PHYSICAL CHEMISTRY 2021

15th International Conference
on Fundamental and Applied Aspects of
Physical Chemistry

Proceedings
Volume II

The Conference is dedicated to the

30th Anniversary of the founding of the Society of Physical Chemists of Serbia

and

100th Anniversary of Bray-Liebhafsky reaction

September 20-24, 2021
Belgrade, Serbia

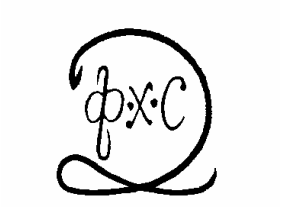
Title: Physical Chemistry 2021 (Proceedings) **ISBN** 978-86-82475-40-8
Volume II: ISBN 978-86-82475-39-2
Editors: Željko Čupić and Slobodan Anić
Published by: Society of Physical Chemists of Serbia, Studentski Trg 12-16, 11158, Belgrade, Serbia
Publisher: Society of Physical Chemists of Serbia
For Publisher: S. Anić, President of Society of Physical Chemists of Serbia
Printed by: ″Jovan″, <Printing and Publishing Company, 200 Copies
Number of pages: 6+388, Format A4, printing finished in December 2021

Text and Layout: ″Jovan″

200 - *Copy printing*

CONTENT

Volume II
Organizer IV
Comittes V
Organic Physical Chemistry 345
Material Science 367
Macromolecular Physical Chemistry 487
Environmental Protection, Forensic Sciences, Geophysical Chemistry, Radiochemistry, Nuclear Chemistry 519
Phase Boundaries, Colloids, Liquid Crystals, Surface-Active Substances 633
Complex Compounds 643
General Physical Chemistry 655
Pharmaceutical Physical Chemistry 669
Food Physical Chemistry 679
Physico-Chemical Analysis 703
Index 725



PHYSICAL CHEMISTRY 2021

15th International Conference on Fundamental and Applied Aspects of Physical Chemistry

Organized by

The Society of Physical Chemists of Serbia

in co-operation with

Institute of Catalysis Bulgarian Academy of Sciences

and

Boreskov Institute of Catalysis Siberian Branch of Russian Academy of Sciences

and

University of Belgrade, Serbia:

Faculty of Physical Chemistry
Institute of Chemistry, Technology and Metallurgy
Vinča Institute of Nuclear Sciences
Faculty of Pharmacy

and

Institute of General and Physical Chemistry, Belgrade, Serbia

International Organizing Committee

Chairman: S. Anić (Serbia)
Vice-chairman: M. Gabrovska (Bulgaria)
A. A. Vedyagin (Russia)
S. N. Blagojević (Serbia)

Members: N. Cvjetićanin (Serbia), S. M. Blagojević (Serbia), M. Daković (Serbia), J. Dimitrić Marković (Serbia), T. Grozdić (Serbia), Lj. Ignjatović (Serbia), D. Jovanović (Serbia), M. Kuzmanović (Serbia), D. Marković (Serbia), B. Milosavljević (USA), M. Mojović (Serbia), N. Pejić (Serbia), M. Petković (Serbia), A. Popović-Bjelić (Serbia), B. Simonović (Serbia), M.Stanković (Serbia), B. Šljukić (Serbia), G. Tasić (Serbia), S. Veličković (Serbia), N. Vukelić (Serbia)

International Scientific Committee

Chairman: Ž. Čupić (Serbia)
Vice-chairman: V. Bukhtiyarov (Russia)
S. Todorova (Bulgaria)
B. Adnađević (Serbia)

Members: S. Anić (Serbia), A. Antić-Jovanović (Serbia), A. Azizoğlu (Turky), R. Cervellati (Italy), G. Ćirić-Marjanović (Serbia), V. Dondur (Serbia), I. I. Grinvald (Russia), R. Jerala (Slovenia), M. Jeremić (Serbia), G. N. Kaluđerović (Germany), E. Kiš (Serbia), A.V. Knyazev (Russia), Lj. Kolar-Anić (Serbia), U. Kortz (Germany), T. Kowalska (Poljska), A. Lemarchand (France), G. Lente (Hungary), Z. Marković (Serbia), S. Mentus (Serbia), K. Novaković (UK), N. Ostrovski (Serbia), V. Parmon (Russia), Z. Petkova Cherkezova-Zheleva (Bulgary), M. Plavšić (Serbia), J. Savović (Serbia), G. Schmitz (Belgium), I. Schreiber (Czech), L. Schreiberova (Czech), D. Stanisavljev (Serbia), N. Stepanov (Russia), M. Stojanović (USA), E. Szabó (Slovakia), Zs. Szakacs (Romania), Z. Šaponjić (Serbia), Á. Tóth (Hungary), M. Trtica (Serbia), V. Vasić (Serbia), D. Veselinović (Serbia), V. Vukojević (Sweden)

Local Executive Committee

Chairman: S. N. Blagojević
Vice-chairman: A. Ivanović-Šašić
N. Jović-Jovičić
A. Stanojević

Members: M. Ajduković, I. N. Bubanja, A. Dobrota, J. Dostanić, D. Dimić, S. Jovanović, Z. Jovanović, D. Lončarević, M. Kragović, J. Krstić, B. Marković, S. Maćešić, J. Maksimović, S. Marinović, D. Milenković, T. Mudrinić, M. Pagnacco, N. Potkonjak, B. Stanković, I. Stefanović, G. Stevanović, A. Stoiljković, M. Vasić

IMPACT OF PHARMACEUTICAL LEVELS IN UNTREATED WASTEWATER ON BELGRADE RIVER WATER QUALITY

Lj. Tolić Stojadinović [1], S. Grujić [2], N. Antić [2] and T. Đurkić [2]

[1] *Innovation Centre of the Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia.*
[2]*University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia. (svetlana.grujic@tmf.bg.ac.rs)*

ABSTRACT
In the city of Belgrade, raw sewage is discharged directly into the Sava and the Danube rivers affecting the quality of river water. To determine the level of this impact, eight frequently used and detected pharmaceuticals were selected for the study. A previously developed method for analysis of pharmaceuticals in different water matrices was used. Sample extracts were analyzed by liquid chromatography-tandem mass spectrometry, using the electrospray ionization technique. The most commonly detected analytes in both municipal wastewater and surface water were carbamazepine, known for its high environmental stability, and diclofenac, known as having high acute ecotoxicity. The dilution effect, noted for most of the detected drugs, was not as pronounced with diclofenac, indicating a higher risk for aquatic organisms.

INTRODUCTION
Pharmaceuticals are among the most important environmental contaminants because of their increasing production and extensive use. They are widely used in human and veterinary medicine and are continuously released into the environment through many human activities and the pharmaceutical industry. However, legal limits of pharmaceuticals in environmental waters have not been established yet, although they are commonly found in surface water at levels that may be harmful to aquatic organisms [1, 2]. Furthermore, there is still limited information on long-term effects of trace levels of pharmaceuticals in the environment. Municipal wastewater is the most significant source of these contaminants in the aquatic environment [1]. Since Belgrade does not have a wastewater treatment plant, raw sewage is discharged directly into rivers the Sava and the Danube through many sewage channels.

The aim of this work was to collect data on the concentrations of selected pharmaceuticals in Belgrade wastewater and corresponding receiving river water in order to determine the impact level of untreated sewage on the surface water quality in Belgrade. Liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS), as the most extensively used technique for the determination of trace levels of contaminants in water matrices, will be employed for this purpose.

METHODS
Commonly used and frequently detected pharmaceuticals were selected for the study: trimethoprim, sulfamethoxazole, azithromycin, erythromycin (antibiotics); carbamazepine, lorazepam, diazepam (sedatives); and diclofenac (nonsteroidal anti-inflammatory drug, NSAID). A previously developed method for the determination of pharmaceuticals in different water matrices was applied [3]. In short, water samples were prepared using solid-phase extraction: 100 mL of the sample (pH = 6) was loaded on the Oasis HLB cartridges (Waters, USA), analytes were eluted with 10 mL of methanol-dichloromethane (1:1) mixture, and the extract was evaporated and reconstituted to the volume of 1.0 mL. As for the LC-MS/MS analysis, Dionex UltiMate 3000 HPLC system (Thermo Fisher

Scientific, Waltham, US) coupled with the linear ion trap mass spectrometer (Thermo Fisher Scientific) was used. The chromatographic separation of compounds was achieved on a reverse-phase Zorbax Eclipse® XDB–C18 column, 75 mm × 4.6 mm ID and 3.5 μm particle size. The mobile phase consisted of methanol, water, and 10% acetic acid. The mass spectrometric analysis was performed using the electrospray ionization technique in the positive mode.

Wastewater samples were collected from three sewage discharges in Belgrade, while the corresponding receiving river water samples were collected downstream (Figure 1).

Figure 1. Sampling sites of wastewater (W1–W3) and surface water (S1–S3).

RESULTS AND DISCUSSION

All investigated pharmaceuticals were detected in Belgrade municipal wastewater, at concentration levels ranging from 54 ng L^{-1} (for azithromycin, Table 1) to as high as 1184 ng L^{-1} (for sulfamethoxazole). Wastewater sample W1, collected at the discharge with the highest sewage inflow, showed trace levels of all selected analytes. The most frequently detected pharmaceuticals, found in all river water samples, as well as in all wastewater samples, were diclofenac and carbamazepine. In ecotoxicity studies of diclofenac, it was determined that it has high acute toxicity for aquatic organisms, the highest within the NSAID group [2]. As for carbamazepine, studies have shown that it is among the most persistent pharmaceuticals in the environment [4].

Table 1. Pharmaceuticals detected in Belgrade municipal wastewater (W1–W3) and corresponding surface water (S1–S3) samples.

Pharmaceuticals	Concentration (SD), ng L^{-1}					
	W1	S1	W2	S2	W3	S3
Trimethoprim	122(12)	–[a]	–	–	482(72)	–
Sulfamethoxazole	122(19)	–	–	–	1184(152)	12(1)
Azithromycin	318(48)	8(1)	54(4)	3(0)	–	–
Erythromycin	133(22)	–	266(34)	–	–	–
Carbamazepine	274(44)	27(4)	313(30)	24(3)	127(25)	56(3)
Lorazepam	171(24)	–	84(3)	–	77(10)	–
Diazepam	163(22)	–	–	–	–	–
Diclofenac	442(73)	263(10)	579(64)	370(9)	782(156)	252(12)

[a]–: not detected

Our results have shown that there is evident contamination of the aquatic environment in Belgrade as a consequence of untreated wastewater discharge. In river water samples collected downstream from the corresponding sewage discharges, significantly lower levels of detected pharmaceuticals were found or drug traces could not be detected, indicating an intense dilution effect (Table 1). However, in the case of diclofenac, the dilution effect was not as pronounced, leading to a higher risk for river organisms. In addition, when aquatic species are continuously exposed to trace levels of contaminants over a long period of time, negative effects slowly accumulate and major changes occur when the cumulative level of these effects is reached [1]. Moreover, the mixtures of drug traces occurring in the environment may have an even greater impact than can be expected from the cumulative effects of individual substances.

CONCLUSION

The study has shown that the discharge of untreated municipal wastewater significantly affects the quality of river water in Belgrade. All investigated pharmaceuticals were detected in wastewater samples, and 50% of the drugs were found in corresponding surface water samples. Although the dilution effect was generally very pronounced, the exception in the case of diclofenac led to a higher risk for aquatic organisms because this drug has high acute toxicity.

Acknowledgement

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Contract no. 451-03-9/2021-14/200287 and 451-03-9/2021-14/200135).

REFERENCES

[1] C. Daughton, T. Ternes, Environ. Health Perspect., 1999, 107, 907–938.
[2] K. Fent, A. Weston, D. Caminada, Aquat. Toxicol., 2006, 76, 122–159.
[3] S. Grujić, T. Vasiljević, M. Laušević, J. Chromatogr. A, 2009, 1216, 4989–5000.
[4] M.J. Benotti, B.J. Brownawell, Environ. Pollut., 2009, 157, 994–1002.

Abakumov A.A. 122
Abazović N. 143,147, 180
Abramović B. 143, 147
Aćimović D. 283, 287
Agan B. 493
Agbaba D. 675
Ajduković M. 151, 187,388
Aleksić M. 294
Aleksieva K. 167, 174, 177
Amić A. 129
Anđelković D. 624, 688, 716
Anđelković T. 612, 616, 620
Anićijević V. 547
Antić B. 483
Antić N. 569
Antonijević M. 347, 351, 355
Antonijević Nikolić M. 645, 648
Armaković S. 143, 147
Aroguz A.Z. 489, 493
Ashkenasy G. 18
Avdalović J. 551, 554, 695
Avdović E. 95, 351, 355
Bajuk-Bogdanović D. 121, 418, 445
Baldinelli L. 10
Bandela A.K. 18
Banković P. 132, 184, 388
Bartolić D. 336
Bartolomei B. 10
Barudžija T.S. 275
Barykin A.V. 47
Bašćarević Z. 438
Bassil B.S. 121
Bauman Yu. 115
Beškoski V. 445
Blagojević D. 25
Blagojević Filipović J.P. 61, 103
Blagojević J. 139
Blagojević S.M. 639
Blagojević S.N. 298, 639, 692
Blagojević V.A. 359
Bogdanović D. 612,616, 620
Bojić A. 468, 472, 476
Bojić D. 472, 476
Bondžić A.M. 328, 332
Bondžić B.P. 114, 328, 332
Boshkov N. 190
Boshkova N. 190
Božić B. 92, 705
Brankov M. 681
Branković M. 624, 688, 716
Brborić J. 294
Brdarić T. 283, 287
Brkljačić J. 480
Bubanja I.N. 238, 445
Bychko I.B. 122
Caballero A. 193
Cherkezova-Zheleva Z. 109
Cvetković V.S. 275, 279
Cvjetićanin N. 291
Červený J. 236
Čolović M.B. 406, 410, 414
Čomor M. 143, 147, 180
Čučulović A. 561
Čučulović R. 561
Čudina O. 294
Čupić Ž. 199, 246, 254
Ćirić-Marjanović G. 121
Ćurčić M. 705
Daković A. 380, 525
Danilov P.A. 369
Despotović V. 143, 147
Devečerski A. 580,584, 588
Dević G. 533, 537
Dietrich J.W. 215
Dimić D. 95, 99, 316
Dimitrić Marković J.M. 95, 129, 316
Dimitrijević A. 592, 600
Dinić I. 399
Dobričić V. 294
Dojčinović B. 184, 483
Dostanić J. 155, 159
Dragić M. 320
Dragičević V. 681
Drakulić D. 25, 308, 324, 572
Dražić B. 645, 648
Džambaski Z. 328, 332
Džunuzović E. 501
Džunuzović J.V. 497, 501, 505
Đorđević D.M. 512
Đorđević I. 132
Đorđević N. 308, 699
Đorović J. 351
Đorović Jovanović J. 99, 347
Đurkić T. 529, 541, 569
Egerić M. 580, 584
Erceg T. 489
Escosura A. 18
Feldhaus D. 275
Filipović N. 572
Filipović Tričković J. 442
Finčur N. 143, 147
Friedrich B. 275
Fulczyk A. 208, 261
Gabrovska M. 163
Gajski G. 414
Gaković B. 369

Gašić U. 692
Gavrilov N. 294, 301
Gavrilović L. 308
Gentili P.L 10
Georgijević J. 720
Gerić M. 414
Gizdavić-Nikolaidis M. 445
Gojgić-Cvijović G. 445
Goldbeter A. 3
Górecki J. 201
Govedarica M. 565
Govedarica O. 139, 489
Grce A. 438, 442
Grinvald I.I. 62, 66
Grković I. 25, 320, 324
Grujić D. 395
Grujić M. 675
Grujić S. 430, 541, 569
Gulicovski J. 576
Gusarova E.V. 43
Gusevac Stojanović I. 52, 324, 572
Gvozdić E. 541
Habuda-Stanić M. 465
Hakky Mohammad A. 596
Hauser M.J.B 4
Hercigonja R. 291
Holgado J.P. 193
Ignjatović Lj. 692
Ilić I. 187, 465,
Ilić M. 533, 554
Ilić S. 438, 442
Ionin. A.A. 369
Isaković A. 406, 410
Ivanković A. 713
Ivanović T. 51
Ivanović-Šašić A. 184, 187, 199, 246
Janićijević D. 418
Janjić G. 132
Janković B. 705
Janković M. 139
Janković-Častvan I. 399, 529
Janošević D. 312
Janošević Ležaić A. 301
Ječmenica Dučić M. 283, 287
Jerala J. 21
Jevremović A. 418, 422
Jocić A. 592, 600
Joksimović K. 551
Joksović Lj. 449
Jovanović D. 332
Jovanović M. 258
Jović A. 291
Jovićević J.N. 275, 279
Jović-Jovičić N. 151, 187, 465
Kačarević-Popović Z. 426, 434
Kadinov G. 167, 174
Kalijadis A. 635
Kaluđerović G. 95
Kaluđerović G.N. 23
Kandić I. 576
Kapustin R.V. 62, 66
Karakirova Y. 163, 177
Katnić Dj. 442
Khan M.S. 135
Khattak R. 135
Kholdeeva O.A. 121
Kijevcanin M. 596
Kirin S.I. 110, 720
Knežević N.Ž. 480
Knyazev A.V. 43, 47
Knyazeva S.S. 43
Kocić G. 616, 620, 688
Kodranov I.D. 480, 483, 604
Kokunešoski M. 438, 442
Kolar-Anić Lj. 199, 246, 250
Kolev H. 163, 174, 193
Konstantinović S.S. 685
Korićanac L. 699
Kortz U. 121, 406, 410, 414
Kostić B. 612
Kostić I. 612, 616, 620
Kostić M. 468, 472, 476
Kowalska T. 208, 261
Kragović M. 576
Krajišnik D. 525
Krasheninnikova O.V. 47
Kretić D.S. 661
Krpić M. 604
Krstić A. 635
Krstić D.Z. 406, 410, 414
Krstić J. 151, 163
Krstić N.S. 457
Krstić S. 580
Kudryashov S.I. 369
Kumrić K. 580, 584, 588
Kusutkina A.M. 43
Kuzmanović M. 74, 74, 82
Lacin D. 489, 493
Lađarević J. 92
Lamueva M. 658
Łata E. 208, 261
Lazarević M. 143, 147
Lazarević-Pašti T. 544, 547
Leach J. 242
Lente G. 123
Leskovac A. R. 332

Lindeboom R. 170
Lješević M. 445
Logacheva A.S. 43
Lolić A. 635
Lončar A. 269, 316
Lončarević B. 445
Lončarević D. 155, 159
Lopičić Z. 551
Lugonja N. 551, 554, 695
Lukić M. 551
Lutsyk V. 658
Ma T. 406, 410, 414
Ma X. 406, 410, 414
Maćešić S. 199, 250, 254
Machado T.D. 399
Maksimchuk N.V. 121
Maksimović J. 70, 449
Maksimović J.P. 269
Maksimović T. 449
Maksin D. 287
Malenov D.P. 61, 453
Maletić M. 529, 628
Mančić L. 399
Manojlović D.D. 480, 604
Manojlović V. 258
Marega C. 501
Marić S. 592, 600
Marinković B.A. 399
Marinović S. 132, 184, 388
Marković B.M. 497, 501, 505
Marković D.M. 521
Marković I.D. 521
Marković M. 82, 380, 525
Marković S. 399
Marković Z. 129, 347, 351, 355
Martinović Bevanda A. 713
Martinović J. 25, 320, 324
Maselko J. 33
Masnikosa R. 720
Mašojević D. 391
Matić Bujagić I. 541
Matijašević S. 430
Matković A. 384
Matović Lj. 584, 588
Mau J. 20
Medaković V.M. 61
Mercader J.P 8
Mihajlović S. 628
Mijajlovic M. 170
Mijin D. 89, 92
Miladinović J.M. 51
Miladinović Z.P 51
Milanović Ž. 95, 347, 355
Milenković D. 129, 347, 351
Miletić J. 308
Miletić S. 533
Milić J. 551, 554, 695
Milićević J. 592
Milojević Rakić M. 418, 422
Milojković J. 551
Milošević I.R. 384, 521
Milošević K. 159
Milovanović B. 151, 388
Milovanović D. 369
Milovanović M.R. 61
Milutinović-Nikolić A. 132, 151, 187
Minić D.M. 402
Minić D.M. 402
Minović Arsić T. 635
Mirković M. 635
Mishakov I. 115
Misirlić-Denčić S. 406, 410
Mitrović A.Lj. 312
Mitrović J. 468, 476
Mitrović N. 25, 320, 324
Mladenović M. 57
Mojović Z. 180
Momčilović M. 283, 521
Morozova-Roche L.A. 307
Mouille G. 312
Mudrinić T. 132, 184, 388
Murić B. 395
Muzika F. 201, 236
Najdanović S. 468, 472
Nastasović A. 497, 501
Nedeljković A. 576
Nedić N. 692
Nedić Vasiljević B. 418, 422
Nedić Z. 449
Negrojević L. 269, 316
Nešović M. 692
Nestorović S. 561
Nikolić G. 612
Nikolić G.M. 457, 665
Nikolić J. 430
Nikolić Lj.B. 509
Nikolić M.G. 457, 665
Nikolić N. 298, 426, 434
Nikolić Z.S. 373, 377
Nikolova D. 163
Ninković D.B. 61
Nišić N. 576
Novakovic K. 230, 242, 250
Novaković T. 180, 184
Obradović D. 671
Obradović M. 380, 525

Ognjanović M. 483
Oliwa P. 237
Omerašević M. 580
Onjia E. 505
Orlik M. 237
Ostojić S. 483
Otoničar M. 391
Pagnacco M. 70, 449
Pajović S.B. 308, 699
Panova A.A. 43
Pantalon Juraj N. 720
Pantelić D. 395
Pantić N. 340
Parac Vogt T. 328
Pavličević J. 139, 489, 493
Pavlović R. 612, 616, 620
Pehar M. 713
Pejić B. 628
Pejić N. 639
Pejić S. 25, 308, 699
Perez-Merkader J. 8
Pergal M. 537
Pergal M.V. 480, 483, 604
Perić B. 720
Perić Grujić A. 628
Perović I. 283, 287
Petković M. 291
Petrović D. 713
Petrović Đ. 584, 588
Petrović M. 468, 472, 476
Plavšić M.B. 512
Plavšić M.M 509, 512, 515
Popadić M. 132
Popović D.Ž. 51
Popović G. 671, 675
Popović N. 308
Popović-Nikolić M. 671, 675
Pošarc-Marković M. 438
Potkonjak N. 544, 547
Premović P.I. 558, 608
Prodanović O. 340
Prodanović R. 340
Prokić D. 529
Prokopijević M. 336, 340
Pupazić J. 665
Radaković N. 561
Radenković M. 565
Radić N. 190
Radić R. 565
Radmilović M. 395
Radonjić V. 163
Radosavljević A. 426, 434
Radotić K. 312, 336, 340
Radović I. 705, 709
Radović Vučić M. 468, 472, 476
Radulović A. 369
Radulović K. 151
Rakić A.A. 99
Randjelović B.M. 373, 377
Ranković D. 74, 78, 82
Rašović A. 359, 363
Ristić M. 628
Ristić N. 576
Ristivojević N. 99
Rodić M. 645
Rottinghaus G.E. 380, 525
Rupar J. 294, 301
Sadihov H. 18
Sajewicz M. 208, 261
Sandić Z.P. 497, 505
Savić B. 283, 287
Savić Biserčić M. 82
Savić D.S. 509, 512, 515
Savić D.S. 515
Savić S.R 515
Savić T.D. 143, 147, 180
Savić V. 430
Savović J. 74, 78, 82
Schmitz G.E. 222
Schreiber I. 236
Senćanski J. 70, 298, 449
Shipilova A.S. 43
Shopska M. 167, 174
Shtereva I. 167, 174
Simić M. 681
Simonović Radosavljević J. 312
Sinadinović-Fišer S. 139
Smiljanić D. 380, 525
Smiljanić S. 430
Spasić A.M. 258
Spasić S. 695
Spasojević D. 340
Spasojević J. 426, 434
Spasojević M. 380, 525
Sretenović D. 95
Stambolova I. 190
Stamenović U. 391
Stanisavljev D. 238, 445
Stanković D. 483, 695
Stanković I.M. 61
Stanković K. 588
Stanković M. 336
Stanković S. 580, 584
Stanojević A. 246
Stanojković A. 422
Stanojković J. 561

Stefanović I.S. 497, 501, 505
Stefanović M. 685
Stevanović G. 151, 388
Stipanović A. 713
Stjepanović M. 465
Stoiljković M. 78, 705, 709
Stojanovic M.N. 657
Stojanović Z. 572
Stojić I. 78
Stojiljković A.S. 246
Stojiljković D.M. 685
Stojiljković V. 308
Stojković Simatović I. 291, 298
Stojmenović M. 576
Stoyanova D. 190
Strizhak P.E. 122
Stroppa A. 22
Sundar A. 121
Suručić Lj.T. 497, 505
Syrov E.V. 47
Szabó R. 123
Szakacs Zs. 461
Šajić A. 78
Šalipur H. 155
Šaponjić A. 438, 442
Škapin S.D. 391
Šljukić B. 291
Šojić Merkulov D. 143, 147
Šolević Knudsen T. 554
Špirkova M. 480
Tadić J. 89
Tadić T.T. 497,501, 505
Talić S. 713
Talik E. 208, 261
Tanasković S. 645, 648
Tančić P. 449
Tasić T. 544
Tatalović N. 25
Telečki I. 588
Teofilović V. 139, 489, 493
Tešević V. 699
Tešić Ž. 692
Thomas M. 19
Todoran D. 461
Todoran R. 461
Todorova S. 174, 177, 193
Todorović A. 25, 308, 572
Todorović Vukotić N. 308, 699
Tolić Stojadinović Lj. 569
Topalović D. 565
Topalović V. 430
Tóth A. 200
Tovilović-Kovačević G. 480
Trivunac K. 628
Troter D.Z. 685
Trtica M. 74, 82
Tsvetkov P. 163
Uskoković Marković S. 418
Uzelac M. 143, 147
Valenta Šobot A. 442, 438
Vasić Anićijević D. 283, 287
Vasić B. 384
Vasić M.M. 402
Vedyagin A. 115
Velić N. 465
Veličković S. 705, 709, 720
Velinov N. 468, 472, 476
Veljković D.Ž. 661
Veljković F. 705, 709, 720
Veljković I.S. 61, 453
Veljković V.B. 685
Veljković Ž. 61
Veselinović D. 561
Veselinović Lj. 399
Veselinović M. 521
Vidojkovic S. 170
Višnjić-Jeftić Ž. 521
Vitnik V. 86, 89, 92
Vitnik Ž. 86, 89, 92
Vodnik V. 391
Vojislavljević-Vasilev D. 61, 661
Vorob'eva V. 658
Vrvić M.M. 533, 554, 695
Vujasin R. 580, 584, 588
Vujin J. 384
Vukčević M. 529, 628
Vukić N. 139, 489
Vukićević N.M. 275, 279
Vuković Z. 388
Wagner N. 18
Zalomaeva O.V. 121
Zarić M. 25, 320, 324
Zarić S.D. 61, 103, 453, 661
Zarkov B. 395
Zdravković S. 265
Zeković S. 265
Zelenaya A. 658
Zildžović S. 430
Zlatković B. 624
Zvezdanović J.B. 685
Žakula J. 699
Žerajić S.A. 509, 515
Živanović S.C. 457
Živković J.M. 61, 652, 665
Živković S. 521

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

544(082)
66.017/.018(082)
502/504(082)
343.98(082)

INTERNATIONAL Conference on Fundamental and Applied Aspects of Physical Chemistry (15; 2021; Beograd)

Physical Chemistry 2021: proceedings: the Conference is dedicated to the 30th Anniversary of the founding of the Society of Physical Chemists of Serbia and 100th Anniversary of Bray-Liebhafsky reaction. Vol. 2 / 15th International Conference on Fundamental and Applied Aspects of Physical Chemistry, September 20-24, 2021, Belgrade, Serbia; [organized by The Society of Physical Chemists of Serbia in co-operation with Institute of Catalysis Bulgarian Academy of Sciences ... [et al.]]; [editors Željko Čupić and Slobodan Anić]. - Belgrade: Society of Physical Chemists of Serbia, 2021 (Belgrade: Jovan). - VI str., str. 347-732: ilustr.; 30 cm

Tiraž 200. - Bibliografija uz svaki rad. - Registar.

ISBN 978-86-82475-39-2
ISBN 978-86-82475-40-8 (niz)

а) Физичка хемија -- Зборници б) Наука о материјалима -- Зборници в) Животна средина -- Зборници г) Форензика -- Зборници

COBISS.SR-ID 53325065