Structure and photocatalytic properties of black titania nanotubes

R. Karpicz[1#], M. Ivanovskaya[2], S. Poznyak[2], E. Ovodok[2], D. Kotsikau[3]

[1]Center for Physical Science and Technology, Savanorių pr. 231, LT-02300 Vilnius, Lithuania
[2]Research Institute for Physical Chemical Problems of the Belarusian State University, Leningradskaya str. 14, 220006, Minsk, Belarus
[3]Belarusian State University, Nezavisimosti av. 4, 220030, Minsk, Belarus

The structural features of white, blue-gray, and black titanium dioxide nanotubes (TiO_2NTs) obtained under different heat treatment conditions [1] were studied to establish the reason for their different photo- and electrocatalytic activity in the oxygen reduction reaction. Changes in color and photo- and photoelectrocatalytic properties of colored TiO_2 nanomaterials are associated with the presence of oxygen vacancies, Ti^{3+} ions, surface Ti–OH groups, and (or) Ti–H groups, impurities (such as N, C, F), or a combined effect of all of these factors. As a rule, electrochemical oxygen reduction in alkaline solutions on TiO_2 electrodes occurs directly through one reduction peak at potentials of about –0.8 V. On black TiO_2NTs obtained by heating in H_2, oxygen reduction occurs at –0.5 V and –0.8 V. A decrease in the potential for electrocatalytic reduction of oxygen, a change in the mechanism of the process, and an increase in current density take place at about –0.8 V. An increase in the photocurrent is also observed upon irradiation with $\lambda > 420$ nm [2]. The peculiarities of its surface structure cause the change in the mechanism of oxygen reduction on black TiO_2NTs. The influence of the structural rearrangement of the TiO_2 surface and carbon impurities on the color and properties of black TiO_2NTs is considered, and the participation of carbon itself in the catalytic reaction is also discussed. Carbon is included in the composition of TiO_2NTs during their formation in an ethylene glycol electrolyte.

Acknowledgment: Himreagent 2021–2025 No. 2.1.04.02; Horizon Europe FLORIN No. 101086142.

[1] Ivanovskaya M., Chernyakova K., Ovodok E., Poznyak S., Kotsikau D., Micusik M. (2023) Mater. Chem. Phys, 297, 127416–10.
[2] Maltanava H. M., Konakov A. O., Gaevskaya T. V., Belko N. V., Samtsov M. P., Poznyak S. K. (2023) J. Appl. Spectr., 90, 882–896.

corresponding author: renata.karpicz@ftmc.lt