

SAMPLE PREPARATION OF URINE SAMPLES FOR VOLTAMPEROMETRIC DETERMINATION OF MEDICINAL SUBSTANCES AND EVALUATION OF THE METHOD FROM THE VIEWPOINT OF ENVIRONMENTALLY

O.M. DUSHNA, M.S. NOVOZHYLOVA, L.O. DUBENSKA

References:

1. Gałuszka, A.; Migaszewski, Z.; Namieśnik, J. The 12 Principles of Green Analytical Chemistry and the SIGNIFICANCE Mnemonic of Green Analytical Practices. *TrAC, Trends Anal. Chem.* **2013**, *50*, 78–84.
2. Pena-Pereira, F.; Lavilla, I.; Bendicho, C. Greening Sample Preparation: An Overview of Cutting-Edge Contributions. *Curr. Opin. Green Sustain. Chem.* **2021**, *30*, 100481.
3. Pacheco-Fernández, I.; Pino, V. Green Solvents in Analytical Chemistry. *Curr. Opin. Green Sustain. Chem.* **2019**, *18*, 42–50.
4. López-Lorente, Á. I.; Pena-Pereira, F.; Pedersen-Bjergaard, S.; et al. The Ten Principles of Green Sample Preparation. *TrAC, Trends Anal. Chem.* **2022**, *148*, 116530.
5. Vuckovic, D. Sample Preparation in Global Metabolomics of Biological Fluids and Tissues. In *Proteomic and Metabolomic Approaches to Biomarker Discovery*; Elsevier, 2020; pp 53–83.
6. Armenta, S.; Esteve-Turrillas, F. A.; Garrigues, S.; et al. Smart Materials for Sample Preparation in Bioanalysis: A Green Overview. *Sustain. Chem. Pharm.* **2021**, *21*, 100411.
7. Niu, Z.; Zhang, W.; Yu, C.; et al. Recent Advances in Biological Sample Preparation Methods Coupled with Chromatography, Spectrometry and Electrochemistry Analysis Techniques. *TrAC, Trends Anal. Chem.* **2018**, *102*, 123–146.
8. Wen, Y.; Li, J.; Ma, J.; et al. Recent Advances in Enrichment Techniques for Trace Analysis in Capillary Electrophoresis. *Electrophoresis*. **2012**, *33* (19–20), 2933–2952.
9. Li, N.; Zhang, T.; Chen, G.; et al. Recent Advances in Sample Preparation Techniques for Quantitative Detection of Pharmaceuticals in Biological Samples. *TrAC, Trends Anal. Chem.* **2021**, *142*, 116318.
10. Kole, P. L.; Venkatesh, G.; Kotecha, J.; et al. Recent Advances in Sample Preparation Techniques for Effective Bioanalytical Methods. *Biomed. Chromatogr.* **2011**, *25* (1–2), 199–217.
11. Wen, Y.; Chen, L.; Li, J.; et al. Recent Advances in Solid-Phase Sorbents for Sample Preparation Prior to Chromatographic Analysis. *TrAC, Trends Anal. Chem.* **2014**, *59*, 26–41.
12. Li, Z.; Shen, F.; Mishra, R. K.; et al. Advances of Drugs Electroanalysis Based on Direct Electrochemical Redox on Electrodes: A Review. *Crit. Rev. Anal. Chem.* **2022**, 1–46.
13. Ozkan, S. A.; Kauffmann, J.-M.; Zuman, P. *Electroanalysis in Biomedical and Pharmaceutical Sciences*; Springer Berlin Heidelberg: Berlin, Heidelberg, 2015.
14. Maccaferri, G.; Terzi, F.; Xia, Z.; et al. Highly Sensitive Amperometric Sensor for Morphine Detection Based on Electrochemically Exfoliated Graphene Oxide. Application in Screening Tests of Urine Samples. *Sens. Actuators B Chem.* **2019**, *281*, 739–745.
15. Sarakhman, O.; Dubenska, L.; Švorc, L. First Voltammetric Behavior Study of Non-Narcotic Analgesic Drug Nefopam and Its Reliable Determination on Boron-Doped Diamond Electrodes. *J. Electroanal. Chem.* **2020**, *858*, 113759.
16. Dushna, O.; Dubenska, L.; Vojs, M.; et al. Highly Sensitive Determination of Atropine in Pharmaceuticals, Biological Fluids and Beverage on Planar Electrochemical Cell with Working Boron-Doped Diamond Electrode. *Electrochim. Acta.* **2022**, *432*, 141182.
17. Soomro, R. A.; Nafady, A.; Hallam, K. R.; et al. Highly Sensitive Determination of Atropine Using Cobalt Oxide Nanostructures: Influence of Functional Groups on the Signal Sensitivity. *Anal. Chim. Acta.* **2016**, *948*, 30–39.
18. Cinková, K.; Zbojeková, N.; Vojs, M.; et al. Electroanalytical Application of a Boron-Doped Diamond Electrode for Sensitive Voltammetric Determination of Theophylline in Pharmaceutical Dosages and Human Urine. *Anal. Methods.* **2015**, *7* (16), 6755–6763.
19. Abd-ElSabour, M.; Alsoghier, H. M.; Alhamzani, A. G.; et al. A Novel Electrochemical Sensor for Detection of Nicotine in Tobacco Products Based on Graphene Oxide Nanosheets Conjugated with (1,2-Naphthoquinone-4-Sulphonic Acid) Modified Glassy Carbon Electrode. *Nanomaterials* **2022**, *12* (14), 2354.
20. Dushna, O.; Dubenska, L.; Marton, M.; et al. Sensitive and Selective Voltammetric Method for Determination of Quinoline Alkaloid, Quinine in Soft Drinks and Urine by Applying a Boron-Doped Diamond Electrode. *Microchem. J.* **2023**, *191*, 108839.
21. Geto, A.; Amare, M.; Tessema, M.; et al. Polymer-Modified Glassy Carbon Electrode for the Electrochemical Detection of Quinine in Human Urine and Pharmaceutical Formulations. *Anal. Bioanal. Chem.* **2012**, *404* (2), 525–530.

22. Ahmar, H.; Fakhari, A. R. Electro-Oxidation and Adsorptive Stripping Voltammetric Determination of Ephedrine and Pseudoephedrine at Carboxylated Multi-Walled Carbon Nanotube-Modified Electrode. *Anal. Methods*. **2012**, 4 (3), 812.
23. Dushna, O.; Dubenska, L.; Plotycya, S.; et al. The Alternative Voltammetric Method for the Determination of Nicotine and Its Metabolite Nicotine N-Oxide. *J. Electrochem. Soc.* **2022**, 169 (1), 016513.
24. Dubenska, L.; Dushna, O.; Pysarevska, S.; et al. A New Approach for Voltammetric Determination of Nefopam and Its Metabolite. *Electroanalysis*. **2020**, 32 (3), 626–634.
25. Pysarevska, S.; Dubenska, L.; Plotycya, S.; et al. A State-of-the-Art Approach for Facile and Reliable Determination of Benzocaine in Pharmaceuticals and Biological Samples Based on the Use of Miniaturized Boron-Doped Diamond Electrochemical Sensor. *Sens. Actuators B Chem.* **2018**, 270, 9–17.
26. Degefu, H.; Amare, M.; Tessema, M.; et al. Lignin Modified Glassy Carbon Electrode for the Electrochemical Determination of Histamine in Human Urine and Wine Samples. *Electrochim. Acta*. **2014**, 121, 307–314.
27. Zaugg, S.; Thormann, W. Capillary Electrophoretic Separation, Immunochemical Recognition and Analysis of the Diastereomers Quinine and Quinidine and Two Quinidine Metabolites in Body Fluids. *J. Pharm. Biomed. Anal.* **2001**, 24 (5–6), 785–799.
28. Samanidou, V. F.; Evaggelopoulou, E. N.; Papadoyannis, I. N. Simultaneous Determination of Quinine and Chloroquine Anti-Malarial Agents in Pharmaceuticals and Biological Fluids by HPLC and Fluorescence Detection. *J. Pharm. Biomed. Anal.* **2005**, 38 (1), 21–28.
29. Kolaei, M.; Dashtian, K.; Rafiee, Z.; et al. Ultrasonic-Assisted Magnetic Solid Phase Extraction of Morphine in Urine Samples by New Imprinted Polymer-Supported on MWCNT-Fe₃O₄-NPs: Central Composite Design Optimization. *Ultrason. Sonochem.* **2016**, 33, 240–248.
30. Ait Lahcen, A.; Amine, A. Mini-Review: Recent Advances in Electrochemical Determination of Sulfonamides. *Anal. Lett.* **2018**, 51 (3), 424–441.
31. Özkan, S. A.; Uslu, B.; Aboul-Enein, H. Y. Analysis of Pharmaceuticals and Biological Fluids Using Modern Electroanalytical Techniques. *Crit. Rev. Anal. Chem.* **2003**, 33 (3), 155–181.
32. Hasanazadeh, M.; Shadjou, N.; Guardia, M. de la. Current Advancement in Electrochemical Analysis of Neurotransmitters in Biological Fluids. *TrAC, Trends Anal. Chem.* **2017**, 86, 107–121.
33. Hrioua, A.; Loudiki, A.; Farahi, A.; et al. Recent Advances in Electrochemical Sensors for Amoxicillin Detection in Biological and Environmental Samples. *Bioelectrochemistry*. **2021**, 137, 107687.
34. Dubenska, L. O.; Dushna, O. M.; Plyska, M. V.; et al. Method Of Polarographic Determination Of Platyphylline In A Form Of N-Oxide And Its Validation In Solution For Injection. *Methods Objects Chem. Anal.* **2020**, 15 (2), 83–92.
35. Plumlee, K. H. Pharmaceuticals. In *Clinical Veterinary Toxicology*; Elsevier, 2004; pp 282–336.
36. Groman, R. P. Miscellaneous Antibiotics. In *Small Animal Critical Care Medicine*; Elsevier, 2015; pp 944–949.
37. Du, J.; Jiang, Q.; Lu, X.; et al. Detection of Sulfadimethoxine Using Optical Images of Liquid Crystals. *Analyst*. **2019**, 144 (5), 1761–1767.
38. Zhang, Y.; Chang, X.; Wang, X.; et al. A Quadruple-Labeling Luminescence Strategy for Multiplexed Immunoassay of 51 Drugs in Milk with an Automated Pretreatment System. *Anal. Methods*. **2019**, 11 (39), 5055–5063.
39. Qiu, J.; Zhao, T.; Liu, Q.; et al. Residual Veterinary Antibiotics in Pig Excreta after Oral Administration of Sulfonamides. *Environ. Geochem. Health*. **2016**, 38 (2), 549–556.
40. Ji, H.; Wu, Y.; Duan, Z.; et al. Sensitive Determination of Sulfonamides in Environmental Water by Capillary Electrophoresis Coupled with Both Silvering Detection Window and In-Capillary Optical Fiber Light-Emitting Diode-Induced Fluorescence Detector. *Electrophoresis*. **2017**, 38 (3–4), 452–459.
41. Bai, Z.; Chen, Y.; Li, F.; et al. Electrochemical Aptasensor for Sulfadimethoxine Detection Based on the Triggered Cleavage Activity of Nuclease P1 by Aptamer-Target Complex. *Talanta*. **2019**, 204, 409–414.
42. de Moura Junior, F. G.; Veloso, W. B.; de Oliveira Junior, J. A.; et al. Voltammetric Determination of Sulfanilamide Using a Cobalt Phthalocyanine Chitosan Composite. *Monats. Chem. – Chem. Mon.* **2021**, 152 (8), 895–902.
43. Wei, X.; Xu, X.; Qi, W.; et al. Molecularly Imprinted Polymer/Graphene Oxide Modified Glassy Carbon Electrode for Selective Detection of Sulfanilamide. *Prog. Nat. Sci.: Mater. Int.* **2017**, 27 (3), 374–379.
44. Chen, X.-X.; Lin, Z.-Z.; Hong, C.-Y.; et al. Label-Free Fluorescence-Based Aptasensor for the Detection of Sulfadimethoxine in Water and Fish. *Appl. Spectrosc.* **2019**, 73 (3), 294–303.
45. Новини лабораторії MTech. Режим доступу: <http://mtech-lab.com.ua/index.htm>.
46. Ermer J., M. J. *Method Validation in Pharmaceutical Analysis: A Guide to Best Practice.*; Wiley-VCH Publishers, 2005.
47. Lurie Yu. *Handbook of Analytical Chemistry 4th Ed., Reworked. and Ext.*; Moscow, 1971.
48. Dar, R. A.; Brahman, P. K.; Tiwari, S.; et al. Electrochemical Studies of Quinine in Surfactant Media Using Hanging Mercury Drop Electrode: A Cyclic Voltammetric Study. *Colloids Surf., B*. **2012**, 98, 72–79.

49. Plotycya, S.; Dubenska, L.; Blazheyevskiy, M.; et al. Determination of Local Anesthetics of Amide Group in Pharmaceutical Preparations by Cyclic Voltammetry. *Electroanalysis*. **2016**, *28* (10), 2575–2581.
50. Boiko, O.; Dubenska, L.; Novozhylova, M.; et al. Method for Polarographic Determination of Famotidine with the Use of Oxon Reagent. *Visnyk of the Lviv University. Series Chemistry* **2020**, *61* (1), 178.
51. Pena-Pereira, F.; Tobiszewski, M.; Wojnowski, W.; et al. A Tutorial on AGREEprep an Analytical Greenness Metric for Sample Preparation. *Advances in Sample Preparation*. **2022**, *3*, 100025.
52. Gałuszka, A.; Migaszewski, Z. M.; Konieczka, P.; et al. Analytical Eco-Scale for Assessing the Greenness of Analytical Procedures. *TrAC, Trends Anal. Chem.* **2012**, *37*, 61–72.
53. Gallart-Mateu, D.; Cervera, M. L.; Armenta, S.; et al. The Importance of Incorporating a Waste Detoxification Step in Analytical Methodologies. *Anal. Methods*. **2015**, *7* (13), 5702–5706.
54. Pena-Pereira, F.; Wojnowski, W.; Tobiszewski, M. AGREE—Analytical GREENness Metric Approach and Software. *Anal. Chem.* **2020**, *92* (14), 10076–10082.
55. Płotka-Wasyłka, J. A New Tool for the Evaluation of the Analytical Procedure: Green Analytical Procedure Index. *Talanta*. **2018**, *181*, 204–209.
56. Nowak, P. M.; Kościelniak, P. What Color Is Your Method? Adaptation of the RGB Additive Color Model to Analytical Method Evaluation. *Anal. Chem.* **2019**, *91* (16), 10343–10352.
57. Płotka-Wasyłka, J.; Wojnowski, W. Complementary Green Analytical Procedure Index (ComplexGAPI) and Software. *Green Chem.* **2021**, *23* (21), 8657–8665.
58. Manousi, N.; Wojnowski, W.; Płotka-Wasyłka, J.; et al. Blue Applicability Grade Index (BAGI) and Software: A New Tool for the Evaluation of Method Practicality. *Green Chem.* **2023**.
59. Furió-Sanz, C.; Gallart-Mateu, D.; Armenta, S.; et al. A Green Evaluation of Ecstasy Determination Methods by Using Different Greenness Criteria. *Talanta Open*. **2023**, *7*, 100195.
60. Sajid, M.; Płotka-Wasyłka, J. Green Analytical Chemistry Metrics: A Review. *Talanta*. **2022**, *238*, 123046.
61. Gallart-Mateu, D.; Gallardo, A.; Garrigues, S.; et al. A Green Methodology for the Determination of Cocaine in Camouflaged Samples. *Anal. Methods*. **2023**, *15* (16), 1969–1978.
62. Azorín, C.; López-Juan, A. L.; Aparisi, F.; et al. Determination of Hexanal and Heptanal in Saliva Samples by an Adapted Magnetic Headspace Adsorptive Microextraction for Diagnosis of Lung Cancer. *Anal. Chim. Acta*. **2023**, *1271*, 341435.
63. Calero-Cañuelo, C.; Casado-Carmona, F. A.; Lucena, R.; et al. Mixed-Mode Cationic Exchange Sorptive Tapes Combined with Direct Infusion Mass Spectrometry for Determining Opioids in Saliva Samples. *J. Chromatogr. A*. **2023**, *1702*, 464097.
64. Suwanvecho, C.; Krčmová, L. K.; Švec, F. Effective, Convenient, and Green Sample Preparation for the Determination of Retinol and Retinol Acetate in Human Serum Using Pipette Tip Microextraction. *Talanta*. **2023**, *262*, 124689.