in the vessel provides ideal environment for corrosion damage processes [2].

During bifurcation stenting physicians can dilate two stents into each other made of a different material (with distinct normal potentials). In this case galvanic or crevice corrosion can occur, so special attention was paid to this field. Only some studies carried out according to stent corrosion and none of them pay attention to the case of overlapping stents with different materials [3,4]. In this study corrosion behaviour of overlapping coronary stents are described.

2. Materials and methods

The investigated stents are made of Co-Cr and Fe-Pt-Cr alloys. According to ISO 5832-5 [5] the material composition of the CoCr alloy can be seen in Tab. 1.

Chemical composition (%)							
Cr	**Ni**	**W**	**Fe**	**Mn**	**Si**	**P**	**C**
19-21	9-11	14-16	3	1-2	0,4	0,4	0,05-0,15

Tab. 1. L605 CoCr material chemical composition

The Pt-Cr alloyed steel cannot be found in any ISO standard because it is protected by the manufacturer [6], the composition can be seen in Tab. 2.

Chemical composition (%)						
Pt	**Cr**	**Ni**	**Mo**	**C**	**Si**	**Others**
32,5-33,5	17,5-18,5	8,5-9,5	2,43-2,83	0,003-0,023	≤0,1	≤0,05

Tab. 2. PtCr material chemical composition

The standard electrode potential of the components: Pt: +1,20 V, Co: -0,28, so galvanic corrosion can be predictable.

The test were carried out at 37°C in 0.9 w/w% saline to establish the actual circumstances in the more approximate environment. One test lasted one hour, during it potentiodynamic test was performed, after that images were taken of the stents and the saline solution was exchanged. The tests were performed with a Zahner IM6e complex electrochemical measuring equipment, CTV 101 PID electrode system, Agilent 347960A data collector. With the measurement results the corrosion rate of the stents for the test environment can be calculated.

Several recordings were made of the stents from different angles with an Olympus SZX16 stereomicroscope and a FEI Inspect S50 scanning electron microscope. JEOL EX-54175JMU energy-dispersive X-ray spectroscopy (EDS) was used to determine the material composition of the samples.

3. Results

The CoCr stent were dilated into the PtCr stent with nominal pressure (Fig. 1.). Two circles (1+1 hour) of corrosion test was performed on the sample.

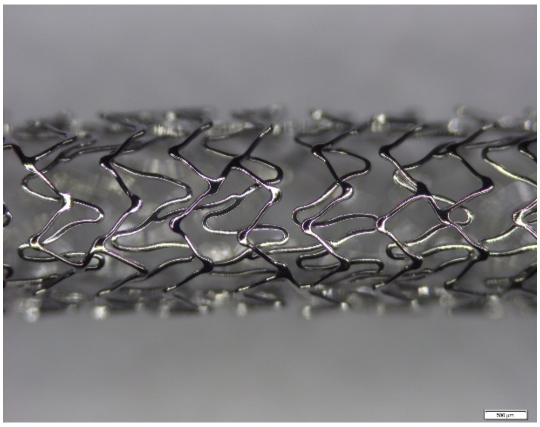

Fig. 1. Stereomicroscopic image of the overlapping stents, CoCr stent is surrounded by the PtCr stent

The mass of the stents were measured before and after each corrosion test session. After 2 hours of measurement 11,63% of the sample disappeared. Most of the mass lost from the CoCr stent.

- Original mass: 0,0430 g
- After 1 hour measurement: 0,039 g
- After another 1 hour measurement: 0,038 g

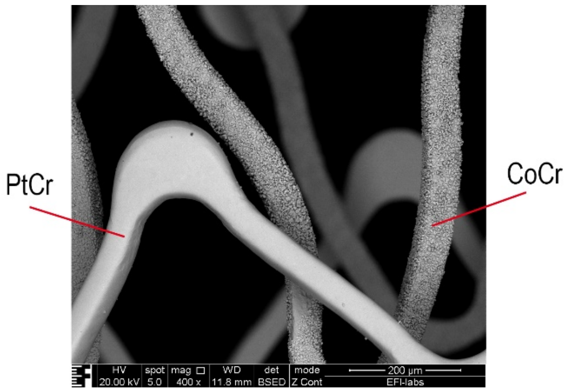

Fig. 2. SEM image of the stents after 1+1 hour of corrosion test

Even after a 2 hours measurement an average corrosion can be observed on the CoCr stent (Fig.2.), and pitting corrosion can be seen on the PtCr stent (Fig.3.) The average size of the hole shaped pit on the PtCr stent is 1-2 µm.

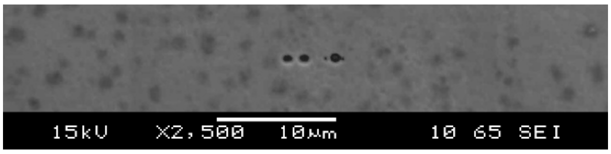

Fig. 3. Pitting corrosion on the PtCr stent

The results of the EDS measurements show that after the 2 hour test less Ni can be found in the CoCr material which means that during the corrosion process Ni can be released to the body.

4. Remarks

- The dilation of overlapping coronary artery stents with different material and standard potential clearly induces galvanic corrosion processes.

Acknowledgements

This research was supported by the National Talent Programme of the Hungarian Ministry of National Resources (NTP-NFTÖ-17-B-0359).

References

[1] A.N. NOWBAR, et al. Global geographic analysis of mortality from ischaemic heart disease by country, age and income. Int. J. of Cardiol. 174:2 (2014) pp.293-298.

[2] M.R. Mohaved, et al. Coronary artery bifurcation lesions: a review and update on classification and interventional techniques. Card. Rev. Medicine 9 (2008) pp.263-268.

[3] H. YANG, et al. Pitting corrosion resistance of La added 316L stainless steel in simulated body fluids. Materials Letters 61. (2007) pp.1154–1157.

[4] C.L. LIU, et al. Anti-corrosion characteristics of nitride-coated AISI 316L stainless steel coronary stents. Surface & Coatings Technology 201. (2006) pp.2802–2806.

[5] ISO 5832-5:2007 Implants for surgery – Metallic materials – Part 5: Wrought cobalt-chromium-tungsten-nickel alloy.

[6] B O'BRIEN, et al. A platinum–chromium steel for cardiovascular stents. Biomaterials 31. (2010) pp.3755–3761.