Hematite Photoanodes for Energy and Environmental Applications

J. Krýsa[a]*, T. Imrich [a,b], M. Neumann-Spallart [a], H. Krýsová [b]

[a] *Dpt. of Inorganic Technology, University of Chemistry and Technology Prague, Czech Republic*

[b] *J. Heyrovsky Institute of Physical Chemistry of the Czech Academy of Sciences, Prague, Czech Republic*

krysaj@vscht.cz

Titania (TiO_2) and hematite (α-Fe_2O_3) have potential applications as semiconducting photoanodes for either hydrogen production via photoassisted water electrolysis or photoelectrochemical (PEC) oxidation of water pollutants. The advantages of TiO2 are high stability, nontoxicity, and low price. However, it absorbs only a very small part of sunlight (3% of the total power). On the other hand, iron oxide (α-Fe_2O_3) has a favourable band gap (2.0 – 2.2 eV), which enables absorption of a substantial fraction of solar light, resulting in the theoretical maximum power conversion efficiency of 27 %. This has created much interest in the past, which has been rekindled by the advent of new thin film preparation and texturization methods. Limitations are the non-ideal position of the conduction band, i.e. too large an electron affinity for spontaneous water reduction, low minority carrier diffusion length, surface states that can mediate recombination, low stability in acidic media, and photocorrosion.

Spray or aerosol pyrolysis is a convenient method for the preparation of Sn or Ti doped hematite photoanodes without the need to use thermal diffusion of dopant from an underlayer or an overlayer. Success in the coverage of hematite by a TiO_2 overlayer (improvement of chemical stability and photocurrent (IPCE) *vs*. potential behaviour) depends on the layer thickness and deposition method. Coverage of hematite by a very thin (2 nm) conformal ALD TiO_2 or SnO_2 overlayer results in the decrease of Faradayic efficiency (f) of hematite photocorrosion and increased stability during long term polarization in acidic environment. Coverage of hematite by a sol-gel TiO_2 film of much higher thickness (63 nm) decreased f only about 25 % but on the other hand photocurrent is only slightly lower than in the case of uncovered hematite.

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