Optimizing ZnO nanorod arrays and their heterostructures as photoanodes in a photoelectrochemical water splitting device

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ABSTRACT

World demand for energy increases continuously mainly due to the increase of energy consumption in developing countries. Currently, the main energy source is based on fossil fuels, which display two critical problems: they are expected to be depleted and in addition they raise environmental concerns. Access to clean alternative energy sources, such as solar energy, is expected to make a huge contribution to resolving the energy crisis issue.

Apart from the direct electricity production through the utilization of solar energy, finding an efficient way of storing and transporting is a great challenge. The formation of molecular hydrogen and oxygen through water splitting is a direct way to store solar energy as fuel and surpasses other methods to produce H_2, such as steam reforming of natural gas. Metal oxide semiconductors such as TiO_2, WO_3 and ZnO possess a special placement in preparing anodes for solar oxygen evolution in a water splitting PEC cell. ZnO is of significant interest as it exhibits the most abundant configurations of nanostructures that one material can form, with the 1-D morphology of ZnO (such as nanorods and nanowires) to be the most preferable.

The role of the ZnO nanorod (NR) morphology on hydrogen production is an open issue to be resolved. Efforts in our laboratories have been directed towards understanding and improving the electrochemical interface between the anodic electrode (ZnO NRs) and the aqueous electrolyte in a PEC cell, as well as to optimize the catalyst morphology and surface [1,2]. However, the wide bandgap of the ZnO limits the light absorption only to the UV part of the solar spectrum, which strictly prevents the efficient exploitation of the solar energy in the visible region. An approach to increase the efficiency of the ZnO anodic electrode, and as a result the total efficiency of a PEC cell, is the surface modification of ZnO NRs. For this reason, efforts have been directed to the growth of core/sheath nanostructure consisting of a metal oxide semiconductor core (ZnO) covered by chalcogenides such as ZnSe.

Another way to increase the efficiency of a PEC cell is the incorporation of various ions dopants (such as N_2, Al, etc) in the ZnO lattice, expected to improve the electrical and optical properties of the ZnO NRs. In our study, doping of ZnO NRs with different atomic concentrations of Aluminum (Al) ions was followed and a systematic effort to combine the observed changes in the PEC efficiency with the defects is undertaken.

REFERENCES

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