Quantum efficiency of photocatalytic sea water splitting by Ag-AgI nanostructures

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Photocatalysis is a promising way to use and convert solar energy. As a result of multistage process under the action of radiation on the surface of the of the photocatalyst gaseous hydrogen and oxygen are synthesized which can be used in other field of industries and as fuel. Water is only one and sufficient reagent for obtaining green hydrogen. Electrolyte is one of the main elements of photocatalytic water splitting. It is the medium into which photogenerated electrons enter to reduce hydrogen, so the number of charges carries affects the water splitting efficiency. Sea water covers about 70% of the earth's surface area. The use of sea water as a reagent for the use photocatalytic production of hydrogen fuel does not require the preparation of special electrolytes. In 1969 R. Horne determined the composition of sea water and proved the constancy of the composition almost anywhere in the world's oceans. [1].

This nanoporous silver films has been synthesized by substitution reaction on a copper subtract from solution from silver nitrate (37.5 g/l $AgNO_3$). [2]. Partial iodide of the films in iodide vapor at room temperature was carried out to obtain Ag-AgI nanostructured composite, which is used as a photocatalyst. When an external voltage of 0.5-4 V was applied the appearance of photocurrent under the action of UV and visible radiation. 0.1M $NaNO_3$ was used as a model electrolyte and electrolyte with a composition close to the sea water composition as the investigated one. Sea water like electrolyte contains NaCl (7.58 w.%), $MgCl_2$ (1.06 w.%), $MgSO_4$ (0.46 w.%).

Quantum efficiency η is calculated as the ratio of the product of measument photocurrent I_{ph} and the photon energy to the product of the radiation power absorbed by sample surface P_{abs} and the electrone charge (1):

$$\eta = (I_{ph}\omega\hbar)(P_{abs}e)^{-1} \quad (1)$$

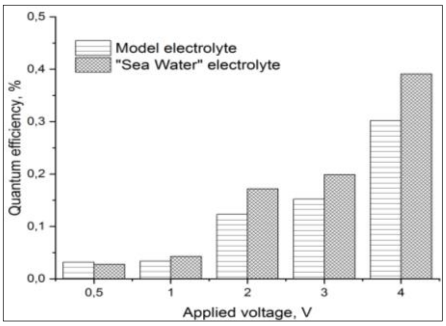

Figure 1. The dependence of quantum efficiency on applied voltage

Under the action of an applied voltage, the quantum efficiency of water splitting increases with increasing voltage. The electrolyte decomposition close to the composition of sea water contains more charge carries, so the electrical conductivity of this electrolyte is higher in compare with model electrolyte. At an applied voltage of 4V with a model electrolyte, the quantum efficiency was 0.3% and when using "sea water" electrolyte – is 0.4%. The average quantum efficiency of water splitting increase with the application voltages of 0.5-4 V was 23%.

References

[1] R. A. Horne. Wiley-Interscience (New York), (1969).

[2] P. A. Bezrukov, N. A. Nashchekin, N. V. Nikonorov, A. I. Sidorov, Phys. Solid State, 8 (2022) 1106.

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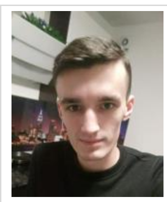

Pavel Bezrukov is a PhD student at ITMO University, works in a project supported by the Russian Science Foundation and related to the photocatalytic water splitting.

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