The Improved Photocatalytic Activity of Semiconductor Photocatalysts TiO_2 and $BiVO_4$ Prepared by a New Photoassisted Sol-gel Method

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Since TiO_2 was found to be an efficient photocatalyst, intense research has concentrated on anatase TiO_2 photocatalysis. In this work TiO_2 nanoparticles were prepared via a new photo-assisted sol-gel method in which ultraviolet light irradiation was used in the preparation process of TiO_2 colloid. After being characterized it was found that the amorphous titania nanoparticles prepared by photo-assisted sol-gel method can be transformed into crystalline anatase phase at lower calcination temperature compared to those prepared by conventional sol-gel method. In addition, the particle size distribution of anatase powder samples was also affected by the UV illumination on the colloid. It is suggested that the UV illumination can induce the formation of oxygen vacancies on the colloid and this results in the accelerated phase transition from amorphous to anatase titania.

Existence of the oxygen defects in the UV-irradiated samples was further confirmed by X-ray photoelectron spectroscopy (XPS). Fig. 1 shows Ti2p and O1s core level XPS spectra of two sets of samples calcined at 100 °C. For UV-irradiated sample the two peaks located at 458.7 and 464.5 eV can be assigned to the core levels of $Ti^{4+}2p_{3/2}$ and $Ti^{4+}2p_{1/2}$ (Fig. 1a), respectively. After curve fitting, two additional peaks located at 456.0 and 461.8 eV ascribed to $Ti^{3+}2p_{3/2}$ and $Ti^{3+}2p_{1/2}$ could be identified, suggesting the presence of Ti^{3+} species in the irradiated sample. The O1s core level spectrum is also asymmetric, after curve fitting, besides the main peak of O1s located at 530.1 eV corresponding to lattice oxygen of TiO_2, a shoulder peak at higher binding energy of 532.4 eV can be identified (Fig.1b). This peak should be attributed to the surface species such as Ti-OH and Ti-O-O^- *etc.* resulting from the reaction of chemisorbed water or/and oxygen molecules with Ti^{3+} on the sample surface. For the non-irradiated sample there is no any additional peaks in Ti2p spectrum except for the $Ti^{4+}2p_{3/2}$ and $Ti^{4+}2p_{1/2}$ (Fig. 1c). So it is concluded that the UV-irradiation induces defects structure of oxygen vacancy and the predominant defect-induced oxidation state of titania is Ti^{3+} species. Furthermore the UV-irradiated TiO_2 powder samples exhibited a higher activity than that of non-irradiated samples in photocatalytic decomposition of organic dyes solutions.

On the other hand it was reported that nanocrystalline monoclinic $BiVO_4$ films on conductive glass electrodes showed an excellent incident photo-to-current conversion efficiency (IPCE) for photoelectrochemical water decomposition under visible light illumination. We used photoassisted method to synthesize the $BiVO_4$ powder samples and then prepare particulate thin film electrodes. It was found that the photoassisted sample exhibited a higher IPCE value than that of non-photoassisted sample in 0.1M Na_2SO_4 aqueous solutions Fig.2 shows the Bi4f core level spectra of $BiVO_4$ powder samples prepared by photoassisted and non-photoassisted method. The different Bi species on the samples surface was most likely the reason for the different photocatalytic activity between photoassisted and non-photoassisted samples.

In summary the photoassisted sol-gel method is effective in preparation of highly efficient semiconductor photocataysts.

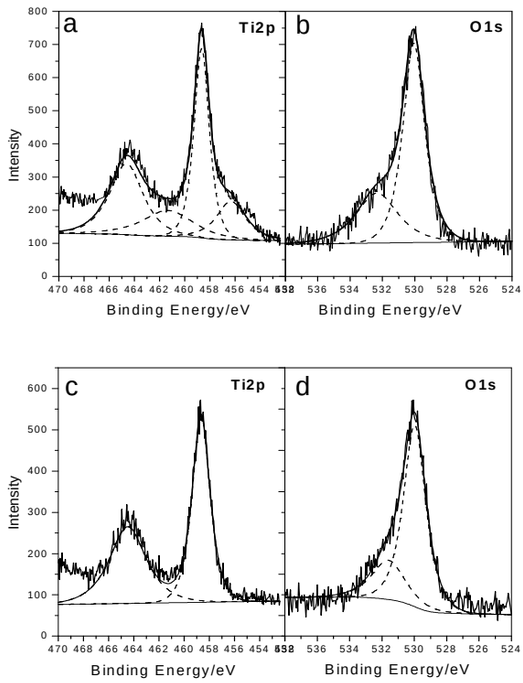

Figure1: The Ti2p and O1s core level spectra of the UV-irradiated (a, b) and non-irradiated sample (c, d) annealed at 100 °C. Dash lines show the curve fitting results.

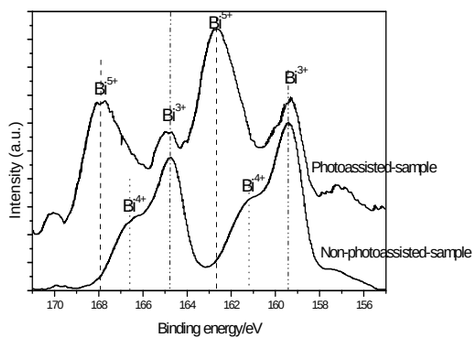

Figure2: The Bi4f core level spectra of $BiVO_4$ powder samples annealed at 300°C prepared by photoassisted and non-photoassisted method.

References

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