

Solar-Hydrogen Production with Reduced Graphene Oxide Supported Metal Chalcogenides

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1. Introduction – Hydrogen, as a clean/green and renewable energy storage and carrier has great potential for decreasing CO₂ emission and thus, resolving the global warming problems. One of the most suitable methods to produce clean and pure hydrogen fuel is to split water by utilization of solar light. For photocatalytic and photoelectrochemical hydrogen evolution reactions, photoactive materials, semiconductors, should have an optimal band structure for maximum utilization of solar energy, suitable band positions and stability against photocorrosion ^[1]. Usually, transition metal chalcogenides (TMC) have been considered as ideal photocatalysts for visible light driven hydrogen evolution reaction (HER) ^[2]. However, photoelectrocatalytic activity of TMC is restricted by the fast recombination of photogenerated charges and photocorrosion ^[3]. One of the possible ways to minimize this problems is to couple TMC with wider band gap semiconductors and graphene derivatives, e.g. Reduced Graphene Oxide (RGO) ^[4]. Therefore, in this work, we have tried to enhance the hydrogen production efficiency of Cd_xZn_{1-x}S photocatalysts by decorating it with RGO As prepared RGO-Cd_xZn_{1-x}S composites have been tested in order to find their possible usage in photocatalytic and photoelectrochemical hydrogen production processes.

2. Experimental - Cd_xZn_{1-x}S photocatalyst were decorated on RGO by usage of a new synthetic method in which reduced graphene oxide (RGO) was processors of the proposed particles. With this method, particles features were easily controlled by decorating proposed particles into RGO sheet. Briefly, for the production of RGO/Cd_xZn_{1-x}S photocatalysts, thermal cracking method was used in which cadmium acetate dihydrate and zinc acetate dihydrate as the sources of Cd and Zn were mixed with RGO and it was reacted with elemental sulfur through thermal sulfurization process. Photoanodes have been prepared by depositing RGO-Cd_xZn_{1-x}S composite photocatalysts on the indium tin oxide (ITO) coated glass and then structural and photoelectrochemical characterization of the electrodes have been made in addition to their optimization. Finally, the optimized photocatalysts and photoanodes were tested for water splitting in sacrificial agent medium and performance of the composite photocatalysts such as stability and efficiency were determined.

3. Results and Discussion - The presence of RGO in Cd_xZn_{1-x}S as electron collector and transporter increased the photocatalytic activity and photocurrents of the photoelectrodes approximately 40%, due to the increase not only in the life-time of photo-generated charge carriers but also in the light absorption as a result of the scattering of the incident light. Among the RGO-Cd_xZn_{1-x}S composites, while the highest photocatalytic H₂ evolution rate was observed with RGO/Cd_{0.7}Zn_{0.3}S structure which was approximately 155 μmolh⁻¹, RGO/CdS photoanode yielded an extremely high photocurrent density of 6.5 mAcm⁻².

4. Conclusions - Better hydrogen production performance was reported with the reduced graphene oxide RGO/Cd_xZn_{1-x}S composites which were synthesized through sulfurization process by using elemental sulfur as sulfur source, since presence of ROG in RGO- Cd_xZn_(1-x)S composites enhance the photocatalytic activity by decreasing the crystallinity sizes of the photocatalysts.

5. References

- [1] J. Zhang, W. Zhao, Y. Xu, H. Xu, B. Zhang, *International Journal of Hydrogen Energy* **2014**, 39, 702-710.
- [2] Q. H. Wang, *Nat. Nanotechnol.* **2012**, 7, 699.
- [3] aY. P. Xie, Z. B. Yu, G. Liu, X. L. Ma, H.-M. Cheng, *Energy & Environmental Science* **2014**, 7, 1895-1901; bH. Yan, J. Yang, G. Ma, G. Wu, X. Zong, Z. Lei, J. Shi, C. Li, *Journal of Catalysis* **2009**, 266, 165-168.
- [4] J. F. Reber, K. Meier, *The Journal of Physical Chemistry* **1984**, 88, 5903-5913.