On the prospects of TiO_2 micropowders for photoctalysis

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О перспективах микропорошков TiO_2 для фотокатализа

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Abstract: *the outcomes of the investigation of the prospects of application of microsized photoctalytic TiO_2 powders to photocatalysis. It was found that photocatalytic micropowders were ineffective for photocatalysis not only because of a small specific surface area, but also because of low specific efficiency of the surface itself.*
Аннотация: *приводятся результаты изучения перспективности использования микроразмерных фотокаталитических порошков TiO_2 для фотокатализа. Установлено, что фотокаталитические микропорошки малоэффективны для фотокатализа не только из-за маленькой удельной площади поверхности, а также из-за маленькой удельной эффективности самой площади.*

Keywords: *renewable energy sources, nanotechnology, photocatalysts, titanium dioxide.*
Ключевые слова: *обновляемые источники энергии, нанотехнология, фотокатализаторы, диоксид титана.*

The energy resources on the Earth are limited, and hence they are exhaustible. Actually inexhaustible energy is in the space. The nearest cosmic object the humanity gets the energy from is the Sun. Operation of renewable forms of energy such as hydropower, wind power, etc. is based just on the application of solar energy. Hydrogen also represents a renewable energy source. It is produced by decomposition of water into hydrogen and oxygen by using the power of sunlight. The product of hydrogen burning is again water. This process can be repeated many times without any adverse impact on the environment.

Water is not directly splitted into hydrogen and oxygen by the power of sunlight. For this purpose, it is used a so-called catalysts through which the sunlight decomposes water. Hence these substances are called photocatalysts, and the reaction is called the photocatalytic reaction. Currently titanium dioxide TiO_2 is deemed to be the most efficient and promising photocatalyst [1-4].

The photocatalytic reaction proceeds as follows. Getting into TiO_2, which is a semiconductor and has an energy gap of 3.2 eV between the valence and conduction bands, a sunlight photon creates an electron-positron pair. Having reached the TiO_2 surface, the produced electrons and holes interact with water molecules and cause their splitting into hydrogen and oxygen (Fig. 1) [1].

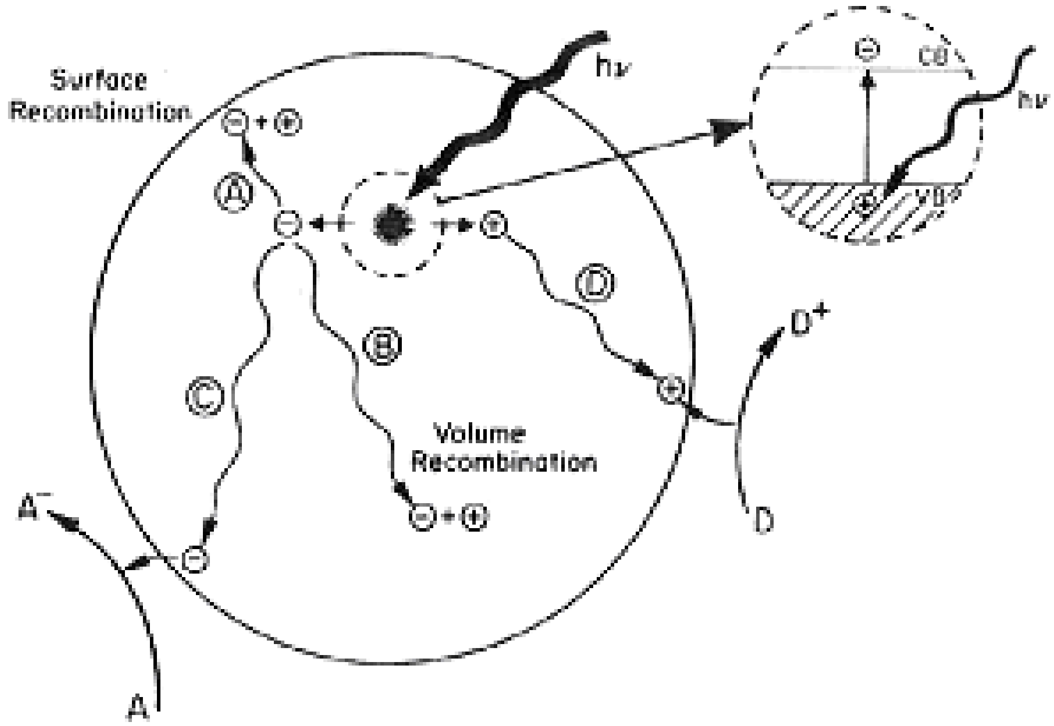

Fig. 1. Electron-positron pair production under the effect of sunlight quanta and their interaction with ambient molecules

As mentioned above, the photocatalytic reaction occurs on the surface. Therefore, it is usually used the photocatalysts in the form of powders in order to increase the surface area. However, in this case, there emerges another problem consisting in the fact that, on the surfaces of small particles, the annihilation of electron-hole pairs happens very soon, and they have no time to participate in the reaction. That is why dot clusters of various substances are deposited on particle surfaces. The clusters capture electrons and holes and hinder their annihilation [Fig. 2], [2].

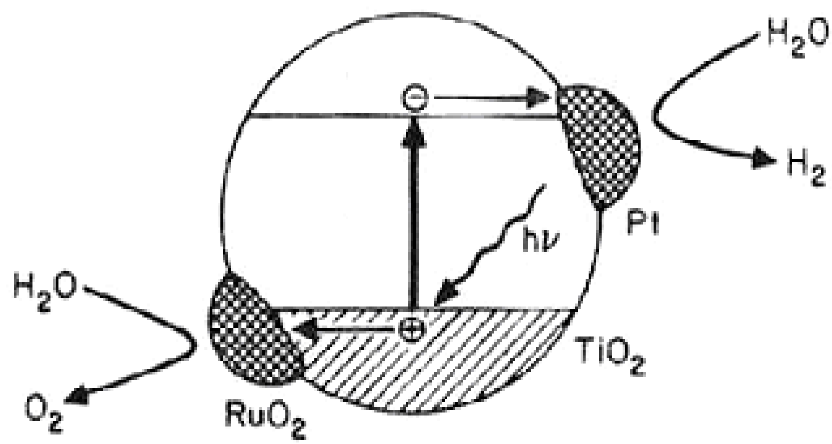

Fig. 2. Electron-positron pair production in cluster-deposited particles of TiO_2 powder under the effect of sunlight quanta and their interaction with ambient molecules

A unique technology of deposition of dot clusters on fine powders was developed at E. Andronikashvili Institute of Physics of Iv. Javakhishvili Tbilisi State University. The technology is electroless and inexpensive, it proceeds at low temperature (50-60^{o}C) and hence changes the properties neither of the material to be coated nor of the material of clusters [5-9].

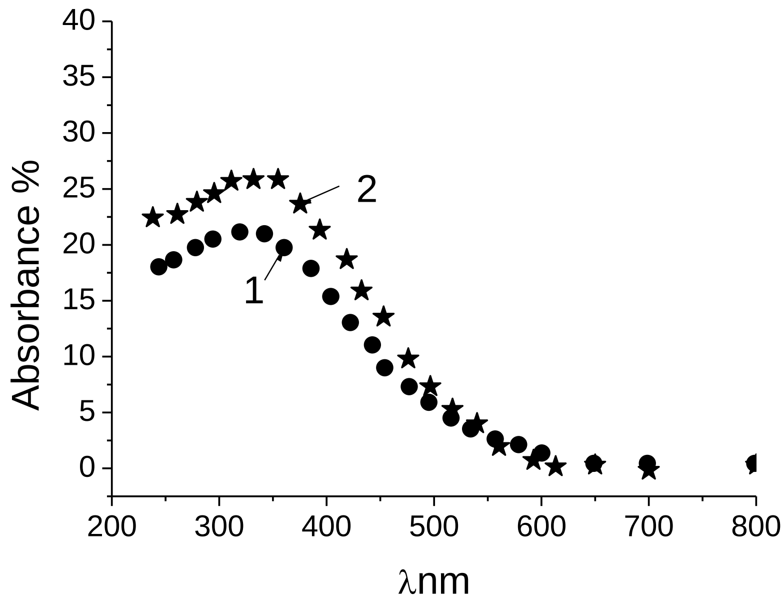

Fig. 3. The effect of nanoclusters on the absorption spectra of TiO_2 micropowders:
1 - Absorption spectrum of TiO_2 micropowders before deposition of clusters;
2 - Absorption spectrum of TiO_2 micropowders after deposition of Co clusters

By this technology, nanosized dot Co clusters were deposited on the surfaces of anatase (TiO_2) powder particles 44 μm in size. The absorption spectra of both cluster-deposited powder and the powder without clusters were investigated. The experimental results are shown in Fig. 3.

Curve 1 corresponds to the absorption spectrum of the powder consisting of the particles without clusters, and Curve 2 – to that of the powder consisting of the particles with deposited Co clusters. As is seen from Fig. 3, the absorption spectrum slightly increased in the result of deposition of clusters, i.e. the value of the deposition effect is low. This indicates that the majority of produced electrons and holes were annihilated before they reached the surface, i.e. the annihilation occurs in the powder particle volume, and hence the deposition of clusters which affects only surface electrons does not exert a significant effect because of a small number of such electrons. Thus, we can conclude that micropowders not only have a small specific area, but also the specific efficiency (efficiency per area unit) of the surface itself is low. Hence we can say that the micropowders have no prospects from the standpoint of their application as photocatalysts in practice.

To our opinion, the nanosize Co coated TiO_2 powders could be more perspective for photocatalitic applications.

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