Photosensitive composites for light activated gas sensors

A.F.Nasriddinov, M.N. Rumyantseva

Department of Chemistry, Lomonosov Moscow State University, Leninskie Gory 1-3, 119991 Moscow, Russia

corresponding author: roum@inorg.chem.msu.ru

This work is devoted to the functionalization of semiconductor oxides to create gas sensors operating under photoactivation instead of thermal heating in order to reduce energy consumption. This goal is achieved by modifying the sensitive layer of semiconductor oxides with photosensitizers. The objects of the study can be divided into 2 groups depending on the type of photosensitizer used. In both cases, wide-band metal oxide semiconductors SnO_2 and In_2O_3 were chosen as the matrix. These semiconductor oxides, on the one hand, are characterized by different concentration of bulk defects that determine the concentration and mobility of free charge carriers, and on the other hand, they differ in their chemical properties that affect the type and concentration of surface active centers.

In the first group, the photosensitizers are Ru (II) heterocyclic complexes. Their photoexcitation with blue LED (λ_{max} = 470 nm) leads to electron-hole pairs generation. The electrons are transferred from the LUMO level to the conduction band of the oxide matrix, which is lower in energy. At the same time, photoexcited holes remaining in the organic complex can also be transferred to an oxide matrix, where they recombine with electrons localized in chemisorbed molecules. Our obtained and published results showed the promise of using organic-inorganic hybrid materials based on semiconductor oxides (SnO_2, In_2O_3) and Ru(II) heterocyclic complexes for NO_2 and NO detection [1, 2].

In the second group, nanocrystalline titanium dioxide was chosen as a photosensitizer, because of its high photocatalytic activity in oxidation of volatile organic compounds (VOCs) at room temperature under UV light. This part of the work is devoted to the detection of VOCs using TiO_2@SnO_2 nanocomposites under UV photoactivation (λ_{max} = 365 nm) [3]. The obtained results showed that SnO_2/TiO_2 nanocomposites can be perspective in formaldehyde detection in sub-ppm range at T = 150 °C. Further modification of SnO_2/TiO_2 nanocomposites with Au NPs increases the sensor signal at T = 100°C, while modification with Pt NPs gives rise to the appearance of sensor response at T = 25°C and 50°C. The reactions of VOCs oxidation are activated by Au and Pt nanoparticles that lead to increased selective sensitivity toward HCHO, especially in 0.1 – 1 ppm concentration range [4].

[1] M. Rumyantseva, A. Nasriddinov, S. Vladimirova, S. Tokarev, O. Fedorova, I. Krylov, K. Drozdov, A. Baranchikov, A. Gaskov, Nanomaterials, **8(9)**, 671 (2018).
[2] A. Nasriddinov, M. Rumyantseva, T. Shatalova, S. Tokarev, P. Yaltseva, O. Fedorova, N. Khmelevsky, A. Gaskov, Nanomaterials, **10(1)**, 70 (2020).
[3] A. Nasriddinov, M. Rumyantseva, A. Marikutsa, A. Gaskov, J.H. Lee, J.H. Kim, J.Y. Kim, H.W. Kim, S.S. Kim, Sensors, **19(14)**, 3182 (2019).
[4] A. Nasriddinov, V. Platonov, A. Garshev, M. Rumyantseva. Nanomaterials, **11(8)**, 2049 (2021).