

Proceedings of the 9th Croatian-Slovenian-Serbian
Symposium on Zeolites

Proceedings of the 9th Slovenian-Serbian-Croatian
Symposium on Zeolites

Proceedings of the 9th Serbian-Croatian-Slovenian
Symposium on Zeolites

Abbreviated title:

Proc. Croat.-Slov.-Serb. Symp. Zeolites

ISSN 2584-3176

Publisher

Croatian Zeolite Association (CROZA)

Editors

Ivona Nuić

Matjaž Mazaj

Aleksandra Daković

Zagreb, 2021

PROCEEDINGS OF THE
9th CROATIAN-SLOVENIAN-SERBIAN
SYMPOSIUM ON ZEOLITES

September 23-25, 2021
Split, Croatia

Organizers
CROATIAN ZEOLITE ASSOCIATION
SLOVENIAN ZEOLITE ASSOCIATION
SERBIAN ZEOLITE ASSOCIATION

Under the auspices of
Federation of European Zeolite Association (FEZA)

Publisher: Croatian Zeolite Association, Bijenička 54, 10000 Zagreb, Croatia
Proceedings publication frequency: every two years

All articles in the Proceedings were reviewed.

Organizing Committee

Chairs:

Assis. Prof. Ivona Nuić, Faculty of Chemistry and Technology, Split, Croatia

Prof. Jasna Hrenović, Faculty of Science, Zagreb, Croatia

Members:

Prof. Nediljka Vukojević Medvidović, Faculty of Chemistry and Technology, Split, Croatia

Prof. Marina Trgo, Faculty of Chemistry and Technology, Split, Croatia

Assis. Prof. Mario Nikola Mužek, Faculty of Chemistry and Technology, Split, Croatia

Prof. Sandra Svilović, Faculty of Chemistry and Technology, Split, Croatia

PhD Josip Bronić, Ruđer Bošković Institute, Zagreb, Croatia

Prof. Nataša Zabukovec Logar, National Institute of Chemistry, Ljubljana, Slovenia

Prof. Nataša Novak Tušar, National Institute of Chemistry, Ljubljana, Slovenia

Assis. Prof. Jelena Dikić, Innovation Center of the Faculty of Technology and Metallurgy, Belgrade, Serbia

Assoc. Prof. Vladislav Rac, Faculty of Agriculture, Belgrade, Serbia

Scientific and Program Committee

Prof. Darko Tibljaš, Faculty of Science, Zagreb, Croatia

Assoc. Prof. Tomislav Ivanković, Faculty of Science, Zagreb, Croatia

PhD Tatjana Antonić Jelić, Ruđer Bošković Institute, Zagreb, Croatia

PhD Sanja Bosnar, Ruđer Bošković Institute, Zagreb, Croatia

Prof. Vesna Tomašić, Faculty of Chemical Engineering and Technology, Zagreb, Croatia

Prof. Xuesen Du, Chongqing University, China

Prof. Qiang Wang, Beijing Forestry University, China

PhD Matjaž Mazaj, National Institute of Chemistry, Ljubljana, Slovenia

PhD Petar Djinović, National Institute of Chemistry, Ljubljana, Slovenia

PhD Andraž Krajnc, National Institute of Chemistry, Ljubljana, Slovenia






PhD Aleksandra Daković, Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, Serbia


Prof. Ljiljana Damjanović-Vasilić, Faculty of Physical Chemistry, Belgrade, Serbia

Prof. Vladimir Simić, Faculty of Mining and Geology, Belgrade, Serbia

9th Croatian-Slovenian-Serbian Symposium on Zeolites

23rd-25th September 2021, Split, Croatia

Time	Thursday, 23. 09. 2021	Time	Friday, 24. 09. 2021	Time	Saturday, 25. 09. 2021
8:30-9:00	Registration				
9:00-9:30	Opening				
	<i>chair Bronić</i>		<i>chair Rakić</i>		<i>chair Vukojević Medvidović</i>
9:30-10:15	PL Mintova	9:00-9:45	PL Giordano	9:00-9:45	PL Migliori
10:15-10:45	IL Byrne	9:45-10:15	IL Žerjav	9:45-10:15	IL Ugrina
		10:15-10:30	OP Kalebić	10:15-10:30	OP Labtim d.o.o.
10:45-11:15	 <i>Coffee break</i>	10:30-11:00	 <i>Coffee break</i>	10:30-10:45	CP Jasika d.o.o.
	<i>chair Novak Tušar</i>		<i>chair Bosnar</i>	10:45-11:00	CP Alumina d.o.o.
11:15-11:20	CP Labtim d.o.o.	11:00-11:15	OP Hrenović	11:00-11:15	Closing remarks and <i>Coffee break</i> 
11:20-11:35	OP Bosnar	11:15-11:30	OP Ivanković		
11:35-11:50	OP Šktjanc	11:30-11:45	OP Dikić		
11:50-12:05	OP Medak	11:45-12:00	OP Vukojević Medvidović		
12:05-12:20	OP Palčić	12:00-12:15	OP Vukojević Medvidović		
12:20-12:35	OP Rac	12:15-12:30	OP Mužek		
		12:30-12:45	OP Nuić		
12:35-14:00	 <i>Lunch</i>	12:45-14:00	 <i>Lunch</i>		
	<i>chair Zabukovec Logar</i>				
14:00-14:45	PL Valtchev				

14:45-15:15	IL Markiv			<p>PL = plenary lecture IL = invited lecture OP = oral presentation CP = company presentation</p>
15:15-15:30	OP Vu			
15:30-15:45	 <i>Coffee break</i>			
	<i>chair Trgo</i>			
15:45-16:00	OP Stojanović			
16:00-16:15	OP Pavlović			
16:15-16:30	OP Smiljanić			
16:30-16:45	OP Dimitrijević	16:00-18:00	<i>Diocletian Palace walking tour</i>	
16:45-17:00	OP Novaković	19:00-	<i>Conference dinner</i>	
17:00-17:15	OP Dib			

CONTENTS

<i>Plenary lecture: Opportunities in defects engineering and healing in zeolites</i>	1
Izabel C. Medeiros-Costa, Eddy Dib, Nikolai Nesterenko, Jean-Pierre Dath, Jean-Pierre Gilson, <u>Svetlana Mintova</u>	
<i>Invited lecture: Examining zeolitic imidazolate frameworks (ZIFs) for ethanol adsorption</i>	2
Ciara Byrne	
Synthesis and characterization of boron modified zeolite with MFI structure	6
<u>Sanja Bosnar</u> , Vladislav Rac, Ljiljana Damjanović-Vasilić, Vladimir Pavlović, Steva Lević, Josip Bronić, Vesna Rakić	
Green synthesis of ZIF-90 and its mixed metal analogues	10
<u>Aljaž Škrjanc</u> , Ciara Byrne, Matjaž Mazaj, Nataša Zabukovec Logar	
Effect of metal cations in FAU type zeolite on acid sites	14
<u>Glorija Medak</u> , Josip Bronić, Andreas Puškarić, Nina Popov	
Distribution of Al sites in SSZ-13 zeolites	18
Katarina Kopljar, Karen Janella Ardila Fierro, Andraž Krajnc, Matjaž Mazaj, <u>Ana Palčić</u>	
Fe and Ce exchanged ZSM-5 zeolites as electrocatalysts for ORR and OER reactions	22
Jadranka Milikić, Biljana Šljukić, Ivana Stojković Simatović, Ljiljana Damjanović-Vasilić, Srna Stojanović, <u>Vladislav Rac</u> , Vesna Rakić	
<i>Plenary lecture: Past and future of zeolite materials</i>	26
Valentin Valtchev	
<i>Invited lecture: The durability properties of concrete incorporating zeolitic tuff</i>	27
Zinoviy Blikharsky, Khrystyna Sobol, <u>Taras Markiv</u> , Oksana Pozniak, Wojciech Franus	
Ni/ZSM-5 as efficient catalyst for the selective hydrogenation of levulinic acid to γ-valerolactone in vapor phase	31
<u>Hue-Tong Vu</u> , Andrii Kostyniuk, Petar Djinović, Miha Grilc, Blaž Likozar, Nataša Zabukovec Logar, Nataša Novak Tušar	
Photocatalysis of bisphenol A in aqueous solution by zeolite/titania composites	35
<u>Srna Stojanović</u> , Vladislav Rac, Vesna Rakić, Ljiljana Damjanović-Vasilić	
Photocatalytic removal of dyes from wastewater under solar lights by natural clinoptilolite from different regions	39
<u>Jelena Pavlović</u> , Andraž Šuligoj, Nevenka Rajić	

Composites of phillipsite-rich tuff and surfactant – their characterization and stability	43
<i>Danijela Smiljanić, Aleksandra Daković, Milica Spasojević, Milena Obradović, Marija Marković, Alessio Langella, Bruno de Gennaro</i>	
Removal of arsenic(III) oxyanions from wastewater using aminosilane-modified natural and synthetic zeolite	47
<i>Jelena Dimitrijević, Jelena Petrović, Dragana Milošević, Jelena Dikić, Sanja Jevtić</i>	
ZSM-5 as sorbent for removal of linuron from water	51
<i>Ivana Mihajlović, Ali Hgeig, <u>Mladenka Novaković</u>, Nevena Živančev, Maja Petrović</i>	
Silanol networks in zeolites investigated with solid-state NMR	55
<i>Eddy Dib, Izabel C. Medeiros-Costa, Georgi Vayssilov, Hristiyan Aleksandrov, Svetlana Mintova</i>	
Characterization of metal species in metal-modified hierarchical mordenite	59
<i>Ivana Landripet, Marko Robić, Andreas Puškarić, Josip Bronić</i>	
Plenary lecture: Zeolite template carbon performances in catalytic and adsorption applications	63
<i>Girolamo Giordano</i>	
Invited lecture: The height of the Schottky barrier versus the photocatalytic activity of TiO₂+Au composites under visible-light illumination	64
<i>Gregor Žerjav, Albin Pintar</i>	
The efficiency of natural clinoptilolite for ciprofloxacin removal from aqueous media	68
<i>Barbara Kalebić, Jelena Pavlović, Jelena Dikić, Aleksander Rečnik, Nikola Škoro, Nevenka Rajić</i>	
Does bacterial surface hydrophobicity level influence their immobilization onto natural zeolite?	72
<i>Jasna Hrenović, Darko Tibljaš, Svjetlana Dekić Rozman, Tomislav Ivanković</i>	
Natural zeolite as a tool for modelling bacterial biofilm development in static conditions	75
<i>Tomislav Ivanković, Katarina Rotim, Jasna Hrenović</i>	
Preparation and antibacterial activity of composites based on thymol/carvacrol and clinoptilolite	79
<i>Jelena Dikić, Ivana Lukić, Jelena Pajnik, Jelena Pavlović, Jasna Hrenović, Nevenka Rajić</i>	
Comparison of coagulation and electrocoagulation with addition of natural zeolite for treatment of biowaste compost leachate	83

<u>Nediljka Vukojević Medvidović</u> , Ladislav Vrsalović, Ivona Jukić, Ana-Maria Šunjić	
Analysis of Bohart-Adams model equations for description of adsorption in fixed bed-column	87
<u>Nediljka Vukojević Medvidović</u> , Sandra Svilović	
Equilibrium study of copper ions adsorption on the natural clinoptilolite-rich zeolitic tuff	91
<u>Mario Nikola Mužek</u> , Anđela Čović, Anita Bašić, Sandra Svilović	
Prediction of zeolite barrier capability in treatment of groundwater polluted by Pb, Cd and Zn	95
<u>Ivona Nuić</u> , Matea Šušnjara, Marina Trgo, Nediljka Vukojević Medvidović, Marin Ugrina	
<i>Plenary lecture: Zeolite surface passivation: “Core-shell” systems from synthesis to catalytic applications</i>	99
Massimo Migliori	
<i>Invited lecture: Environmental-friendly modified natural zeolites as sorbents for <i>in situ</i> remediation of mercury-contaminated soil in Idrija region, Slovenia</i>	100
<u>Marin Ugrina</u> , Teja Čeru, Ivona Nuić, Marina Trgo, Aleksandra Daković	
Authors index	104

Boris Subotić: 75th anniversary of life and 52 years of scientific work

Dr. sc. Boris Subotić is a retired senior scientist at the Ruđer Bošković Institute. He is a well-known and internationally recognized scientist in the field of microporous and mesoporous materials, especially zeolites.

Dr. sc. Boris Subotić was born on December 02, 1946. in Dugo Selo, near Zagreb, Croatia. He achieved the BS degree at the Faculty of Science, University of Zagreb, and was employed in the Laboratory for Colloid Chemistry of the Ruđer Bošković Institute in 1969. In 1976 he obtained the Ph.D degree in Chemistry at the Ruđer Bošković Institute and the University of Zagreb. In 1988 he became a co-founder and member of the Laboratory for the Synthesis of New Materials, and from 1995 to 2011 he was the head of the same laboratory. He was also a member of the Institute's Scientific Council for a long time, and from 2005 to 2009 he was a member of director's advisory team and President of the Institute's Commission for Innovation. He was also co-founder of the Croatian Zeolite Association and the first president of the Association.

During his long scientific work, he established the research of zeolites at the



Dr. sc. Boris Subotić

Ruđer Bošković Institute (synthesis, characterization and application) with a special emphasis to investigation of mechanisms of crystallization and transformation of zeolites. In this context, he established theoretical basis of the model of autocatalytic nucleation of zeolites, and together with co-workers, experimentally proved validity and significance of the model. In the meantime, together with the coworkers, he developed the model of crystallization of zeolites based on the population balance theory, including all relevant sub-processes (mechanism and kinetics of precipitation amorphous aluminosilicate precursor, its dissolution as well as nucleation and crystal growth of zeolites). The results of more recent investigations showed that crystallization of zeolites in heterogeneous systems (aluminosilicate hydrogels) occur via formation/transformation of three different

alumino-silicate precursors (gel, worm-like particles and condensed aggregates), and that crucial importance in the process of crystallization play the core-shell nano-precursors (3–20 nm in size) formed at the very early stage of the crystallization process. For this reason his very recent and present investigations are focused on the investigation of chemical and structural properties of the core (amorphous silica)@shell (TAA-polysilicates) and their influence on the course of crystallization and properties of products (zeolites).

Besides the main directions of investigation, dr. Boris Subotić and co-workers also studied solution-mediated transformations of thermodynamically less stable types of zeolites (mainly zeolite A) and some other materials (orthombic barium fluoride) to more stable ones (zeolite P, hydroxysodalite, cubic zeolite P), thermodynamics and kinetics of exchange of cations from solution with the host ions from zeolites, mechanochemical transformations of zeolites to amorphous phase, high-temperature transformations of zeolites, amorphous aluminosilicates to ceramics, etc.

Dr. sc. Boris Subotić is still very active scientist publishing regularly in prestigious world's journals.

He has published more than two hundred scientific papers, and between them more than hundred are included in Web of Science Core Collection. The number of citations of dr. sc. Boris Subotić is about 3000, and his h-index is 29. He is the author

of five chapters in books and four patents. He has been the supervisor of one post-doctoral fellowship, ten PhD thesis and four master's theses.

Also for a great contribution in establishing of cooperation with many scientists, what is, in addition to scientific results, nice way to enrich knowledge of our and world's culture and art.

We wish him many years of good health and fruitful work.

Congratulations are joined by the Slovenian Zeolite Association and the Serbian Zeolite Association.

Tatjana Antonić Jelić (*Croatian Zeolite Association*)