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POTENTIOMETRIC STRIPPING ANALYSIS OF THE SOLUBLE LEAD RELEASED FROM DENTAL CERAMIC MATERIALS

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Abstract. *Lead belongs to the group of very toxic elements with cumulative toxic effects. Considering the fact that dental implants are to stay in the human organism for a long time, it is necessary to check for the possible release of heavy metals. We analyzed the soluble lead content of the ceramic materials used in the dental-prosthetic practice. Potentiometric stripping analysis (PSA) was employed for such an analysis because it is highly sensitive, selective and reproductive method. The soluble lead content of the dental ceramic materials was found to be at the ppb level, except for one sample containing about 1ppm of lead.*

Key words: *dental ceramic materials, lead, potentiometric stripping analysis*

1. INTRODUCTION

Dental ceramic is alkaline alumosilicate and has a very wide application in dental prosthetic practice. It is used for the production of ceramic and metal ceramic implants, crowns and bridges [1]. Considering the fact that dental implants remain in the human organism for a long time, and that they are made of foreign constructive material, it is necessary to check their possible harmful effects upon the human health. The adverse effect of the use of implants could be chronic intoxication with the heavy metals [2].

Lead belongs to the group of highly toxic elements with cumulative effects, which may cause a variety of adverse health effects in humans [3,4]. At relatively low levels of exposure, these effects may include interference with red blood cell chemistry, delays in normal physical and mental development in babies and young children, slight deficiency in the attention span, hearing and learning abilities of children, and slight increases in the blood pressure of some adults. Lead also has the potential to cause cancer from a lifetime exposure at levels above the action level.

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For that reason the determination of the soluble lead content in dental ceramic materials has special importance for reducing the risk of possible lead intoxication. The aim of this paper is to present the results of the soluble lead content determination in dental ceramic materials.

The soluble lead content was determined by the potentiometric stripping analysis (PSA). This technique was selected as sensitive, selective, inexpensive and dependable, and it was also proved to give the results that are in good agreement with the results obtained by the flameless atomic absorption spectrophotometry (AAS) [5,8].

2. EXPERIMENT

Apparatus. All stripping analyses were performed using a commercially available computerized analyzer (Faculty of Technology, Novi Sad and "Elektrouniverzal", Leskovac) [6]. The electrochemical cell comprises a processing vessel bowl, a mechanical stirrer and a tree-electrode system. A glassy carbon disc working electrode was used as an inert support for the mercury film. Before electrode formation, the glassy carbon surface was prepared by being swept with filter paper first soaked with acetone and then with distilled water. The mercury film was formed electrolytically from a solution containing 100 mg/dm^3 mercury (II)-ions and 0.02 mol/dm^3 hydrochloric acid, at a constant current of 5 μA for 240 s [5,7,8]. An Ag/AgCl, KCl (3.5 mol/dm^3) electrode was used as the reference and a platinum wire as a counter electrode [7].

Sample preparation. The samples analyzed in this work were two different components of dental materials, two different colors and two finished dental implants prepared according to the usual procedure applied in the dental prosthetic practice. One gram of each sample was treated with 100cm^3 of 4% acetic acid for 24 hours ± 10 minutes. For the PSA an aliquot of 25 cm^3 was taken and analyzed without dilution.

The PSA of lead. The PSA is one of the most sensitive techniques for trace metal analysis and its sensitivity for lead determination may be up to 50 ng/dm^3 [9]. We employed the PSA modification using oxygen as the oxidant with the diffusion conditions of the mass transfer during the analytical step [6]. This PSA modification is the simplest one since it uses already dissolved oxygen as the oxidant thus reducing the contamination risk arising from the application of some other oxidizing agent. The parameters for PSA determination of lead in 4% acetic acid, which also served as supporting electrolyte, have been optimized earlier [5]. The PSA of lead was performed at the electrolysis potential of −0.966 V against the Ag/AgCl, KCl (3.5 mol/dm^3) electrode, during 600 s and at the solution stirring rate of 4000 rpm.

Lead determination in the acetate extracts of dental materials was carried out by both the calibration curve and the standard addition methods.

3. RESULTS AND DISCUSSION

First of all, both the linearity and the reproducibility of the PSA analytical signal of lead in solution were checked. The PSA analytical signal dependence on the mass concentration of lead in solution is shown in Figure 1.

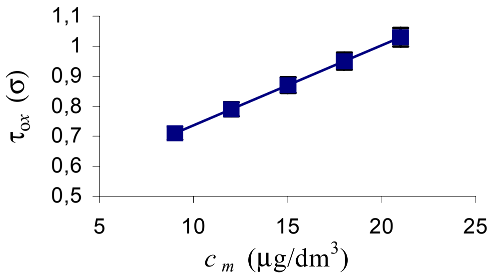

Fig. 1. Linearity of the PSA analytical signal of lead in solution.
$\tau_{ox} = 37.647 + 2.213 \cdot c_m$; $r = 0.998$

Regarding the high value of the correlation coefficient ($r > 0.990$) it may by said that there is very good linearity of the PSA analytical signal within the examined lead concentration range.

The results of the soluble lead content determination in the dental ceramic materials are given in Table1.

Table 1. The soluble lead content of the dental ceramic materials determined by the PSA method.

Sample	Number of Measurements	Lead concentration (µg/dm³)*	
		Calibration curve method	Standard addition method
Component I	5	3.27 ± 0.35	2.95 ± 0.51
Component II	5	1043 ± 0.67	1058 ± 0.77
colour I	5	12.59 ± 0.42	13.13 ± 0.80
Colour II	5	13.76 ± 1.24	17.95± 0.97
Finished implant I	5	5.04 ± 0.34	5.43 ± 0.90
Finished implant II	5	7.38 ± 0.34	6.91 ± 0.78

* Lead concentrations ± standard deviations

The soluble lead content of samples investigated was at the ppb level, except for one of the components, which contained around 1ppm of soluble lead (for that sample a separate calibration curve was used). Although finished prosthetic products (teeth) contained the component II with a relatively high soluble lead content their soluble lead content was similar to the other component and colours. This is probably the consequence of their compact dense structure, which allowed the acetic acid to extract lead only from the shallow surface region of these samples.

The results obtained in this work proved that PSA method is suitable for studying the lead leaching from dental ceramic materials.

4. CONCLUSION

Potentiometric stripping analysis was applied for the determination of the soluble lead content in dental ceramic materials. The samples (the components, the colours and the finished implants) were treated with 4% acetic acid.

The results obtained in this work show that the soluble lead content of dental materials investigated was at the ppb level, except for one component where it was around 1ppm. Soluble lead content of the final product was similar to that of the starting components.

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ODREĐIVANJE RASTVORLJIVOG OLOVA IZ DENTALNOG KERAMIČKOG MATERIJALA POTENCIOMETRIJSKOM STRIPING ANALIZOM

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Olovo spada u grupu veoma toksičnih elemenata sa kumulativno-toksičnim dejstvom. S obzirom na to da dentalni implantati ostaju u ljudskom organizmu u dugom vremenskom periodu izloženi dejstvu različitih agenasa, bitno je proveriti da li je iz njih moguće ispuštanje teških metala. Analiziran je keramički materijal koji se koristi u stomatološko-protetičkoj praksi na sadržaj rastvorljivog olova. Za analizu ovog visoko čistog materijala primenjena je potenciometrijska srtiping analiza (PSA) kao vrlo osetljiva, brza, jednostavna i pouzdana metoda. Utvrđeno je da je sadržaj rastvorljivog olova u keramičkom materijalu na nivou ppb, dok je kod jedne od komponenti taj sadržaj oko 1 ppm.