STUDYING THE PHOTOCATALYTIC ACTIVITY OF IRON OXIDES SYNTHESIZED BY PLASMA DYNAMIC METHOD*

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The beginning of the 21st century is characterized by a transition from the use of traditional fuels (mainly carbon raw materials) to more environmentally friendly and energy efficient ones. In this direction, the photoelectrochemical water splitting with the formation of gaseous hydrogen, which can be further used as a fuel, is one of the most interesting researching areas. The obtained hydrogen gas is used not only as a pure energy carrier, but also as a reagent for other chemical reactions, for example, the reduction of carbon dioxide to hydrocarbons.

The photoelectrochemical water splitting includes two half-reactions occurring in an photoelectrochemical cell. Two water molecules are oxidized at the photoanode under the influence of the light to form an oxygen molecule, while hydrogen is generated at the cathode. The water splitting reaction that occurs on the photoanode surface is endothermic under standard conditions and requires the presence of free energy of 1.23 eV. Various metal oxides such as TiO_2 [1], Fe_2O_3 [2, 3], WO_3 [4], ZnO [5] $BiVO_4$ [6] were investigated as possible catalytic material for photoanodes. Among them, the most common and widely spread metal oxide is iron oxide (Fe_2O_3), which exists in four different polymorphic states, namely alpha, betta, gamma and epsilon. Until recently, the most stable α-Fe_2O_3 (hematite) was considered as the most promising candidate for photoelectrochemical cells [2,5], and its theoretically predicted maximum conversion coefficient of solar energy into hydrogen was 15% [7].

On the other hand, there have recently been reports about the possibility of using another metastable polymorph of iron oxide (ε-Fe_2O_3), which is extremely rare, for ethanol photoreforming [8]. Being inherently magnetoelectric and ferroelectric, as well as having a band gap of 1.9 eV, this polymorph can exhibit increased photoabsorption and lower recombination rate that can lead to an improvement in the conversion coefficient of solar energy to hydrogen and increase the overall efficiency of photoelectrochemical cells. However, due to some peculiarities of the synthesis process this phase is difficult to be obtained in the form of ultradispersed powder that limits the possibility of studying its catalytic activity in the photoelectrochemical water splitting.

In this work, both iron oxide phases ε-Fe_2O_3 and α-Fe_2O_3 were successfully synthesized in the ultradispersed form by the plasma dynamic method based on the generation of an iron-containing arc discharge flowing into oxygen atmosphere. By varying the process conditions, the final phase composition of synthesized iron oxide powders can be controlled. Thus, the photocatalytic activity of both phases was studied in the three-electrode photoelectrochemical cell under the influence visible range light, after producing the photoanodes from the initial ultradispersed powders by the electrophoretic deposition.

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