The Effect of Si-doping in $(CdS)_{1-x-y}(ZnS)_xSi_y$ Photocatalysts Studied by Electrochemical Impedance Spectroscopy and Band Bending Theory.

M. E. Rincón, W. Martínez and I. González*

Centro de Investigación en Energía - UNAM
Apartado Postal 34, Temixco, Mor. 62580, MEXICO

*Universidad Autónoma Metropolitana-Iztapalapa
Apdo. 55-534, México, D.F. 09340, MEXICO

Films of $Cd_{1-x}Zn_xS$ have been the subject of intense research due to their potential application as window material in solar cells [1-3] and to the possible use as photocatalysts for hydrogen production by visible light [4-5]. In aqueous media, hydrogen production has been implemented with the addition of sacrificial agents such as sulfide and sulfite, since it is well known that the binary materials, CdS and ZnS, photocorrode in this media [4]. More recently, the enhancement in photocatalytic activity in the $Cd_{1-x}Zn_xS$ system was reported by Chandra et al. [5], who incorporated n-type silicon into the semiconductor system [5]. According to these authors, hydrogen evolution is sustained for a few days, even though Si normally undergoes thermochemical oxidation instantaneously in aqueous alkaline media, producing hydrogen and an oxide of Si. They proposed a mechanism based on the following assumptions: silicon is being encased in a sheet of CdS/ZnS; Si is acting as a source of e- to the conduction band of n-CdS; Si is a sink for e- trap in shallow levels of n-CdS.

In the present work, we report the optical, structural and electrochemical characterization of CdZnS photocatalysts with different stoichiometry, and the effect of Si doping on the stability and photoresponse of the compound film. CdS and ZnS precipitates (chemical bath) were incorporated in different ratios, through screen printing and sintering techniques. Voltamperometric studies in the dark and under illumination indicate stable systems when the formation of ternary compounds is possible. The excess of binary compounds, particularly ZnS, could be correlated to the electrochemical instability of the films. The effect of CdS on the optical band gap of ZnS follows the expected trend of sensibilization to longer wavelengths [2-3]. Two levels of Si doping, 4% and 8% in weight, were attempted in this work. Our findings indicate better results for the lower level of doping. In general, Si causes a red shift in the optical band gap of the films, which, in turn, gives a larger photoelectrochemical response. Doping with Si also affects the stability of the compound films. Unstable CdS:ZnS ratios becomes stable with the addition of Si and this is explained in terms of the effects of Si in the crystalline structure of the films. Electrochemical impedance studies and modeling of the different films through band bending theory (Mott-Schottky curves) will be presented and discussed in reference to the mechanism proposed by Chandra et al. to attest to the potential application of these photocatalysts in environmental remediation and/or photoelectrolytic hydrogen production.

References

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