PHOTOCHEMICAL FORMATION OF METAL LEAD NANOPARTICLES IN A POLYMERIC MATRIX

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One of the basic ways of nanoparticles production and stabilization is fixing of them in a polymeric matrix. It is possible to use some photochemical methods for this purpose. Particles of noble metals and copper have been produced in such way. We have developed a method of metal lead production [1]. It isn't possible yet to produce the particles of metals with one lower redox potential in such way. For the production of lead nanoparticles, the composition from the water dissolved polymer (polyvinylalcohol (PVA), galantine, polyvinylacetate) and semiconductor photocatalyst (ZnO, TiO_2) was prepared. Then this composition was doped by lead acetate from water solution. After dehydrating and exposing by UV light, formation of nanometer scale lead particles was observed in these compositions. This process can be carried out also in pure polymer and in polymer with the homogeneous photocatalyst (dye). The polymer must contain small quantity of moisture, otherwise the reaction does not occur. We suppose that there are two basic mechanisms of the reaction. 1) The electrons injected from photocatalyst or appeared immediately in matrix reduce lead ions. 2) Decay of excitons leads to the lead ions reduction and finally to the formation of metal particles.

It is known that nanoparticles and nanocomposites have different properties, in comparison with massive samples. One of these is the ability of metal nanoparticles to the efficient absorption of electromagnetic radiation. The application of them in photography is based on this peculiarity. The lead particles, which are produced by an exposure of compositions with lead acetate, create a strong direct blackening. It can run to the value of optical density D~2.0 measured by the reflectance method. In the wide range the optical density is proportional to logarithm of exposure (see the picture). It is a valuable property for photographic materials. It gives the possibility of half-tone image reproduction. It is assumed that in conventional silver photographic materials the optical density is proportional to the surface density of metal. For the compositions mentioned above this statement needs confirmation. The particles of lead are less stable, than the particles of noble metals. They are easily dissolved at wetting of a sample. After dehydrating another image can be obtained on the same sample. Due to this peculiarity, the compositions such as PVA-ZnO-$Pb(CH_3COO)_2$ can be used as the reversal photographic materials with a direct blackening. Another interesting property of lead nanoparticles in a PVA-ZnO composition is their ability to activate excitonic luminescence of zinc oxide. The picture shows the dependence of optical density D and excitonic luminescence intensity of ZnO from exposure time. D increases monotonously with the time. It is reasoned by increasing metal amount. Excitonic luminescence intensity of ZnO with maximum at wavelength λ=385 nm decreases initially due to absorption of exciting and luminescent radiation by metal particles. Then the luminescence intensity increases. It can be affected by the influence of metal nanoparticles on the probability of radiation transitions [2].

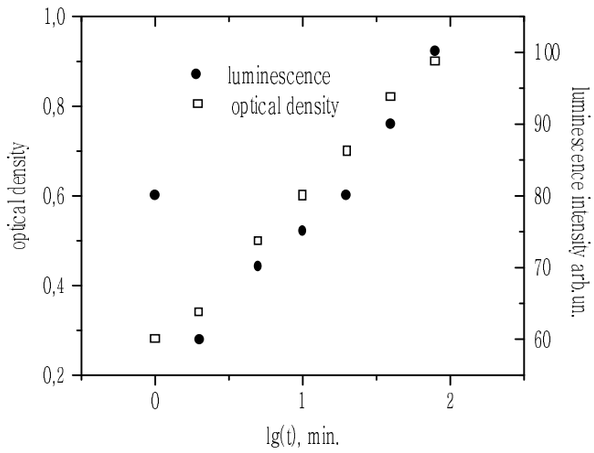

Fig. The dependence of optical density D and excitonic luminescence intensity of ZnO from exposure time.

It is necessary to note, that the semiconductor - polymer compositions are perspective materials for optoelectronics. The materials with fractal structure of heterojunction can be created on the base of these compositions. Semiconductor nanoparticles [3], whiskers and dendrites in polymeric matrix can be used for this purpose. Such devices can have high efficiency of light energy conversion due to repeated passage of a light beam through the phase boundary.

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3. Y. Haga, H. An, R. Yosomiya. J. of Mater. Sci. 1997. V.32. P.3183.