NTA2022

2nd International Conference on
Nanotechnology: Theory and Applications,
Cairo, 19 – 21 Dec., 2022

Ref. 062

Design and fabrication of nanostructured electrode materials for energy conversion

A.N. El-Shazly*[1], M.M. Rashad[1], Nageh K. Allam[2]

[1]Central Metallurgical Research and Development Institute, P.O. Box 87, Helwan, Cairo, Egypt
ayatelshazly@gmail.com, rashad133@yahoo.com

[2] Energy Materials Laboratory (EML), School of Sciences and Engineering, The American University in Cairo, New Cairo, 11835, Egypt. nageh.allam@aucegypt.edu

KEYWORDS

Photocatalysis, Hydrogen, Solar cell, Visible-light

SHORT SUMMARY

Photocatalysis as a green and sustainable technology has received much attention as its potential solutions for solar energy and environmental aspects. In order to promote the research work of the field and meet the requirements of practical applications, it is necessary to develop high efficiency visible-light-driven photocatalysts, especially semiconductor photocatalysts. This work summarizes our work recently made in this field, focusing on the scientific possibilities offered by different semiconductor photocatalysts for water splitting, organic pollutants degradation, and solar cells. The recent progress is discussed and explained in detail, including the synthesis, characterization, and applications of visible light-driven photocatalysts. Finally, we conclud by summarizing both findings and perspectives.

EXTENDED ABSTRACT

Introduction

Green and efficient energy technologies are crucial where nanotechnology could assist in the paradigm shift from fossil fuels to renewable energy resources [1]. Hydrogen gas has been investigated as an outstanding substitute to the traditional fossil fuels because of its clean combustion process yielding water vapor, being made of water, the main resource on the earth, and the high efficiency of its evolution from and conversion into electricity [2,3]. Due to their outstanding prospective to employ clean, inexhaustible, and permanently accessible solar energy in vital energy conversions [4], semiconductor-assisted photocatalysis has been extensively investigated for about half a century [5,6]. Since the pioneering work of Fujishima and Honda [7], photocatalytic water splitting became one of the top research interests as a green renewable source of energy [8], and TiO2 became one of the most widely utilized photocatalysts owing to its perfect photocatalytic behavior, non-toxicity, long durability, availability, low cost, photostability, and chemical stability, see Figure 1 [9]. However, its rapid e-h recombination rate and large bandgap energy are the major disadvantages of TiO_2 that severely affect its photocatalytic performance and limit its functionality to the UV region, hindering its practical application [10]. Therefore, as shown in Figures 2,3, it still remains a challenge to develop novel, robust, non-toxic, low-cost, and efficient visible-light-driven photocatalysts with high light-harvesting efficiency and abundant catalytically active sites [11].

Acknowledgments

Authors would acknowledge the support of the Central Metallurgical Research and Development Institute and the American University in Cairo.

* corresponding author

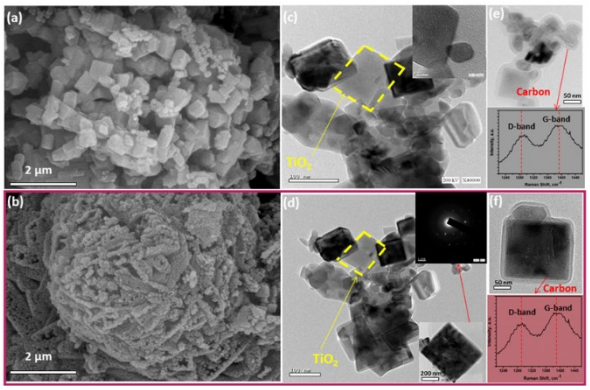

Figure 1 SEM and TEM of TiO_2 mesocrystals

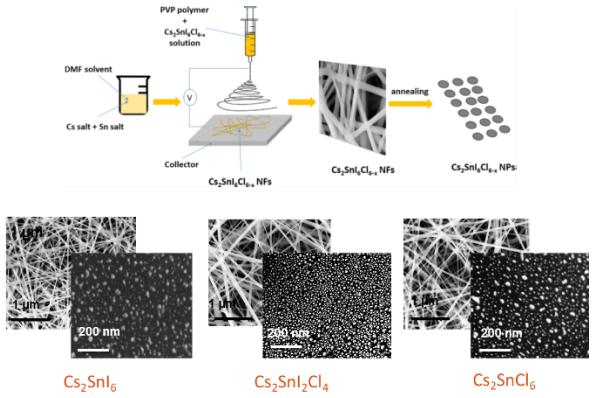

Figure 2 Double perovskites ($Cs_2SnI_6Cl_{6-x}$) nanofiber

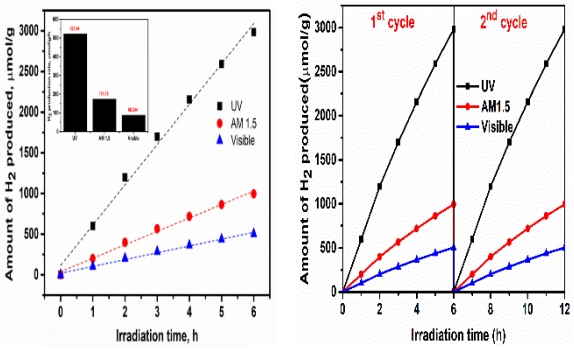

Figure 3 Photocatalytic hydrogen production performance of $Bi_2(CrO_4)_3$

References

[1] Mokhtar AM, Salem KE, Hassan HA, Allam NK. Multiple synergistic effects of Zr-alloying on the phase stability and photostability of black niobium oxide nanotubes as efficient photoelectrodes for solar hydrogen production. Appl Catal B Environ 2021:119961.

[2] Atef N, Emara SS, Eissa DS, El-Sayed A, Abdelraouf OAM, Allam NK. Well-dispersed Au nanoparticles prepared via magnetron sputtering on TiO2 nanotubes with unprecedentedly high activity for water splitting. Electrochem Sci Adv 2021;1:e2000004.

[3] Chen D, Liu Z, Zhang S. Enhanced PEC performance of hematite photoanode coupled with bimetallic oxyhydroxide NiFeOOH through a simple electroless method. Appl Catal B Environ 2020;265:118580.

[4] Biby AH, Tolba SA, Allam NK. Unveiling the role of carbon defects in the exceptional narrowing of m-ZrO2 wide bandgap for enhanced photoelectrochemical water splitting. Int J Hydrogen Energy 2021

[5] El-Shazly AN, Hegazy AH, El Shenawy ET, Hamza MA, Allam NK. Novel facet-engineered multi-doped TiO2 mesocrystals with unprecedented visible light photocatalytic hydrogen production. Sol Energy Mater Sol Cells 2021;220:110825

[6] Ren X, Xu F, Peng Z, Chi Q, Li W, Wang J, Tao T, Ye W, Gao P. Boosting visible light driven hydrogen production: bifunctional interface of Ni(OH)2/Pt cocatalyst on TiO2. Int J Hydrogen Energy 2020;45:16614e21.

[7] Fujishima A, Honda K. Electrochemical photolysis of water at a semiconductor electrode. Nature 1972;238:37e8.

[8] Shen H, Ni D, Niu P, Zhou Y, Zhai T, Ma Y. Enhancing photocatalytic H2 evolution from water on CuO-Co3O4/TiO2: the key roles of Co3O4 loading amounts. Int J Hydrogen Energy 2017;42:30559e68. https://doi.org/10.1016/j.ijhydene.2017.10.133.

[9] Zhang H, Xing Z, Zhang Y, et al (2015) Ni2+ and Ti3+ co-doped porous black anatase TiO2 with unprecedented-high visible-light-driven photocatalytic degradation performance. RSC Adv 5:107150–107157. https://doi.org/10.1039/c5ra23743b

[10] Ahmed N, Ramadan M, El Rouby WMA, Farghali AA, Allam NK. Non-precious co-catalysts boost the performance of TiO2 hierarchical hollow mesoporous spheres in solar fuel cells. Int J Hydrogen Energy 2018;43:21219e30.

[11] Bhatia V, Dhir A. Transition metal doped TiO2 mediated photocatalytic degradation of anti-inflammatory drug under solar irradiations. J. Environ. Chem. Eng. 2016;4:1267e73.