



University of Belgrade
Technical Faculty in Bor,
Mining and Metallurgy
Institute Bor

**54th International
October Conference
on Mining and Metallurgy**

PROCEEDINGS

Editors:

Ljubiša Balanović

Dejan Tanikić



18-21 October 2023, Bor Lake, Serbia

**PROCEEDINGS,
54th INTERNATIONAL OCTOBER CONFERENCE
on Mining and Metallurgy**

Editors:

Prof. dr Ljubiša Balanović

Prof. dr Dejan Tanikić

University of Belgrade, Technical Faculty in Bor

Technical Editor:

M. Sc. Miljan Marković

University of Belgrade, Technical Faculty in Bor

Publisher: University of Belgrade, Technical Faculty in Bor

For the publisher: Dean Prof. dr Dejan Tanikić

Circulation: 200 copies

CIP - Каталогизacija у публикацији Народна библиотека Србије, Београд

622(082)(0.034.2)

669(082)(0.034.2)

INTERNATIONAL October Conference on Mining and Metallurgy (54 ; 2023
; Borsko jezero)

Proceedings [Elektronski izvor] / 54th International October Conference on Mining
and Metallurgy - IOC 2023, 18-21 October 2023, Bor Lake, Serbia ; [organized by]
University of Belgrade, Technical Faculty in Bor and Mining and Metallurgy Institute
Bor ; editors Ljubiša Balanović, Dejan Tanikić. - Bor : University of Belgrade,
Technical Faculty, 2023 (Niš : Grafika Galeb). - 1 USB fleš memorija ; 1 x 1 x 5 cm

Sistemska zahteva: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 200. -
Preface / Ljubiša Balanović. - Bibliografija uz svaki rad.

ISBN 978-86-6305-140-9

a) Рударство -- Зборници b) Металургија -- Зборници

COBISS.SR-ID 126659849

Bor Lake, Serbia, October 18-21, 2023



Conference is financially supported by
The Ministry of Science, Technological
Development and Innovation
of the Republic of Serbia

Platinum Donors



Gold Donors



Silver Donor



Exhibitions



Friends of the Conference



THE FOUNDATION 'B.SC. ENG. BOŠKO INJAC'

SCIENTIFIC COMMITTEE

Prof. Dr Dejan Tanikić (Serbia) - president
Prof. Dr Nada Štrbac (Serbia) - vice-president
Prof. Dr Radoje Pantović (Serbia) - vice-president

Dr Ana Kostov (Serbia)
Prof. Dr Adam Grajcar (Poland)
Prof. Dr Adina Negrea (Romania)
Dr Andrei Rotaru (Romania)
Prof. Dr Batrić Pešić (USA)
Dr Biserka Trumić (Serbia)
Prof. Dr Boštjan Markoli (Slovenia)
Dr Branislav Marković (Serbia)
Prof. Dr Cornelia Muntean (Romania)
Prof. Dr Daniela Grigorova (Bulgaria)
Prof. Dr Dejan Ivezić (Serbia)
Prof. Dr Desimir Marković (Serbia)
Prof. Dr Dimitris Pnias (Greece)
Prof. Dr Dimitriu Sorin (Romania)
Prof. Dr Dmitry Vasilyev (Russia)
Dr Dragan Komljenović (Canada)
Prof. Dr Dragan Manasijević (Serbia)
Dr Dragan Milanović (Serbia)
Prof. Dr Dragan Milovanović (Serbia)
Prof. Dr Dragoslav Gusković (Serbia)
Prof. Dr Dušan Orać (Slovakia)
Prof. Dr Duško Minić (Serbia)
Prof. Dr Endre Romhanji (Serbia)
Prof. Dr Essen Suleimenov (Kazakhstan)
Prof. Dr Farzet Bikić (Bosnia and Herzegovina)
Prof. Emeritus Fathi Habashi (Canada)
Prof. Dr Grozdanka Bogdanović (Serbia)
Prof. Dr György Kaptay (Hungary)
Prof. Dr Ivan Mihajlović (Serbia)
Prof. Dr Iveta Vaskova (Slovakia)
Prof. Dr Jakob Lamut (Slovenia)
Prof. Dr Jasmin Suljagić (Bosnia and Herzegovina)
Dr Jasmina Stevanović (Serbia)
Dr Jasna Stajić Trošić (Serbia)
Prof. Dr Jovica Sokolović (Serbia)
Prof. Dr Jožef Medved (Slovenia)
Prof. Dr Kaikun Wang (China)
Prof. Dr Karl Heinz Spitzer (Germany)
Prof. Emeritus Karlo Raić (Serbia)
Prof. Dr Kemal Delijić (Montenegro)
Prof. Dr Komnitsas Konstantinos (Greece)
Prof. Dr Kostas Matis (Greece)
Prof. Dr Krzysztof Fitzner (Poland)
Prof. Dr Luis Filipe Malheiros (Portugal)
Prof. Dr Milan Antonijević (Serbia)
Prof. Dr Milan Trumić (Serbia)
Dr Mile Bugarin (Serbia)

Dr Milenko Ljubojev (Serbia)
Prof. Dr Milovan Vuković (Serbia)
Prof. Dr Mira Cocić (Serbia)
Mirjam Jan-Blažič (Slovenia)
Prof. Dr Mirjana Rajčić Vujasinović (Serbia)
Prof. Dr Mirko Gojić (Croatia)
Dr Miroslav Sokić (Serbia)
Prof. Dr Mirsada Oruč (Bosnia and Herzegovina)
Dr Nadežda Talijan (Serbia)
Prof. Dr Natalija Dolić (Croatia)
Prof. Dr Nedeljko Magdalinović (Serbia)
Prof. Dr Nenad Radović (Serbia)
Prof. Dr Nenad Vušović (Serbia)
Prof. Dr Nicanor Cimpoesu (Romania)
Prof. Dr Nobuyuki Masuda (Japan)
Prof. Dr Onuralp Yucel (Turkey)
Prof. Dr Pavel Broz (Czech Republic)
Prof. Dr Petr Solozhenkin (Russia)
Prof. Dr Petrica Vizureanu (Romania)
Dr Sun Zhongmei (China)
Prof. Dr Ridvan Yamanoglu (Turkey)
Prof. Dr Rodoljub Stanojlović (Serbia)
Prof. Dr Rositsa Paunova (Bulgaria)
Prof. Dr Sead Čatić (Bosnia and Herzegovina)
Prof. Dr Sergey Krasikov (Russia)
Dr Slavomír Hredzák (Slovakia)
Prof. Dr Snežana Milić (Serbia)
Prof. Dr Snežana Šerbula (Serbia)
Prof. Dr Srba Mladenović (Serbia)
Dr Srećko Stopić (Germany)
Prof. Dr Stojan Groudev (Bulgaria)
Prof. Dr Sulejman Muhamedagić (Bosnia and Herzegovina)
Prof. Dr Svetlana Ivanov (Serbia)
Prof. Dr Tatjana Volkov-Husović (Serbia)
Prof. Dr Tomáš Havlik (Slovakia)
Prof. Dr Velimir Radmilović (Serbia)
Prof. Dr Velizar Stanković (Serbia)
Prof. Dr Vesna Grekulović (Serbia)
Dr Vladan Ćosović (Serbia)
Vladan Mihailović (Serbia)
Dr Vladan Kašić (Serbia)
Prof. Dr Vladimir Krstić (Canada)
Prof. Dr Vladislav Kecojević (USA)
Dr Walter Valery (Australia)
Prof. Dr Xuewei Lv (China)
Prof. Dr Yong Du (China)
Prof. Dr Žarko Radović (Montenegro)
Prof. Dr Zdenka Zovko Brodarac (Croatia)
Dr Zoran Stevanović (Serbia)
Prof. Dr Željko Kamberović (Serbia)

ORGANIZING COMMITTEE

Prof. dr Ljubiša Balanović, Full Professor (UB TF Bor) - president
Prof. dr Saša Stojadinović, Full Professor (UB TF Bor) - vice-president
Prof. dr Srba Mladenović, Full Professor (UB TF Bor) - vice-president
Dr Ana Kostov, Principal Research Fellow (MMI Bor) - vice-president

Prof. dr Nada Štrbac, Full Professor (UB TF Bor)
Prof. dr Dragan Manasijević, Full Professor (UB TF Bor)
Prof. dr Vesna Grekulović, Full Professor (UB TF Bor)
Prof. dr Đorđe Nikolić, Full Professor (UB TF Bor)
Prof. dr Milan Radovanović, Full Professor (UB TF Bor)
Prof. dr Marija Petrović Mihajlović, Full Professor (UB TF Bor)
Prof. dr Zoran Štirbanović, Associate Professor (UB TF Bor)
Prof. dr Milan Gorgievski, Associate Professor (UB TF Bor)
Prof. dr Saša Marjanović, Associate Professor (UB TF Bor)
Prof. dr Ivana Marković, Associate Professor (UB TF Bor)
Prof. dr Žaklina Tasić, Associate Professor (UB TF Bor)
Doc. dr Dejan Petrović, Assistant Professor (UB TF Bor)
Doc. dr Anđelka Stojanović, Assistant Professor (UB TF Bor)
Doc. dr Uroš Stamenković, Assistant Professor (UB TF Bor)
Dr Jasmina Petrović, Assistant with PhD (UB TF Bor)
Vladimir Nikolić, Assistant (UB TF Bor)
Milica Zdravković, Assistant (UB TF Bor)
Miljan Marković, Assistant (UB TF Bor)
Milijana Mitrović, Assistant (UB TF Bor)
Milan Nedeljković, Assistant (UB TF Bor)
Avram Kovačević, Teaching Assistant (UB TF Bor)
Sandra Vasković, English Lecturer (UB TF Bor)
Oliver Marković, IT service (UB TF Bor)
Violeta Aleksić, Liquidator (UB TF Bor)

PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October 18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović

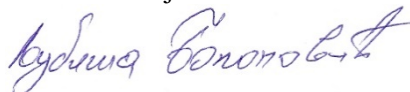


TABLE OF CONTENTS

Plenary Lectures

Velimir R. Radmilović (SERBIA)

Energy: One of the biggest challenges in 21st century 3-3

Jing Yu, Mingshui Luo, Junyi Xiang, Yang You, Zhixiong You, Xuewei Ly (CHINA)

Efficient extraction of vanadium from vanadium slag 4-8

Invited Lectures

Batrić Pešić (UNITED STATES)

The ongoing restructuring of universities to adopt the sophistication offered by internet 11-19

Yaima Filiberto, Alberto Montenegro, Eugenio Alvarez (SPAIN)

Machine learning applied to improving the scrap recycling and melting process in all types of ferrous alloys and steel 20-22

Slobodan Kostić, Qi Fenglai, Savo Pirgić, Nenad Botić, Dobrica Milovanović, Čedomir Sušić, Igor Zlatković (SERBIA)

Construction of a new sintering plant 180 m² within the HBIS Group Serbia Iron & Steel 23-26

Satyananda Patra (INDIA)

Acid activation of bentonite: Physico-Chemical characterization and application in goethitic iron ore green pelletization 27-35

Ridvan Yamanoglu (TURKEY)

Production of metal-based powders by atomization techniques 36-45

Yong Du, Rainer Schmid-Fetzer, Jincheng Wang, Shuhong Liu, Jianchuan Wang, Qiang Lu, Yuhui Zhang, Kai Li (CHINA, GERMANY)

Computational design of engineering materials: case studies for a cemented carbide and a heat resistant Al alloy 46-46

Conference Papers

Ordinartsev Denis, Nadezhda Pechischeva, Svetlana Estemirova, Andrey Rempel (RUSSIA)

Cr(VI) photosorption on composite sorbent of montmorillonite with amorphous TiO₂ 49-52

Mikhail Korovkin, Ludmila Ananyeva, Andrey Zherlitsyn, Sergey Kondratyev, Olesya Savinova (RUSSIA)

Electro-pulse crushing in high-purity quartz production 53-55

Žarko Radović, Nebojša Tadić (MONTENEGRO)

Analytical simulation of EAF dust enrichment 56-59

<u>Nebojša Tadić, Žarko Radović</u> (MONTENEGRO) <i>Thermal and mechanical relaxation of residual stresses in cold rolled aluminium alloy strips</i>	60-63
Dragan Šabaz, Miloš Stojanović, Dejan Petrović (SERBIA) <i>Selection of anchor type using AHP method</i>	64-67
<u>Miloš Stojanović, Veljko Lapčević, Ivica Vojinović</u> (SERBIA) <i>Blast fragmentation analysis in Jama Bor by using WipFrag software</i>	68-71
<u>Veljko Lapčević, Toma Jovičić, Slavko Torbica</u> (SERBIA) <i>Mine ventilation model validation by PQ survey</i>	72-75
<u>Jelena Đorđević, Jelena Stefanović, Sandra Guševac, Ivan Jelić, Stefan Trujić</u> (SERBIA) <i>Life cycle analysis (LCA) of asphalt layers containing recycled asphalt pavement</i>	76-79
<u>Jelena Ivaz, Dejan Petrović, Predrag Stolić, Mladen Radovanović, Dragan Zlatanović, Saša Stojadinović, Pavle Stojković</u> (SERBIA) <i>Occupational injuries in underground coal mining: statistical analysis of data</i>	80-83
<u>Jelena Ivaz, Dejan Petrović, Mladen Radovanović, Dragan Zlatanović, Saša Stojadinović, Pavle Stojković</u> (SERBIA) <i>Prediction of methane emissions in coalmine - Soko</i>	84-87
<u>C. Prochaska, E. Kokkinos, D. Merachtsaki, A. Lampou, E. Peleka, K. Simeonidis, G. Vourlias, A. Zouboulis</u> (GREECE) <i>Recovery of metallic fractions from medical products labelled for single use</i>	88-91
<u>Nataša Sarap, Marija Janković, Vojislav Stanić, Ivana Jelić, Marija Šljivić-Ivanović</u> (SERBIA) <i>Analysis of gross alpha and gross beta activity in samples around former uranium mine Gabrovnica</i>	92-95
<u>Dragan Manasijević, Ljubiša Balanović, Ivana Marković, Uroš Stamenković</u> (SERBIA) <i>Latent heat of some aluminium based phase change alloys for thermal energy storage</i>	96-99
<u>Anđelka Stojanović, Ivica Nikolić, Isidora Milošević</u> (SERBIA) <i>Position of European countries in sustainable resource management</i>	100-103
<u>Aleksandar Đorđević, Duško Minić, Milena Zečević, Dragan Manasijević</u> (SERBIA) <i>Mechanical and electrical properties of the ternary Ag-Ge-Sn alloys</i>	104-107
<u>Milena Zečević, Duško Minić, Aleksandar Đorđević, Dragan Manasijević</u> (SERBIA) <i>Effect of chemical composition on the corrosion resistance of the ternary Ag-Ge-Sn alloys</i>	108-111
<u>Tatiana Aleksandrova, Nadezhda Nikolaeva</u> (RUSSIA) <i>Extraction of low-dimensional structures of nonferrous and noble metals from refractory raw materials</i>	112-115
<u>Viša Tasić, Tatjana Apostolovski-Trujić, Bojan Radović, Nevena Ristić, Tamara Urošević, Vladan Kamenović, Zvonko Damjanović</u> (SERBIA) <i>Air quality measurements in the Bor city during the reconstruction of the copper smelter Bor in 2022</i>	116-119

<u>Slavica Miletić, Biserka Trumić, Suzana Stanković</u> (SERBIA) <i>Application of control charts in the laboratory for testing the metallic materials</i>	120-123
<u>Alexey M. Amdur, Sergei A. Fedorov, Andrey A. Forshev, Nikolay V. Grevtsev, Vera V. Yurak</u> (RUSSIA) <i>Technological aspects of the use of peat as a component of pulverated coal fuel for blast furnaces</i>	124-127
<u>Ljiljana Avramović, Zoran Stevanović, Vanja Trifunović, Radmila Marković, Dragana Božić, Daniela Urošević, Silvana Dimitrijević</u> (SERBIA) <i>Hydrometallurgical treatment of mining waste from Bor - Serbia in aim of copper recovery</i>	128-131
<u>Daniel Kržanović, Radmilo Rajković, Ivana Jovanović, Milenko Jovanović, Miomir Mikić</u> (SERBIA) <i>Determination the final contour of the open pit Veliki Krivelj for the mining capacity 23.1 million tons of ore</i>	132-135
<u>Vladan Marinković, Miroslava Maksimović, Milenko Jovanović, Goran Pačkovski</u> (SERBIA) <i>The use of unmanned aerial vehicles for making the precise 3D topo models and orthophoto images</i>	136-140
<u>Dejan Tanikić, Anđela Stojić, Jelena Đoković, Miloš Stoljiljković</u> (SERBIA) <i>Mechanical characteristics of the shape memory alloy Cu-Zn-Al</i>	141-144
<u>Ljiljana Avramović, Vanja Trifunović, Zoran Stevanović, Radmila Marković, Dragana Božić, Dejan Bugarin, Silvana Dimitrijević</u> (SERBIA) <i>Copper recovery from RE-flotation tailings by combined process</i>	145-148
<u>Milenko Jovanović, Daniel Kržanović, Radmilo Rajković, Vladan Marinković, Miroslava Maksimović, Miomir Mikić</u> (SERBIA) <i>Application of hybrid geogrids in mining</i>	149-153
<u>Stefan Trujić, Miroslava Maksimović, Vladan Marinković, Ljiljana Avramović, Vanja Trifunović, Dragana Božić</u> (SERBIA) <i>Geological exploration of the technogenic deposit - old flotation tailing pit - Bor with the possibility of leaching</i>	154-157
<u>Zoran Stevanović, Radmila Marković, Ljiljana Avramović, Vojka Gardić, Jelena Petrović, Dragana Božić</u> (SERBIA) <i>Sustainable and smart mining</i>	158-161
<u>Snežana Ignjatović, Ivana Vasiljević, Branisav Sretković, Milanka Negovanović</u> (SERBIA) <i>Using gravity data to define structural correlation affecting the formation of Neogene basins</i>	162-165
<u>Deniz Eylül Akpınar, Batuhan Turgut, Ugur Gurol, Savas Dilibal</u> (TURKEY) <i>Characterization of wire arc additively manufactured wear-resistant bimetallic component</i>	166-169
<u>Mistreanu Sebastian, Ramona Cimpoesu, Dragoş Achiţei, Mihai Popa, Daniela Lucia Chicet, Vasile Manole, Ana-Maria Scripcariu, Nicanor Cimpoesu</u> (ROMANIA) <i>Sandblasting process influence on stainless steel cutting element properties</i>	170-174

<u>Dorđe Petrović, Katarina Stanković, Latinka Slavković Beškoski, Ksenija Kumrić</u> (SERBIA) <i>Removal of Cu(II) from aqueous solutions using adsorbent based on chitosan hydrogel beads</i>	175-178
<u>Jovan P. Šetrajčić, Siniša M. Vučenović</u> (BOSNIA AND HERZEGOVINA) <i>Modified basic properties of electrons in layered nanocrystals with a complex lattice</i>	179-182
<u>Irena Nikolić, Milena Tadić, Dijana Đurović, Nevena Cupara, Ivana Milašević</u> (MONTENEGRO) <i>Kinetic and thermodynamic aspects of strontium adsorption by steelmaking slag</i>	183-186
<u>Miomir Mikić, Milenko Jovanović, Sandra Milutinović, Daniel Kržanović, Radmilo Rajković</u> (SERBIA) <i>New flotation plant Veliki Krivelj monitoring plan</i>	187-190
<u>Miomir Mikić, Radmilo Rajković, Daniel Kržanović, Sandra Milutinović</u> (SERBIA) <i>Recultivation of open pit Veliki Krivelj</i>	191-194
<u>Farzet Bikić, Khaola Awad, Halim Prčanović, Mirnes Duraković</u> (BOSNIA AND HERZEGOVINA) <i>Analysis of influenced factors on tropospheric ozone content in the city of Zenica during 2020</i>	195-198
<u>Sandra Milutinović, Ljubiša Obradović, Daniel Kržanović, Miomir Mikić, Radmilo Rajković</u> (SERBIA) <i>Flotation tail storage methods</i>	199-202
<u>Sandra Milutinović, Milena Kostović, Ljubiša Obradović, Srđana Magdalinović, Sanja Petrović</u> (SERBIA) <i>Methods of transportation and discharge of tails to flotation tailings pond</i>	203-206
<u>Uğur Gürol, Ceren Çelik, Müesser Göçmen, Mustafa Koçak</u> (TURKEY) <i>Microstructural and mechanical characterization of armor steel joint welded with sandwich design</i>	207-210
<u>Branka Pešovski, Milan Radovanović, Vesna Krstić, Danijela Simonović, Silvana Dimitrijević</u> (SERBIA) <i>Electrochemical characteristics of the anodized titanium oxide films in sulfuric acid</i>	211-215
<u>Duško Đukanović, Nemanja Đokić, Zoran Aksentijević, Daniel Radivojević, Branisl Stakić</u> (SERBIA) <i>Methane as an untapped energy potential of the "Soko" brown coal mine</i>	216-220
<u>Žaklina Tasić, Marija Petrović Mihajlović, Ana Simonović, Milan Radovanović, Maja Nujkić, Milan Antonijević</u> (SERBIA) <i>Electrochemical methods for the determination of tryptophan and caffeine</i>	221-224
<u>Isidora Milošević, Anđelka Stojanović, Sanela Arsić, Ivica Nikolić, Ana Rakić</u> (SERBIA) <i>Circular economy in the era of Industry 5.0</i>	225-228

<u>Almaida Gigović-Gekić, Elvis Agović, Belma Fakić, Hasan Avdušinović</u> (BOSNIA AND HERZEGOVINA) <i>Effect of delta ferrite on microstructure and hardness welded joints of steel S21800</i>	229-232
<u>Radmila Marković, Dragana Bozić, Zoran Stevanović, Tatjana Apostolovski Trujić, Vojka Gardić, Ljiljana Avramović, Vesna Marjanović</u> (SERBIA) <i>Combining neutralization and adsorption methods for metals removal from Saraka stream</i>	233-236
<u>Ana Petrović, Radmila Marković, Emina Požega</u> (SERBIA) <i>CNTs as potential material for wastewater purification: a review</i>	237-240
<u>Zdenka Stanojević Šimšić, Ana Kostov, Aleksandra Milosavljević, Slavica Miletić</u> (SERBIA) <i>Experimental investigations of CuAlNi alloys with 70 at%Cu</i>	241-244
<u>Ana Kostov, Aleksandra Milosavljević, Zdenka Stanojević Šimšić, Ivan Jovanović</u> (SERBIA) <i>Determination of melt properties in Cu-Fe alloys</i>	245-248
<u>Vladimir Nikolić, Milan Trumić</u> (SERBIA) <i>A simple method of determining of bond work index for finer samples</i>	249-252
<u>Ivan Jovanović, Novica Staletović</u> (SERBIA) <i>Management of risk assessment in environmental protection in surface copper mine</i>	253-256
<u>Jovan P. Šetrajić, Stevo K. Jaćimovski, Siniša M. Vučenović</u> (BOSNIA AND HERZEGOVINA) <i>Possibility of localized electron states appearance in ultrathin layered crystalline structures</i>	257-260
<u>Jovica Sokolović, Ivana Ilić, Dragiša Stanujkić, Zoran Štirbanović</u> (SERBIA) <i>Application of VIKOR method for comparison of the washability of coals</i>	261-264
<u>Vladimir Jovanović, Dejan Todorović, Branislav Ivošević, Dragan Radulović, Sonja Milićević, Marija Ercegović, Slavica Mihajlović</u> (SERBIA) <i>The process of obtaining biochar and the development of the products thus obtained</i>	265-269
<u>Jelena Petrović, Marija Ercegović, Marija Simić, Marija Koprivica, Jelena Dimitrijević, Marija Marković</u> (SERBIA) <i>Mg/Fe-modified hydrochar with promoted adsorption performances</i>	270-273
<u>Esra Dokumaci Alkan, Nurdan Ari, Murat Alkan</u> (TURKEY) <i>A coating application of IN718 via self-propagating high-temperature synthesis method</i>	274-277
<u>Murat Alkan, Esra Dokumaci Alkan, Dilan Ugurluer, Aslihan Karakanat</u> (TURKEY) <i>Production of AlCoCrCuXFeNi alloys via self-propagating high-temperature synthesis method</i>	278-281
<u>Jarmila Trpčevská, Iveta Vasková, Katarína Pauerová, Martina Laubertová, Dušan Oráč</u> (SLOVAKIA) <i>Zinc volatilization in the primary and the secondary zinc production</i>	282-286

<u>Dragan Ignjatović, Lidija Đurđevac Ignjatović, Vanja Đurđevac, Katarina Milivojević, Ivan Jovanović (SERBIA)</u> <i>Application of the numerical method in the definition of a substrate of circular cross section</i>	287-291
<u>Dragan Ignjatović, Lidija Đurđevac Ignjatović, Vanja Đurđevac, Mladen Supić, Dušan Tašić (SERBIA)</u> <i>Influence of the subsoil bearing capacity during formation of high landfills</i>	292-296
<u>Bojana Živković, Jelisaveta Marjanović, Jelena Đokić, Maja Petrović (SERBIA)</u> <i>Soil and rock properties as a basis for the sanitary landfill settings</i>	297-300
<u>Milan Gorgievski, Miljan Marković, Nada Štrbac, Vesna Grekulović, Kristina Božinović, Milica Zdravković, Marina Marković (SERBIA)</u> <i>Adsorption kinetics for copper ions adsorption onto onion peels</i>	301-304
<u>Saba Nourozi, Fatemeh Pourasgharian, Ahmad Khodadadi Darban (IRAN)</u> <i>Recovery of copper from low-grade copper ore using organic acid</i>	305-308
<u>Maria Krasteva (BULGARIA)</u> <i>Methodology and equipment for researching corrosion cracking processes in steel 3H14L (BDS 3692-78)</i>	309-312
<u>Jasmina Nešković, Pavle Stjepanović, Nenad Milojković, Dejan Lazić, Klara Konc Janković, Svetlana Polavder, Ivana Jovanović (SERBIA)</u> <i>Testing the Bond work index on limestone from flue gas desulphurization plant in TPP Ugljevik</i>	313-317
<u>Biljana Zlatičanin, Sandra Kovačević (MONTENEGRO)</u> <i>Impact of titanium addition on microstructure and properties of as-cast Al-Cu15 alloys</i>	318-321
<u>Biljana Zlatičanin, Sandra Kovačević (MONTENEGRO)</u> <i>Effect of cooling rate on mechanical properties of binary Al-Cu23 alloys</i>	322-324
<u>Desislav Ivanov, Irena Peytcheva, Marko Holma (BULGARIA)</u> <i>Horizon Europe AGEMERA project - Agile Exploration and Geo-modelling for European Critical Raw Materials: The potential of Assarel porphyry copper deposit for critical raw materials</i>	325-328
<u>Shehret Tilvaldyev, Uzziel Caldiño Herrera, Jose Omar Davalos, Manuel Alejandro Lira Martinez, Marlenne Alejandra Hernandez Lira, Diego Adan Villordo Melendez (CANADA)</u> <i>Problems of anthropogenic pollution of space</i>	329-334
<u>Mohammed Derqaoui, Abdelmoughit Abidi, Abdelrani Yaacoubi, Khalid El Amari, Omar Oabi, Abdelaziz Bacaoui (MOROCCO)</u> <i>Apatite flotation from low-grade sedimentary phosphate ore</i>	335-338
<u>Nadezhda Kazakova, Alexandar Popov, Georgi Chernev (BULGARIA)</u> <i>Influence of the distribution and content of limestone particles on the properties of blended cements</i>	339-342

<u>Daniel Ogochukwu Okanigbe, Shade Rouxzeta Van Der Merwe</u> (SOUTH AFRICA) <i>Rocks of Obafemi Awolowo University and Environ, Nigeria: structural analysis of geological contact</i>	343-347
<u>Vladan Kašić, Ana Radosavljević Mihajlović, Jovica Stojanović, Slavica Mihajlović, Melina Vukadinović, Nataša Đorđević, Ivana Jelić</u> (SERBIA) <i>Study of thermally treated zeolitic tuffs of Serbia, deposits "Zlatokop" and "Općište"-Beočin</i>	348-352
<u>Vesna Grekulović, Aleksandra Mitovski, Milica Zdravković, Nada Štrbac, Milan Gorgievski, Milovan Vuković, Miljan Marković</u> (SERBIA) <i>Electrochemical behavior of copper in chloride medium in the presence of nettle extract</i>	353-356
<u>Marko Pavlović, Marina Dojčinović, Muhamed Harbinja, Atif Hodić, Dragan Radulović, Mirjana Stojanović, Zagorka Aćimović</u> (SERBIA, BOSNIA AND HERZEGOVINA) <i>Effects of the application of pyrophyllite in the composition of protective coatings</i>	357-360
<u>Tamara Ristić, Nenad Milosavljević, Dobrica Milovanović</u> (SERBIA) <i>Measures for the processing of iron with a higher incoming phosphorus content at the steel shop</i>	361-365
<u>Ivana Mikavica, Dragana Randelović, Milena Obradović, Jovica Stojanović, Jelena Mutić</u> (SERBIA) <i>Microplastic textile fibers in urban soils of Serbia</i>	366-369
<u>Jianbo Zhao, Xinnan Zhao, Donglai Ma, Yang You, Zhixiong You, Xuewei Lv</u> (CHINA) <i>Preparation of ferronickel by semi-molten smelting a mixture of two types of laterite ore</i>	370-374
<u>Mladen Radovanović, Dejan Petrović, Jelena Ivaz, Dragan Zlatanović</u> (SERBIA) <i>Possibility of copper ores exploitation using in situ leaching method</i>	375-378
<u>Ivan Jelić, Nikola Lekić, Nikola Stanić, Miomir Mikić</u> (SERBIA) <i>Selection of an optimal route for relocation of the Čehotina river bed</i>	379-382
<u>Milica Zdravković, Vesna Grekulović, Bojan Zdravković, Nada Štrbac, Milan Gorgievski, Miljan Marković</u> (SERBIA) <i>Electrochemical behavior of steel in 0.1 mol/dm³ HCl in the presence of potato peel juice</i>	383-386
<u>Ivana Marković, Dalibor Jović, Uroš Stamenković, Dragan Manasijević, Ljubiša Balanović, Milan Gorgievski</u> (SERBIA) <i>Microstructure and thermal properties of leaded brass after quenching</i>	387-390
<u>Mehmet Ali Yildiz</u> (SERBIA) <i>Hot strip mill walking beam slab reheating project</i>	391-394
<u>Peter Polyak</u> (SERBIA) <i>Finishing mill automation upgrade at hot strip mill</i>	395-400
<u>Branislav Potić, Ana Arifović</u> (SERBIA) <i>The metallurgical testing results of the boron mineralized material from Valjevo-Mionica basin</i>	401-406

<u>Uroš Stamenković, Ivana Marković, Srba Mladenović, Saša Marjanović, Avram Kovačević, Milijana Mitrović, Filip Basarabić (SERBIA)</u> <i>The influence of quenching media on different properties of C45 carbon steel</i>	407-413
<u>Yang You, Jiabao Guo, Zhixiong You, Xuewei Lv (CHINA)</u> <i>Investigation of the mixing and granulation behavior of iron ore fines in horizontal high-shear granulator</i>	414-417
<u>Jovica Sokolović, Grozdanka Bogdanović, Velizar Stanković, Gracijan Strainović, Ivana Ilić, Milan Gorgievski, Miljan Marković (SERBIA)</u> <i>Investigation on beneficiation of iron from copper ore of Mauritania Copper Mine (MCM) by magnetic separation</i>	418-421
<u>Essen Suleimenov, Rustam Sharipov, Galymzhan Maldybayev, Zhibek Orazaliyeva (KAZAKHSTAN)</u> <i>Investigation of the influence of pulsed electric current on the efficiency of decomposition of aluminate solution</i>	422-423
<u>Lovro Liverić, Tamara Holjevac Grgurić, Sunčana Smokvina Hanza, Wojciech Sitek, Vedrana Špada, Marko Kršulja (CROATIA)</u> <i>Influence of silver content on martensitic transformation of Cu-Al-Ag alloy</i>	424-427
<u>Hasan Ali Taner, Vildan Onen (TURKEY)</u> <i>Evaluation of the efficiency of different collectors in the chalcopyrite flotation</i>	428-434
<u>Vesna Conić, Dragana Božić, Miloš Janošević, Ljiljana Avramović, Vanja Trifunović, Dejan Bugarin, Ivana Jovanović (SERBIA)</u> <i>A pyro-hydrometallurgical process for the recovery of zinc from jarosite waste</i>	435-438
<u>Maria Krasteva, Rumen Petkov (BULGARIA)</u> <i>Research the rate of chemical corrosion of steel 3X14H2 (BDS 3692-78)</i>	439-442
<u>Srba Mladenović, Bojan Novaković, Ivana Marković, Uroš Stamenković (SERBIA)</u> <i>Effect of casting speed and water flow on tensile strength, elongation and microstructure of continuous cast copper wire</i>	443-447
<u>Nadira Bušatlić, Ilhan Bušatlić, Dženana Smajić-Terzić (BOSNIA AND HERZEGOVINA)</u> <i>Dependence of compressive strength of geopolymer based on fly ash and alkaline activator ratio</i>	448-451
<u>Gergana Meracheva, Efrosima Zaneva-Dobranova, Nikolay Hristov (BULGARIA)</u> <i>Hydrocarbon potential of the Lower Paleozoic sediments in NE Bulgaria by geochemistry and well-logging</i>	452-455
<u>Dragana Marilović, Grozdanka Bogdanović, Sanja Petrović (SERBIA)</u> <i>Leaching of flotation tailings with a solution of sulfuric acid and ionic liquid</i>	456-459
<u>Ivana Jovanović, Vesna Conić, Dragan Milanović, Daniel Kržanović, Tanja Stanković, Daniela Urošević, Miloš Janošević (SERBIA)</u> <i>Determination of Bond rod mill work index of a very low-grade copper ore</i>	460-463

<u>Hasan Ali Taner, Ali Aras, Muhammad Hashim Rasa (TURKEY)</u> <i>Investigation of the effect of depressant and collector conditioning times on cobalt recovery by flotation</i>	464-467
<u>Aleksandar Cvetković, Žaklina Tasić, Marija Petrović Mihajlović, Maja Nujkić, Milan Radovanović, Ana Simonović (SERBIA)</u> <i>Microplastics</i>	468-471
<u>Sanja Petrović, Srđana Magdalinović, Ljubiša Obradović, Sandra Milutinović, Bojan Drobnjaković, Slađana Krstić (SERBIA)</u> <i>Tailing management: tailings filtering equipment</i>	472-475
<u>Jelena Stefanović, Jelena Đorđević, Sandra Guševac (SERBIA)</u> <i>XRD analysis of corrosion product formed in industrial aggressive environment</i>	476-480
<u>Muhamad Ghulam Isaq Khan, Filip Rajković, Miljana Popović, Dejan Prelević, Aleksandar Ćitić, Tamara Radetić (SERBIA)</u> <i>Initiation of abnormal grain growth in cold-rolled sheet of AA5182 Al-Mg alloy: role of texture</i>	481-484
<u>Danijela Voza, Hesam Dehghani, Milica Veličković (SERBIA)</u> <i>The dissolved oxygen prediction based on the machine learning techniques</i>	485-488
<u>Hasan Acan, Hasan Ergin (TURKEY)</u> <i>A novel model for minimizing mine closure costs and the optimum final quarry boundry</i>	489-492
<u>Ivana Jovanović, Dragan Milanović, Oliver Dimitrijević, Vesna Conić, Igor Svrkota (SERBIA)</u> <i>Role of wing tank in DMS process. Suspension velocity through the seal leg orifice – case study</i>	493-496
<u>Dejan Petrović, Jelena Ivaz, Saša Stojadinović, Predrag Stolić, Dragan Zlatanović (SERBIA)</u> <i>Risk management and mining machines maintenance – a brief review</i>	497-500
<u>Stefan Đorđievski, Dragana Adamović (SERBIA)</u> <i>History of surface water pollution by mining and metallurgical activities in Bor, Serbia</i>	501-504
<u>Olivera Dragutinović, Vaso Manojlović, Đorđe Veljović, Stefan Dikić, Marko Simić (SERBIA)</u> <i>Investigation of the properties of Co-Cr-W and Co-Cr-Mo alloys coated with hydroxyapatite for use in dental implants</i>	505-509
<u>Zoran Karastojković, Dragoslav Gusković, Ognjen Ristić, Zorica Kovačević (SERBIA)</u> <i>About the “relative plasticity” between steel matrix and non-metallic inclusions</i>	510-513
<u>Aleksandar Jovanović, Mladen Bugarčić, Milena Milošević, Marija Vuksanović, Muna Abdualatif Abdurahman, Miroslav Sokić, Aleksandar Marinković (SERBIA, LIBYA)</u> <i>Modified hybrid cellulose membrane for Nickel(II) ions removal from industrial wastewater</i>	514-517
<u>Elena Todorova, Nadezhda Kazakova, Georgi Chernev (BULGARIA)</u> <i>Structural investigation via SEM analysis of silica hybrid materials</i>	518-521

<u>Tanja Kalinović, Jelena Kalinović, Jelena Milosavljević, Ana Radojević, Snežana Šerbula (SERBIA)</u> <i>Atmospheric bulk deposition as environmental quality indicator</i>	522-526
<u>Gordana Marković, Vaso Manojlović, Miroslav Sokić, Jovana Ružić, Dušan Milojkov (SERBIA)</u> <i>Designing biocompatible high entropy alloys using Monte Carlo simulations</i>	527-530
<u>Tatjana Volkov-Husović, Sanja Martinović, Ana Alil, Milica Vlahović (SERBIA)</u> <i>Application of image analysis for cavitation erosion resistance monitoring of some engineering materials</i>	531-534
<u>Milan Nedeljković, Srba Mladenović, Jasmina Petrović, Milijana Mitrović (SERBIA)</u> <i>Changes in the structure and density of copper during the refining smelting process</i>	535-538
<u>Jasmina Petrović, Srba Mladenović, Ivana Marković, Milan Nedeljković, Milijana Mitrović (SERBIA)</u> <i>Microstructure analysis of EN AW 6061 alloy using a SEM microscope after artificial aging</i>	539-542
<u>Milijana Mitrović, Saša Marjanović, Biserka Trumić, Jasmina Petrović, Milan Nedeljković (SERBIA)</u> <i>Effects of cold rolling and annealing processes on the microstructure and properties of micro-alloyed copper</i>	543-546
<u>Makedonka Dimitrova, Jasminka Dimitrova Kapac (NORTH MACEDONIA)</u> <i>Unlocking energy efficiency: financing preferences for SMEs in the Republic of North Macedonia</i>	547-555
<u>Zoran Štirbanović, Vesna Vojinović, Jovica Sokolović, Maja Trumić (SERBIA)</u> <i>Analysis of the effectiveness of different methods for cutting samples</i>	556-559
<u>Ivica Nikolić, Isidola Milošević, Anđelka Stojanović (SERBIA)</u> <i>Land turnover increases due to mining: An empirical analysis of Bor, Serbia, 2013-2022.</i>	560-563
DONORS	565-590
AUTHOR INDEX	591-596

ELECTROCHEMICAL BEHAVIOR OF COPPER IN CHLORIDE MEDIUM IN THE PRESENCE OF NETTLE EXTRACT

Vesna Grekulović¹, Aleksandra Mitovski², Milica Zdravković¹,
Nada Štrbac¹, Milan Gorgievski¹, Milovan Vuković¹, Miljan Marković¹

¹ Technical Faculty Bor, University of Belgrade, V.J. 12, 19210 Bor, Serbia,

² Engineering Dobersek GmbH, 41169 Moenchengladbach, Germany

Abstract

The use of plant extracts to inhibit copper corrosion is the subject of numerous scientific studies. This paper presents the results of research the electrochemical behavior of copper during oxidation in a 0.5 mol/dm³ NaCl solution in the absence and presence of nettle extract (NE) in different concentrations. The electrochemical behavior of copper was investigated using the cyclic voltammetry and the potentiostatic method. The results of cyclic voltammetry showed that three current peaks appear on the anodic polarization curves, which correspond to the formation of copper chloride and copper oxide. Potentiostatic polarization was performed at 0 mV vs. SCE during 100 s at 25 °C. The potentiostatic curves indicate that the stationary currents decrease with increasing extract concentration in the electrolyte. Microphotographs confirmed that in the presence of NE, a protective layer was formed on the copper surface, which prevents the corrosion process.

Keywords: copper, electrochemical behavior, chloride medium, nettle extract

1. INTRODUCTION

Copper has been for decades one of the most strategically important metals in the industry, because of its physical and chemical properties, which enable its wide range usage in numerous products of modern society. Copper corrosion and its inhibition in various environments are the subject of numerous scientific investigations [1-3]. Inhibitors are substances added in different concentrations to a given solution containing aggressive ions. They can be of the organic or inorganic origin. However, many inhibitors are toxic. Plant extracts as potential environmental corrosion inhibitors have become the subject of numerous scientific investigations in the last few years. Various plant parts can be extracted and used as metal corrosion inhibitors [3].

This paper presents the results of investigation the addition of nettle extract (in following text: NE) on the copper corrosion behavior in 0.5 mol/dm³ NaCl solution.

2. EXPERIMENTAL

The experiments were carried out in a system consisting of an electrochemical cell and a hardware interface for computerized control and data acquisition. In a standard three-electrode electrochemical cell, the working electrode was made of copper, whose potential was controlled against a reference saturated calomel electrode (SCE). Platinum foil was used as a counter electrode. The computerized control (National Instruments card, NI-6251) and data acquisition software (LabVIEW 8.2 platform), fully developed at the Technical Faculty in Bor [4], were used to run the electrochemical experiments.

Investigation of the copper electrochemical behavior in 0.5 mol/dm³ NaCl solution in the absence and the presence of NE was performed by recording the anodic polarization curves. The curves were recorded in the potential range of -0.4 V vs. SCE up to 1 V vs. SCE with a scan rate of 20

mV/s. The potentiostatic curves were recorded at 0 V vs. SCE for 100 s. Optical microscopy was used for the electrode surface characterization after potentiostatic oxidation.

The substances used for the preparation of the working solutions were NaCl (p.a purity), manufactured by d.d. "Zorka Pharma" Šabac and fresh nettles harvested in the vicinity of Bor. The NE was prepared as follows: 100 g of nettle was chopped and placed in 200 mL of 96% ethanol. After standing in ethanol solution for one month, the solution was filtered and the obtained nettle extract was stored in the refrigerator.

3. RESULTS AND DISCUSSION

Figure 1 shows the anodic polarization curves recorded for copper in 0.5 mol/dm³ NaCl without and with NE of different volumes.

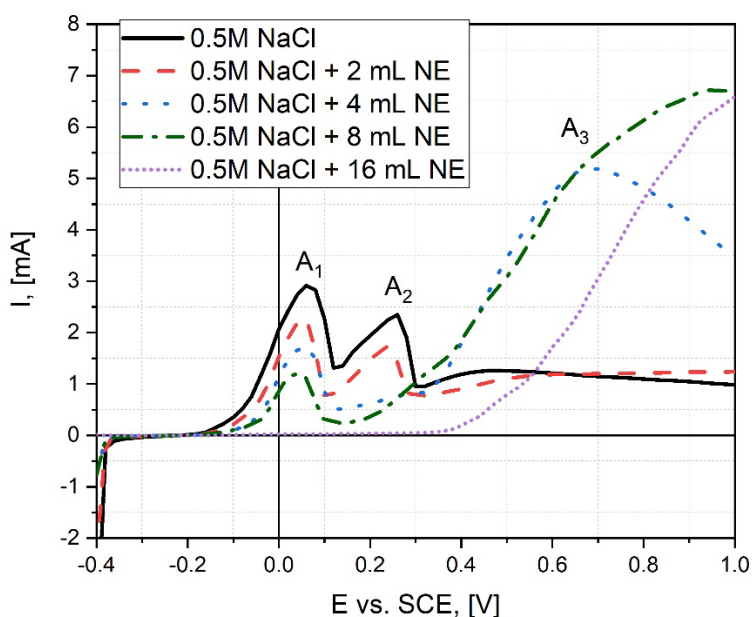


Figure 1 - Anodic polarization curves for copper with a scan rate of 20 mV/s in 0.5 mol/dm³ NaCl with and without the addition of NE

On the anodic polarization curve, obtained for 0.5 mol/dm³ NaCl, three current peaks appeared. They correspond to the formation of copper chloride and copper oxide [5, 6]. Comparing the anodic polarization curves for copper obtained in the presence of NE with the anodic polarization curve without the NE, it can be observed that the current values for the current peaks A1 and A2 in the presence of 2 mL, 4 mL and 8 mL NE are lower in relation to the current values without NE. The best inhibitory effect is achieved with the addition of 16 mL NE, as shown by the current values of the current peaks A1 and A2, which are approximately equal to zero. With the addition of 2 mL NE in the potential area where the current peak A3 appears, the current values are approximately equal to the current values without the addition. With the addition of 4 mL NE, a clearly defined current peak A3 appears, which represents the formation of copper oxide. In the presence of 8 mL and 16 mL NE, there is a sudden current value increase in the potential area where the current peak A3 appears, which indicates that there is a separation of oxygen and the formation of a certain amount of copper oxide.

Figure 2 shows the potentiostatic curves after the potentiostatic treatment of copper during 100 s in 0.5 mol/dm³ NaCl without and with the addition of NE.

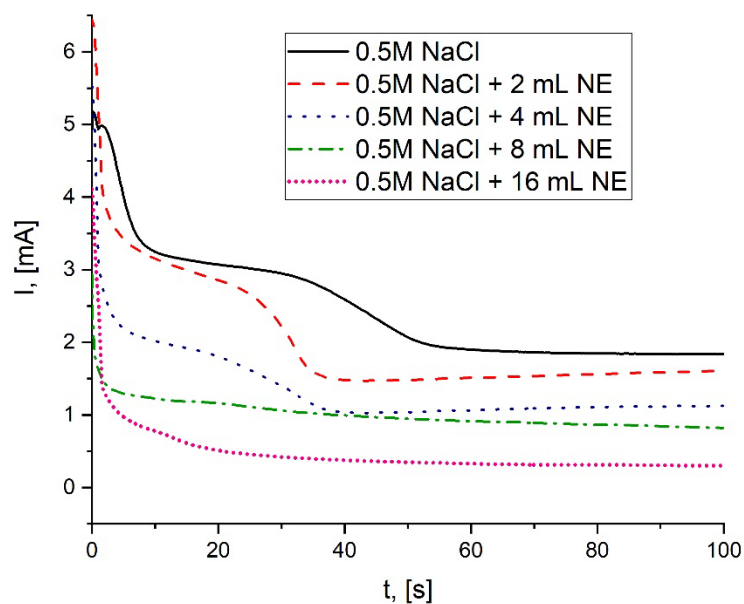


Figure 2 - Potentiostatic curves for copper in 0.5 mol/dm³ NaCl without and with the addition of NE at 0 V vs. SCE

The current strength for copper in 0.5 mol/dm³ NaCl without the addition of NE drops sharply in the first 8 s, then slowly decreases until about 55 s, after which it stabilizes. The value of the stationary current strength amounts to 1.838 mA. With the addition of 2 mL and 4 mL NE, there is a sudden drop in the current strength in the first 4 s, then it slowly decreases until about 40 s, after which there is a slight increase and stabilization. The value of the stationary current with the addition of 2 mL NE is 0.818 mA, and with the addition of 4 mL NE is 0.565 mA. The potentiostatic curve obtained for copper with the addition of 8 mL NE drops sharply in the first few seconds, then continues to decrease slightly and stabilizes at about 90 seconds, with the value of the stationary current strength being 0.536 mA. With the addition of 16 mL NE, the current drops sharply in the first seconds, after which it slowly decreases until about 60 s, and then it stabilizes and reaches the stationary current value of 0.499 mA. Based on the obtained results, it can be concluded that with an increase in the volume of NE, the stabilization of the current is achieved faster and the values of the stationary current are lower, which indicates that a protective layer is formed on the copper surface.

Analysis of the copper surface by optical microscopy was performed after the potentiostatic treatment of copper in the presence and in the absence of NE.

Figures 3a, 3b, 3c, 3d and 3e show microphotographs of the copper surface after potentiostatic treatment in a solution of 0.5 mol/dm³ NaCl without and with the addition of NE. Figure 3a shows a microphotograph of the copper surface after potentiostatic treatment in 0.5 mol/dm³ NaCl, where it is clearly seen that the surface is significantly damaged and that copper chlorides and copper oxide were formed on the surface during the oxidation process. In the presence of NE, a protective film is formed, which protects the copper surface from corrosion. As the volume of NE increases, the copper surface is less damaged and there is less presence of chlorides and oxides. With the addition of 16 mL NE only a black phase is present on the copper surface. This confirms the results obtained by the method of cyclic voltammetry, that the NE prevents the formation of copper chloride, and stimulates the process of copper oxide formation.

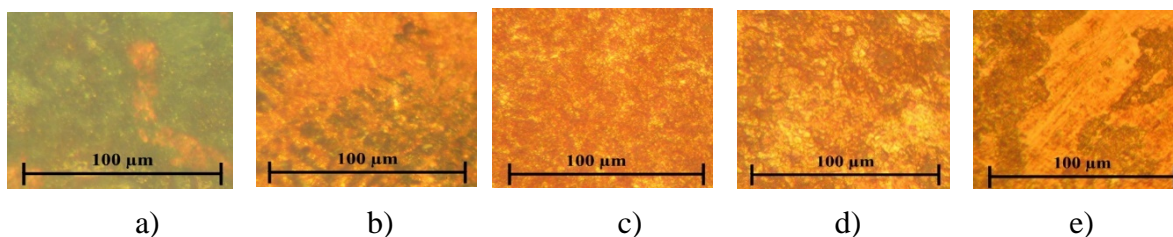


Figure 3 - Microphotographs of the copper surface after potentiostatic treatment on the potential of 0 V vs. SCE during 100 s: a) in 0,5mol/dm³ NaCl; b) in 0,5mol/dm³ NaCl + 2 mL NE; c) in 0,5mol/dm³ NaCl + 4 mL NE; d) in 0,5mol/dm³ NaCl + 8 mL NE; e) in 0,5mol/dm³ NaCl + 16 mL NE

4. CONCLUSION

Based on the performed experiments, the following conclusions can be drawn:

Investigation of the electrochemical behavior of copper using the cyclic voltammetry method in 0.5 mol/dm³ NaCl, three current peaks appeared on the anodic polarization curve, which corresponds to the formation of copper chloride and oxide. In the presence of NE, the inhibitory effect is achieved in the area of copper chloride formation potential at all tested concentrations of NE, while in the area of copper oxide formation potential, NE acts as a corrosion activator. Potentiostatic tests show that the stationary current strength in the presence of nettle extract is significantly lower compared to the stationary current strength in 0.5 mol/dm³ NaCl. Lower stationary current values in the presence of the extract indicate that a protective layer was formed on the copper surface, which prevents the corrosion process. With the increase of NE concentration, the values of the stationary current are lower. After the potentiostatic treatment of copper in 0.5 mol/dm³ NaCl solution, the microphotograph of the copper surface shows that copper chloride and oxide are formed and that the copper surface is significantly damaged. In the presence of NE, damage on the copper surface is less noticeable and the copper chloride and oxide amount are decreased. As the concentration of the extract increases, the damage is less noticeable, which indicates that the NE provides good protection of copper against corrosion.

ACKNOWLEDGEMENTS

The research presented in this paper was done with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-47/2023-01/ 200131.

REFERENCES

- [1] M. Rajčić Vujasinović, V. Grekulović, Z. Stević, D. Dragulović, S. Dimitrijević, Bakar, 41 (2) (2016) 35-40.
- [2] M. Scendo, Corros. Sci., 50 (6) (2008) 1584-1592.
- [3] M. Sangeetha, S. Rajendran, T. S. Muthumegala, A. Krishnaveni, Mat. Prot., 52 (2011) 3-19.
- [4] Z. Stević, M. Rajčić Vujasinović, Hem. Ind., 61 (2007) 1-6.
- [5] T. Kosec, I. Milosev, B. Pihlar, Appl. Surf. Sci., 253 (2007) 8863-8873.
- [6] M. Pourbaix., Atlas d'équilibres électrochimiques, Gauthier-Villars et Cie, Paris, 1963.

ISBN-978-86-6305-140-9

