electronics

Supplementary material

Solar energy conversion and storage using a photocatalytic fuel cell combined with a supercapacitor

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Construction of the photoelectrode

1. Materials

Unless otherwise specified, all reagents were obtained from Sigma-Aldrich and were used as received. Thus Fluorine-doped Tin Oxide electrodes (8 ohm/square) were purchased from Pilkington (USA), carbon cloth (CC) from Fuel Cell Earth (Wobum, MA, USA) and carbon black (CB) from Cabot Corporation (Vulcan XC72, Billerica, MA, USA).

2. Construction of the CdS/TiO_2/FTO photoelectrode

The CdS/TiO_2/FTO electrode was constructed by the following procedure. An FTO glass was cut in the appropriate dimensions and was carefully cleaned first with soap and then by sonication in acetone, ethanol and water. A compact titania layer was first deposited on the clean electrode by a sol gel procedure. A precursor solution was prepared by mixing 3.5 g of Triton X-100 with 19 mL of ethanol to which 3.4 mL of glacial acetic acid and 1.8 mL of titanium isopropoxide was added under stirring. This solution was used for dipping FTO electrodes, which were patterned by covering with tapes the back side and the front side parts which should remain clear. Then it was calcined up to 550°C. This was repeated once, to ensure a complete coverage of the active electrode area. Next, a mesoporous titania layer was deposited on this compact layer by doctor blading, using a paste, composed of Degusa P25 nanoparticles and prepared by a standard procedure based on Ref. **[1]**. The mesoporous film was calcined at 550 °C. This procedure was repeated once again to ensure that a mesoporous film of around 10 μm thickness was obtained. Film thickness was approximately determined by scanning electron microscopy (SEM). The active area of the titania film was 1 cm^2 (1 cm x 1 cm). A fresh titania film was sensitized by CdS nanoparticles by the SILAR method (Successive Ionic Layer Adsorption and Reaction) **[2,3]** using 0.1 M cadmium nitrate as Cd^{2+} and 0.1 M sodium sulfide as S^{2-} source. 10 SILAR cycles were sufficient to color titania with the yellow CdS layer. This method does not produce a separate CdS layer but rather CdS nanoparticles are formed within the titania mesoporous structure **[2]** (see image here below). At the end, the film was first dried in a nitrogen stream and then for a few minutes in an oven at 70 °C.

Characterization of the photoelectrode and the air-electrode

The following FESEM images show the mesostructure of the active components of the presently used photoelectrode and air-electrode.

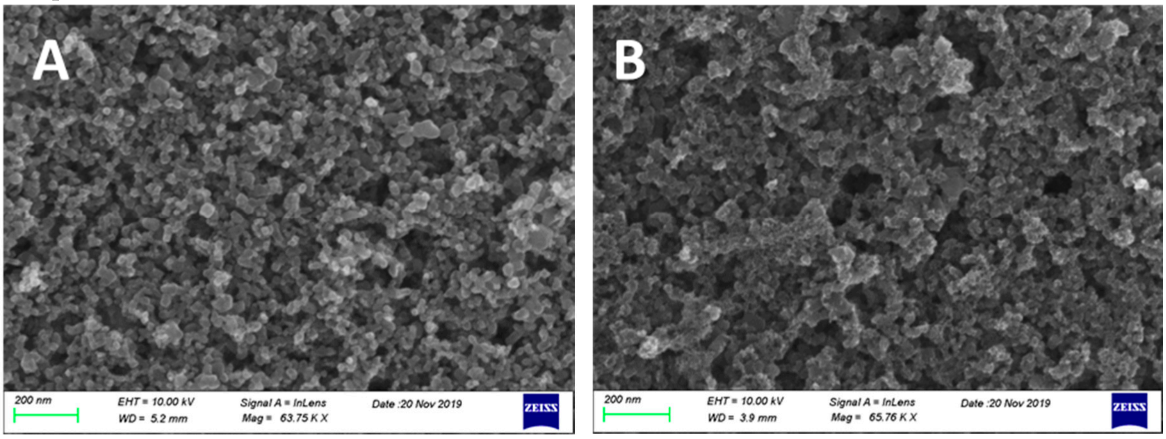

Figure 1. FESEM images of the TiO_2/FTO (A) and the CdS/TiO_2/FTO (B) film. Comparison of the two images reveals that CdS is formed within the mesostructure of titania and does not form a separate layer. The scale bar is 200 nm in both cases. Titania particle sizes ranged between 20 and 30 nm while CdS nanoparticles were smaller than 10 nm.

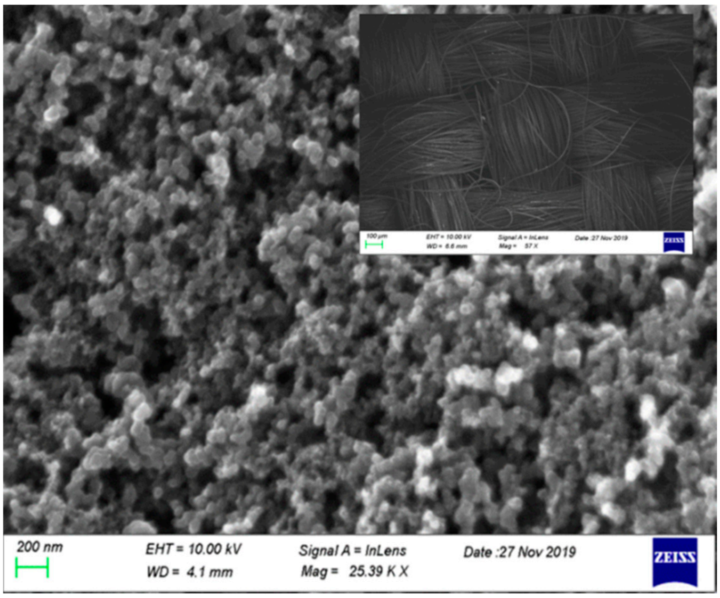

Figure 2. FESEM image of carbon nanoparticles loading the carbon cloth electrode. Insert: The structure of the carbon cloth.

Finally the following diagram shows the diffuse reflectance absorption spectrum of the TiO_2/FTO and the CdS/TiO_2/FTO film.

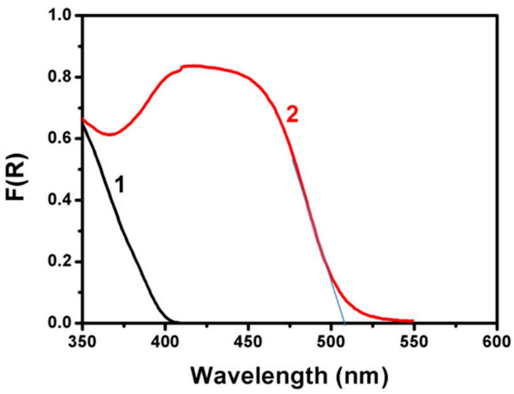

Figure 3. Diffuse reflectance absorption spectrum of the TiO_2/FTO (1) and the CdS/TiO_2/FTO film (2).

EDX data

EDX spectra were recorded in order to study the composition of the presently used activated carbon in contrast with carbon black.

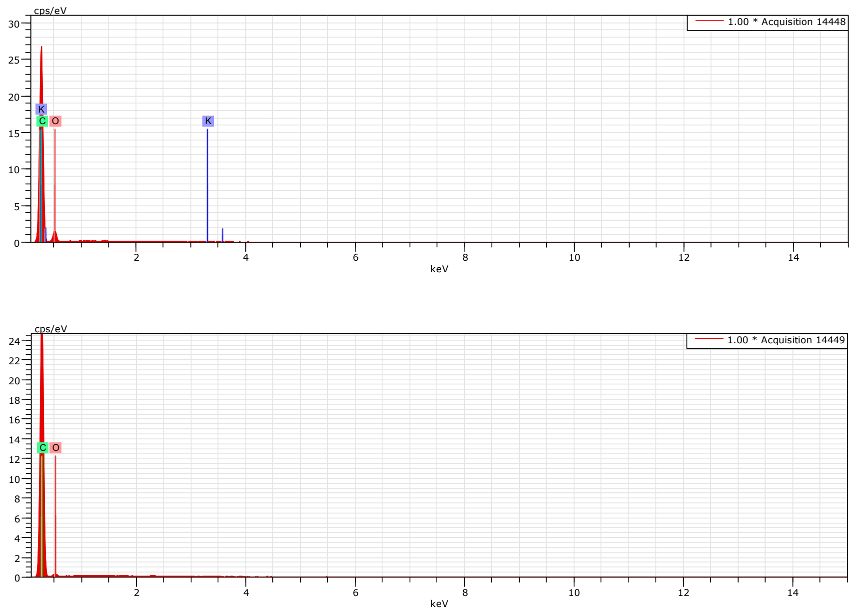

Figure 4. EDX spectra of activated carbon (upper spectrum) and carbon black (lower spectrum).

Table 1. Elemental composition of the materials used to make the supercapacitor electrode**.**

Material	Element	Atomic percentage (%)	Error (%)
Activated Carbon	C	74.6	22.4
-//-	O	25.2	10.1
-//-	K	0.2	0.1
Carbon Black	C	89.7	26.7
-//-	O	10.3	4.9

References

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