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Photocatalytic activity of ternary nanocomposite material "TiO_2-graphene oxide-Ag"

In recent years, hydrogen-based energy has been widely used form of renewable energy. During strict environmental requirements-this "zero emission fuel" serves as a suitable choice to replace conventional fossil fuel energy. Hydrogen is therefore the preferred choice for storing inexhaustible solar energy in the absence of sunlight. Hydrogen production is the most important step in the development of solar energy.

In [1] it was shown for the first time, that photoelectrochemical water of splitting occurs on the surface of titanium dioxide (TiO_2). It has already been proved that titanium dioxide occupies a special place among semiconductor photocatalysts because of its physical and chemical properties. To create highly efficient photocatalysts based on TiO_2, which is one of the promising methods are composite materials. The formation of composites based on other semiconductors, metals and carbon materials reduces the rate of recombination TiO_2. Graphene and its derivatives are a promising material in the production of photocatalysts due to their excellent thermal conductivity, charge carrier mobility and large specific surface area [2]. Nanocomposites have already been obtained on the basis of these excellent materials [3] and its photocatalytic activity for hydrogen production is being studied. Studies of synthesized nanocomposites based on graphene oxide and TiO_2 show improved photocatalytic activity in the decomposition of water and the generation of hydrogen H^+.

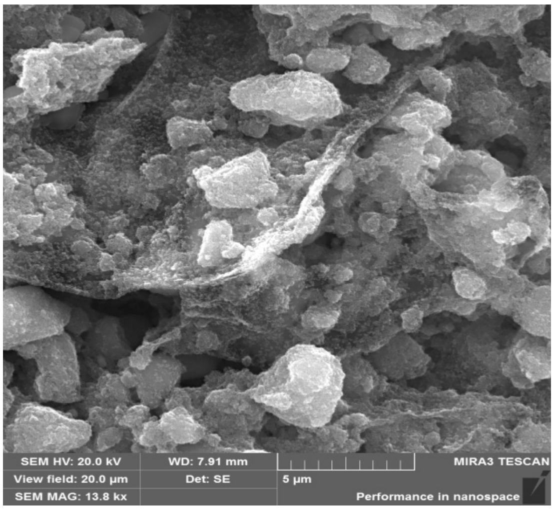
In this paper, the nanocomposite material TiO_2-GO/Ag-TiO_2 with the addition of nanostructures (NS) "core-shell" composition of Ag-TiO_2 was synthesized and its photocatalytic activity was investigated. The addition of NS "core-shell" will increase the photocatalytic characteristics of the nanocomposite by increasing its absorption capacity in the visible light region (~420 nm).

According to work [4] synthesis of nanocomposite materials was carried out by hydrothermal method on the basis of graphene oxide and TiO_2. It is shown, that the nanocomposite has higher electrotransport characteristics and high photocatalytic activity compared to TiO_2 [5]. Also, studies have shown the formation of a bond between graphene oxide and TiO_2.

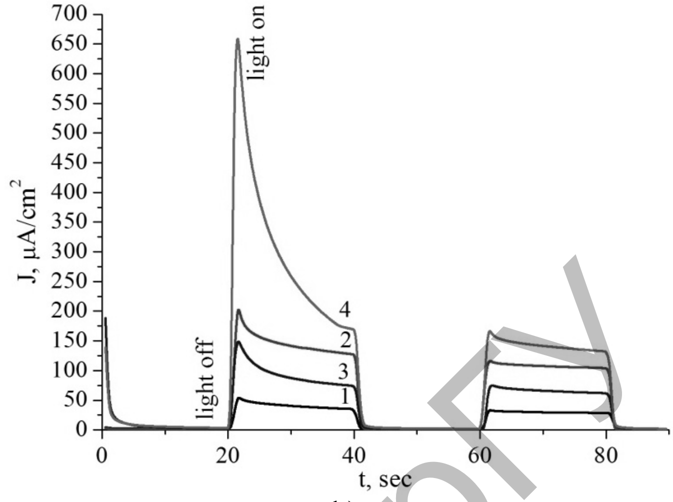
Thus, when recording Raman spectra, the presence of characteristic peaks of the initial materials was observed in the nanocomposite TiO_2-GO. And bond between the titanium, oxygen and carbon was confirmed by FT-IR analysis. FT-IR spectrum shows TiO_2-GO manifested absorption below 1000 cm^{-1}. This peak can be seen as a combination of oscillations of the bonds Ti-O-Ti (about 695 cm^{-1}) and Ti-O-C (about 792 cm^{-1}).

The film of the ternary nanocomposite material was prepared as follows: in 150 mg of TiO_2 powder, was added "core-shell" the Ag-TiO_2 and stirred for 24 hours on a magnetic stirrer to form a homogeneous paste. After application and drying, the film was gradually heated in an argon atmosphere for 2 hours. The study of the transient characteristics of the photocurrent of the obtained materials was carried out by registering the photoinduced current in a standard photoelectrochemical three-electrode cell.

The results showed that the nanocomposite TiO_2-GO with the addition of core-shell Ag-TiO_2, which has improved photocatalytic activity compared with the addition of Ag-TiO_2 to TiO_2 (Fig.1).



a)



b)

Figure 1. SEM-image nanocomposite TiO_2-GO and transient characteristics of the photocurrent:
1-TiO_2, 2-TiO_2/Ag-TiO_2, 3-TiO_2-GO, 4-TiO_2-GO/Ag-TiO_2

Figure 1, a shows the SEM image of the nanocomposite TiO_2-GO. The figure shows that nanoparticles are aggregated in the bulk sample of titanium dioxide. Single-layer sheets of graphene oxide are embedded between TiO_2 nanoparticles in the form of transparent sheets and are clearly visible in the image.

Figure 1, b shows the photocatalytic activity of the nanocomposite and TiO_2 with/without the addition of the core shell structure Ag-TiO_2. Figure 1, b shows that when the film is illuminated, TiO_2 generates a photocurrent of about 40.5 μA/cm^2. The addition of graphene oxide has been shown to increase photocurrent generation in the nanocomposite. The TiO_2-GO nanocomposite generates a photocurrent of about 93.1 μA/cm^2 and this value is 2.3 times bigger than pure TiO_2.

When Ag-TiO_2 is added to the TiO_2 film, the value of the generated photocurrent increases to ~ 144.8 μA/cm^2. Thus, the generation of photocurrent increases in 3.6 and 1.6 more TiO_2 and TiO_2 nanocomposite. The TiO_2-GO nanocomposite with the addition of Ag-TiO_2 shows the value of the generated photocurrent ~298.0 μA/cm^2 and exceeds the value of the nanocomposite by 3.2 times.

Thus, in the study of the photocatalytic activity of the synthesized nanocomposite material TiO_2-GO with adding core-shell by structure of Ag-TiO_2 increases the generation of photoinduced current in 3.2 and 7.4 times more than the nanocomposite and pure TiO_2, respectively.

Since the efficiency of photocatalytic splitting of water into molecular oxygen and hydrogen will directly depend on the magnitude of the photoinduced electrons, it can be assumed that when using the core-shell structure Ag-TiO_2, hydrogen generation will be higher compared to other nanocomposites.

References

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