

PLANAR ELECTRODES, MODIFIED WITH GOLD AND CARBON NANOMATERIALS AS SENSITIVE ELEMENTS OF H<sub>2</sub>O<sub>2</sub> VOLTAMMETRIC SENSORS

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## References:

1. Terner E., Kube I., UilsonDzh. Biosensory: osnovy I prilozheniya. Moscow: Mir, 1992. P. 614. (in Russ.).
2. Wang, J., Lin, Y., Chen, L. Organic-phase biosensors for monitoring phenol and hydrogen peroxide in pharmaceutical antibacterial products. *Analyst*. 1993, 118 (3), 277–280.
3. Eggins B., Khimicheskies I biologicheskies sensory, Moscow., Tekhnosfera, 2005. P. 335.
4. Evtugyn G., Biosensors: Essentials, Springer-Verlag: Berlin Heidelberg, 2014, P. 274.
5. Budnikov G.K., Evtugyn G.A., Maistrenko V.N. Modifitsirovannye elektrody dlya vol'tamperometrii v khimii, biologii I meditsine. Moscow: BINOM, Laboratoriyaznaniy, 2009, P. 416.
6. Yang C., Denno M. E., Pyakurel P., Venton B. J. Recent trends in carbon nanomaterial-based electrochemical sensors for biomolecules: A review. *Anal. Chim. Acta*, 2015, 887 (5), 17-37.
7. Pumera M., Sanchez S., Ichinose I., Tang J., Electrochemical nanobiosensors. Review, *Sens. Actuators, B: Chemical*, 2007, 123 (2), 1195–1205.
8. Thiyagarajan N., ChangJ-L., Senthilkumar K., ZenJ-M., Disposable electrochemical sensors: A mini review, *Electrochem. Commun.*, 2014, 38 (1), 86–90.
9. Brinker C.J., Scherer G.W. Sol-Gel Science: the physics and chemistry of sol-gel processing, San Diego: Academic Press, 1990. P. 912.
10. Gupta R., Chaudhury N.K. Entrapment of biomolecules in sol-gel matrix for applications in biosensors: problems and future prospects. *Biosens and Bioelectron*. 2007, 22(11), 2387–2399.
11. Sayen S., Walcarius A., Electro-assisted generation of functionalized silica films on gold, *Electrochem. Commun.* 2003, 5 (4), 341-348.
12. Nadzhafova O., Etienne M., Walcarius A. Direct electrochemistry of hemoglobin and glucose oxidase in electrodeposited sol-gel silica thin films on glassy carbon. *Electrochem Commun.* 2007, 9 (5), 1189–1195.
13. Mazurenko I., Tananaiko O., Biloivan O., Zhybak M., Pelyak I., Zaitsev V., Etienne M., Walcarius A. Amperometric Biosensor for Choline Based on Gold Screen-Printed Electrode Modified with Electrochemically- Deposited Silica Biocomposite, *Electroanalysis*, 2015, 27 (7), 1685 – 1692.
14. Zhou X., Xu W., Liu G., Panda D., Chen P. Size-Dependent Catalytic Activity and Dynamics of Gold Nanoparticles at the Single-Molecule Level. *J. Am. Chem. Soc.* 2010, 132 (1), 138–146.
15. Haruta, M. Size- and support-dependency in the catalysis of gold. *Catal. Today*. 1997, 36 (1), 153 – 166.
16. Valden M, Lai X., Goodman D.W. Onset of catalytic activity of gold clusters on titania with the appearance of nonmetallic properties. *Science*. 1998, 281(5383), 1647 – 1650.
17. Zhang Y., Suryanarayanan V., Nakazawa I., Yoshihara S., Shirakashi T. Electrochemical behavior of Au nanoparticle deposited on as-grown and O-terminated diamond electrodes for oxygen reduction in alkaline solution. *Electrochim. Acta*. 2004, 49 (28), 5235-5240.
18. SahaK., Agasti S., Kim C., Li X., Rotello V.M. Gold Nanoparticles in Chemical and Biological Sensing. *Chem. Rev.*, 2012, 112 (5), 2739–2779.
19. Martin A., Escarpa A. Graphene: The cutting-edge interaction between chemistry and Electrochemistry. *Trends Anal. Chem.* 2014, 56, 13–26..
20. Jin H., HuangH., He Y., Feng X., Wang S., Dai L., Wang J. Graphene Quantum Dots Supported by GrapheneNanoribbonswith Ultrahigh Electrocatalytic Performance for Oxygen Reduction. *J. Am. Chem. Soc.* 2015, 137 (24), 7588–7591.
21. Kumar S., Ahlawat W., Kumar R., Dilbaghi R., Graphene, carbon Nanotubes, zinc oxide and gold as elite nanomaterials for fabrication of Biosensors for healthcare. *Biosens and Bioelectron*. 2015, 70, 498-503.
22. Alexeyeva, N.; Kozlova, J.; Sammelselg, V.; Ritslaid, P.; Mandar, H.; Tammeveski, K. Electrochemical and surface characterization of gold nanoparticle decorated multi-walled carbon nanotubes. *Appl. Surf. Sci.* 2010, 256(10), 3040-3046.
23. Liu, Y., Wang, M.K., Zhao, F., Guo, Z.H., Chen, H.J., Dong, S.J., Direct electron transfer and electrocatalysis of microperoxidase immobilized on nanohybrid film. *J. Electroanal. Chem.* 2005. 581 (1), 1–10.
24. Chen S., Yuan R., Chai Y., Zhang L., Wang N., Li X. Amperometric third-generation hydrogen peroxide biosensor based on the immobilization of hemoglobin on multiwall carbon nanotubes and gold colloidal nanoparticles. *Biosens and Bioelectron*. 2007, 22 (7) , 1268–1274.
25. Yu, R., Chen, L., Liu, Q., Lin, J., Tan, K.L., Ng, S.C., Platinum Deposition on Carbon Nanotubes via

Chemical Modification. *Chem. Mater.* 1998, 10 (3), 718–722.

26. Zhou M., Wang H-L., Guo S. Towards high-efficiency nanoelectrocatalysts for oxygen reduction through engineering advanced carbon nanomaterials, *Chem. Soc. Rev.* 2016, 45 (5), 1273-1307.

27. Alekseev S., Korytko D., Iazykov M., Khainakov S., Lysenko V. Electrochemical Synthesis of Carbon Fluorooxide Nanoparticles from 3C-SiC Substrates, *J. Phys. Chem. C.* 2015, 119 (35), 20503–20514.

28. Trejo G., Gil A. F., González I., Temperature Effect on the Electrocrystallization Processes of Gold in Ammoniacal Medium, *J. Electrochem. Soc.* 1995, 142 (10), 3404-3408.

29. Liu Y., Wu S., Ju H., Xu L. Amperometric Glucose Biosensing of Gold Nanoparticles and Carbon Nanotube Multilayer Membranes, *Electroanalysis.* 2007, 19 (9), 986 – 992.

30. *Osnovy Analiticheskoi Khimii.* v.1. Ed. by Yu. A. Zolotov, third ed., Moscow: Vysshaya. shkola., 2004. 361 p. (in Russ).

31. García-Santamarina S, Boronat S, Hidalgo E. Reversible cysteine oxidation in hydrogen peroxide sensing and signal transduction. *Biochemistry.* 2014, 53(16), 2560-2580.

32. Husmann S., Nossol E., Zarbin A. J. G. Carbon nanotube/Prussian blue paste electrodes: Characterization and study of key parameters for application as sensors for determination of low concentration of hydrogen peroxide, *Sens. Actuators, B Chem.* 2014, 192(3), 782–790.

33. X. Zhu, X. Niu, H. Zhao, M. Lan, Doping ionic liquid into Prussian blue-multiwalled carbon nanotubes modified screen-printed electrode to enhance the nonenzymatic H<sub>2</sub>O<sub>2</sub> sensing performance, *Sens. Actuators, B Chem.* 2014, 195(6), 274–280.

34. H. Liu, Y. Cui, P. Li, Y. Zhou, X. Zhu, Y. Tang, et al., Iron(III) diethylenetriaminepentaacetic acid complex on polyallylamine functionalized multiwalled carbon nanotubes: immobilization, direct electrochemistry and electrocatalysis, *Analyst.* 2013, 138(9), 2647–2653.

35. C. Kaçar, B. Dalkiran, P.E. Erden, E. Kiliç, An amperometric hydrogen peroxide biosensor based on Co<sub>3</sub>O<sub>4</sub> nanoparticles and multiwalled carbon nanotube modified glassy carbon electrode, *Appl. Surf. Sci.* 2014, 311, 139–146.