Efficient and Low Cost Solar-Driven Water Splitting Involved with Nanostructures

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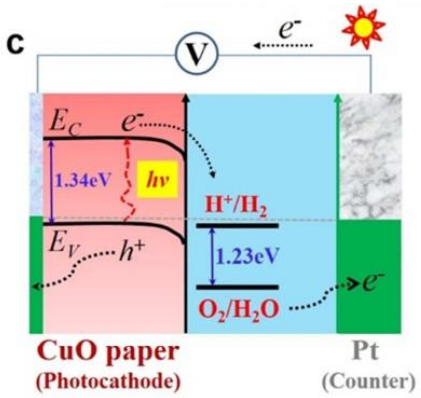
Abstract

One of the main challenges in today's world is for sure requirement of clean energy. Hydrogen as a propitious energy carrier can help with elimination of fossil fuel dependency. Creation of hydrogen by water splitting solar driven approaches is a very attractive way to achieve clean and renewable energy. Recently, there have been many researches devoted on exploiting novel materials and techniques so as to improve the efficiency of the process. Efficient method for solar-driven water splitting can happen aided by nanostructures such as nanowires (1-4), nanoparticles (5), nanopyramids (6), nanofibers(7), quantum dots (8), nanoclusters (9), nanorods (10, 11), nanoflakes (12) playing role as photoelectrode and photocatalyst. These nano-configurations have been reached for ZnO, graphene, TiO_2, Fe_2O_3, $BiVO_4$, GaP, GaN, Cu_2O and etc. Herein, comparative study on solar to hydrogen conversion efficiency of water splitting systems improved by various techniques is demonstrated through most recent studies as well as detailed explanation regarding the utilized fabrication methods.

Keywords: Solar-driven device, Water splitting, Nanostructures, Hydrogen



Scheme. Process of photoelectrochemical cell performing water splitting based on nanostructured metal oxide; CuO paper;/ITO photocathode; e^- and h^+ denote electron and hole. Scheme from Ref (13). Thermodynamically, minimum of 1.23eV is needed to separate H_2 and O_2 from H_2O. So, an external bias potential is required to overcome the kinetic barrier. In fact, nanocrystallined CuO because of having a conduction band edge with more negative potential (1.34eV band gap) can play a reliable role as a photocathode to split water

References:

1. Luo J, Steier L, Son MK, Schreier M, Mayer MT, Gratzel M. Cu2O Nanowire Photocathodes for Efficient and Durable Solar Water Splitting. Nano Lett. 2016;16(3):1848-57.
2. Kibria MG, Chowdhury FA, Zhao S, AlOtaibi B, Trudeau ML, Guo H, et al. Visible light-driven efficient overall water splitting using p-type metal-nitride nanowire arrays. Nat Commun. 2015;6:6797.
3. Standing A, Assali S, Gao L, Verheijen MA, van Dam D, Cui Y, et al. Efficient water reduction with gallium phosphide nanowires. Nat Commun. 2015;6:7824.
4. Kargar A, Sun K, Jing Y, Choi C, Jeong H, Jung GY, et al. 3D Branched nanowire photoelectrochemical electrodes for efficient solar water splitting. ACS Nano. 2013;7(10):9407-15.
5. Tricoli A. Flame Synthesis of Highly Transparent and Robust Nano-Layers for Enhanced Photo-Electrochemical Water Splitting. 2016.
6. Wei Y, Su J, Wan X, Guo L, Vayssieres L. Spontaneous photoelectric field-enhancement effect prompts the low cost hierarchical growth of highly ordered heteronanostructures for solar water splitting. Nano Research. 2016;9(6):1561-9.
7. Li Z, Yao C, Yu Y, Cai Z, Wang X. Highly efficient capillary photoelectrochemical water splitting using cellulose nanofiber-templated TiO(2) photoanodes. Adv Mater. 2014;26(14):2262-7, 110.
8. Chinnusamy Jayanthi S, Kaur R, Erogbogbo F. Graphene Quantum Dot - Titania Nanoparticle Composite for Photocatalytic Water Splitting. MRS Advances. 2016;1(28):2071-7.
9. McInnes A, Plant SR, Ornelas IM, Palmer RE, Wijayantha KGU. Enhanced photoelectrochemical water splitting using oxidized mass-selected Ti nanoclusters on metal oxide photoelectrodes. Sustainable Energy Fuels. 2017;1(2):336-44.
10. Pihosh Y, Turkevych I, Mawatari K, Uemura J, Kazoe Y, Kosar S, et al. Photocatalytic generation of hydrogen by core-shell WO(3)/BiVO(4) nanorods with ultimate water splitting efficiency. Sci Rep. 2015;5:11141.
11. Sun B, Shi T, Tan X, Liu Z, Wu Y, Liao G. Titanium Dioxide Nanorods with Hydrogenated Oxygen Vacancies for Enhanced Solar Water Splitting. Journal of Nanoscience and Nanotechnology. 2016;16(6):6148-54.
12. Wang L, Nguyen NT, Zhang Y, Bi Y, Schmuki P. Ehanced Solar Water Splitting by Swift Charge Separation in Au/FeOOH Sandwiched Single Crystalline Fe2O3 Nanoflake Photoelectrodes. ChemSusChem. 2017.
13. Zhang M, Hou C, Halder A, Chi Q. Ultralight, Flexible, and Semi-Transparent Metal Oxide Papers for Photoelectrochemical Water Splitting. ACS Appl Mater Interfaces. 2017;9(4):3922-30.