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CORROSION, MATERIALS AND ENVIRONMENTAL PROTECTION

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ZAŠTITE MATERIJALA I ŽIVOTNE SREDINE*

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Table of Contents

PLENARY LECTURES PLENARNA PREDAVANJA	1
Environmental protection with natural zeolite – a circular economy approach Nediljka Vukojević Medvidović	2
Where is biodiesel technology going – a critical view on raw materials, catalysts and processes Vlada Veljković	3
Raw Materials Supply in Future - A Duck Soup Issue??? Svetomir Hadži Jordanov	5
Optimization of preventive activities and maintenance of water wells exposed to corrosion and encrustation processes Vaso Novaković, Nikola Nikolić	6
INVITED LECTURES PREDAVANJA PO POZIVU	7
New Porous Coordination Polymers Based on 3d Metal Ions Traian-Dinu Pasatoiu, Radu Cristian Dascalu, Catalin Maxim, Marius Andruh	8
Photosynthetic efficiency and morphological damage symptoms of <i>Juglans regia</i> L. leaves in urban environment Dragana Pavlović, Marija Matić, Veljko Perović, Zorana Mataruga, Milica Marković, Miroslava Mitrović, Pavle Pavlović	9
Comparison of bioactivity, cytotoxicity, antimicrobial and corrosive behavior of ceramic coatings with and without polymer on titanium Marijana R. Pantović Pavlović, Miroslav M. Pavlović, Jasmina S. Stevanović, Vladimir V. Panić, Nenad L. Ignjatović	19
ORAL PRESENTATIONS USMENA SAOPŠTENJA	31
Electrochemical properties of pigment extracts from dark red corn grains Maja Stevanović, Jelena Lović, Sanja Stevanović, Marija Mihailović	32
Electrochemical quantitative determination of sertraline in pharmaceutical formulation using a gold electrode in bicarbonate solution Jelena Lović, Dušan Mijin, Milka Avramov Ivić	37
Ecophysiological response of <i>Tilia sp</i> and <i>Pinus nigra</i> to Pb in urban environment Marija Matić, Dragana Pavlović, Veljko Perović, Dragan Čakmak, Miroslava Mitrović, Pavle Pavlović	42
Bacterial nanocellulose as green support for platinum catalysts in methanol electrooxidation reaction Sanja Stevanović, Marijana Ponjavić, Jasmina Nikodinović Runić, Vesna Maksimović, Vladan Ćosović	49
Application of Collaborative Robots in the Fourth Industrial Revolution - Industry 4.0 Isak Karabegović, Edina Karabegović, Ermin Husak, Mehmed Mahmić	51
Protection against electrochemical corrosion of steel tank floors by installing a cathodic protection system Željko Krivačević, Dejan Grgić, Saša Stojanović, Aleksandar Pešić	60

Research on The Application of Mobile Robots for Disinfection of Contaminated Space With Virus "Covid-19"	
Isak Karabegović, Ermin Husak, Lejla Mehmedović Banjanović, Safet Isić	66
Aqueous electrolyte polypyrrole zinc cell with supercapattery performance	
Marija Janačković, Milica Gvozdenović, Branimir Jugović, Branimir Grgur	75
Testing the effectiveness of raspberry flower extract as an inhibitor of copper's corrosion in 3%NaCl	
Dejana Kasapović, Fehim Korać, Farzet Bikić	76
Fabrication and characterization of manganese ferrite/expanded vermiculite as a magnetic adsorbent of nickel ions	
Mladen Bugarčić, Miroslav Sokić, Branislav Marković, Milan Milivojević, Aleksandar Marinković, Jovana Perendija, Zorica Lopičić	84
POSTER PRESENTATIONS I POSTERSKA SAOPŠTENJA	95
Impact of Noise During the Reconstruction of The Section of the Tivat-Jaz Main Road and During Traffic on the Local Population	
Darko Vuksanović, Dragan Radonjić, Jelena Šćepanović	96
Level of Environmental Quality Improvement by Disposal of Municipal Waste in Sanitary Cell	
Jelena Šćepanović, Darko Vuksanović, Dragan Radonjić	103
Analysis of the Possibility of Collection, Transport, Storage and Processing of Waste Tires in Order to Improve the Quality of the Environment	
Dragan Radonjić, Darko Vuksanović, Jelena Šćepanović	114
Commercial food supplements of 'bee products' as inhibitors of corrosion processes	
Regina Fuchs–Godec, Marija Riđošić, Milorad. V. Tomić, Miomir G. Pavlović	126
Thin TiO ₂ -based coatings for the purpose of corrosion protection	
Regina Fuchs–Godec	131
Influence of recasting on the structure and properties of Ni-Cr dental alloy	
Vesna M. Maksimović, Aleksandra D. Čairović, Ivana Lj. Cvijović-Alagić	136
Synthesis and characterization of silver-doped ceria nanopowders	
Branko Matović	137
Microstructural refinement influence on the Ti-45Nb alloy properties in physiological conditions	
Ivana Cvijović-Alagić, Slađana Laketić, Dejan Zagorac, Jelena Bajat, Đorđe Veljović, Vesna Kojić, Marko Rakin	138
The influence of self-doping on electrochemical synthesis and behaviour of polyaniline	
Milica Gvozdenović, Branimir Jugović, Bojan Jokić, Enis Džunuzović, Branimir Grgur	139
Electrodeposition of Nd and Pr onto W from fluoride based melts	
Vesna S. Cvetković, Dominic Feldhaus, Nataša M. Vukićević, Nebojša D. Nikolić, Bernd Friedrich, Jovan N. Jovićević	140
Influence of regime of electrolysis on morphology and structure of copper dendrites	
Nebojša D. Nikolić, Vesna M. Maksimović, Zvezdana Baščarević, Predrag M. Živković, Miomir G. Pavlović	145
Low cost hydrothermal synthesis of shining carbon quantum dots	
Biljana Babić, Ana Kalijadis, Marko Nikolić, Martina Gilić, Branislav Jelenković, Bojan Jokić	146

Chemometric approach in the monitoring of the TiNi alloy corrosion behaviour under different coastal conditions Đendi Vaštag, Špiro Ivošević _____	147
The influence of electrolyte temperature on corrosion of CuAlMnZn alloy in Na ₂ SO ₄ solution Ladislav Vrsalović, Senka Gudić, Ines Garvanović, Dražan Jozić, Ivana Ivanić, Mirko Gojić, Stjepan Kožuh _____	148
New biomedical materials based on metal-doped fluorapatite Dusan Milojkov, Vaso Manojlovic, Miroslav Sokic _____	159
Influence of Current Density and Ultrasound on the Morphology and Roughness of Zn-Mn-CeO ₂ Nanocomposite Coatings Marija Riđošić, Mihael Bučko, Regina Fuchs Godec, Milorad Tomić, Jelena Bajat, Miomir Pavlović _____	166
Solvent Extraction of Copper From Oxide Ore By Organic Extragens Branko Bojić, Ljubica Vasiljević, Danijela Rajić _____	167
Corrosion protection of ship structures Srđan Bulatović, Vujadin Aleksić, Bojana Zečević _____	177
Oil Recovery from Roadside Pennycress (Thlaspi Alliaceum L.) Seeds and its Application for Biodiesel Production Milan Kostić, Olivera Stamenković, Vlada Veljkovi¹ _____	183
Precipitation behaviour in pH adjusted lateritic ore solution Jonas Mitterecker, Marija Mihailović, Milica Košević, Jasmina Stevanović, Srečko Stopić, Vladimir Panić, Bernd Friedrich _____	190
Electrochemical investigation of lateritic ore leachates for metal ions extraction Jonas Mitterecker, Milica Košević, Marija Mihailović, Jasmina Stevanović, Srečko Stopić, Bernd Friedrich, Vladimir Panić _____	195
Synthesis and Characterization of New Coordination Polymers Obtained Using 3d and 3d-4f Nodes Traian-Dinu Pasatoiu, Catalin Maxim, Augustin Madalan, Marius Andruh _____	199
Method development and removal study of amoxicillin by RP-HPLC Maria Uzelac, Katarina Modić, Nemanja Banić _____	199
Removal of methyl orange using combined ZnO/Fe ₂ O ₃ /ZnO-Zn composite coated to the aluminium foil in the presence of simulated solar radiation Nemanja Banić, Jugoslav Krstić, Maria Uzelac _____	211
Overview of Fuel A-1 and Lubricants for Mlas Motors Božidarka Arsenović, Darinka Jevtić, Zorica Ristić _____	223
Damage and Defects in Welded Joints Emina Dzindo, Rodoljub Milicevic _____	234
Mechanisms and morphologies of cavitation damage of NN 70 steel Vujadin Aleksić, Marina Dojčinović, Ljubica Milović, Bojana Aleksić, Ana Prodanović _____	237
Electrochemical examination of the pyrocatechol influence on the Bray-Liebafsky reaction after the oscillatory period Jelena P. Maksimović, Maja C. Pagnacco _____	249
SPONSORS SPONZORI _____	255

Microstructural refinement influence on the Ti-45Nb alloy properties in physiological conditions

Uticaj usitnjavanja mikrostrukture na svojstva Ti-45Nb legure u fiziološkim uslovima

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Abstract

The high-pressure torsion (HPT) post-processing treatment influence on the grain refinement, corrosion behavior, and biocompatible properties of the Ti-45Nb (mass%) alloy, as a promising new hard-tissue replacement material, was investigated in the present study. The HPT-induced microstructural alterations were experimentally analyzed by electron backscatter diffraction (EBSD), transmission electron microscopy (TEM), x-ray diffraction (XRD), and Vickers microhardness measurements, while additional theoretical investigations on the ab initio level were conducted to fully investigate the HPT influence on the alloy microstructural properties. Results showed that significant microstructural refinement was achieved through the HPT processing while a change in alloy phase composition was not detected. In both, unrefined and refined, microstructures the β -Ti and Ti4Nb phases were identified and confirmed by the ab initio modeling results. The microstructural alterations effect on the alloy corrosion behavior in simulated physiological conditions was examined through the potentiodynamic polarization measurements. In vitro tests were conducted to determine the grain refinement influence on the investigated alloy and live cells interaction. Attained results indicated that the HPT treatment can be successfully applied to improve the Ti-45Nb alloy bio-corrosive performance through an increase of the alloy hardness, corrosion resistance, and live cells viability during the alloy-cells interaction.

Keywords: Ti-45Nb alloy; structural investigations; grain size; bio-corrosion resistance.

Izvod

Tokom prezentovanog istraživanja ispitan je uticaj postupka uvijanja pod visokim pritiskom (UVP) na rafinaciju zrna, koroziono ponašanje i biokompatibilna svojstva Ti-45Nb (mas.%) legure, kao potencijalnog materijala za izradu kostnih implanata. Mikrostrukturne promene, uslovljene primenom UVP postupka, analizirane su elektronskom difrakcijom, transmisijom elektronskom mikroskopijom, difrakcijom x-zraka i određivanjem mikrotvrdoće, dok su teorijska istraživanja na ab initio nivou izvršena u cilju potpunog ispitivanja uticaja UVP metode na mikrostrukturna svojstva legure. Primenom UVP postupka postignuto je značajno usitnjavanje mikrostrukture bez promene faznog sastava legure. U nerafinisanoj i rafinisanoj mikrostrukтури identifikovane su β -Ti i Ti4Nb faze, što su potvrdili i rezultati ab initio modelovanja. Uticaj promene mikrostrukturnih svojstava na korozionu postojanost legure u simuliranim fiziološkim uslovima ispitan je potenciodinamičkom metodom. Uticaj rafinacije zrna na potencijalnu interakciju implantne legure sa živim ćelijama ispitan je primenom in vitro metoda. Potvrđeno je da se UVP obrada može uspešno primeniti za poboljšanje bio-korozionog ponašanja Ti-45Nb legure kroz povećanje tvrdoće i korozione otpornosti legure, kao i vijabilnosti ćelija tokom interakcije legure sa živim ćelijama.

Ključne reči: Ti-45Nb legura; strukturna ispitivanja; veličina zrna; bio-koroziona postojanost.