Studies of $Bi_2S_3$ Nanoparticles on Planar Tin Oxide

J.P.Waggett and D.J.Riley
University of Bristol
School of Chemistry
Bristol, BS8 1TS, UK

Nanocrystalline semiconductors[1] exhibit a wide range of physical and chemical properties that are finding application in devices such as solar cells[2], supercapacitors[3], photocatalytic coatings[4] and electrochromic windows[5]. If the particles are sufficiently small, the electronic bands split into discrete energy levels as the electrons become quantum confined. Thus, as particle size decreases, an increase in band gap is observed. This leads to the possibility of replacing the dye used in the nanocrystalline $TiO_2$ solar cell pioneered by O'Regan and Grätzel[6] with semiconductor nanoparticles. Previous work on CdS nanoparticles by Peter, Riley, Tull and Wijayantha[7] demonstrated proof of concept. In order to optimise sunlight absorption, the material used to sensitise the cell should have a band gap of around 1.4 eV. Bismuth sulfide is a possible candidate as a sensitiser as it has a bulk indirect bandgap of 0.4 eV and a bulk direct band gap of 1.3 eV. This paper will investigate the possibility of preparing $Bi_2S_3$ nanoparticles using the same strategy used by Peter, Riley, Tull and Wijayantha in CdS nanoparticle preparation outlined in Fig.1. This method allows the particles to be grown directly on the electrode surface. In this work the nanoparticles are attached to a flat $SnO_2$ electrode. The photoelectrochemical properties of the $Bi_2S_3$ particles are also studied.

A JEOL 2010 TEM, operating at 200kV was used to find the size distribution and crystal structure of the nanoparticles. A representative TEM image is shown in Fig.2. All electrochemical experiments were measured at –0.2 V vs. Ag|AgCl|3 M KCl in 1 M aqueous $Na_2SO_3$ solution. Monochromatic light and a lock-in amplifier were used to record the photocurrent spectra of the $Bi_2S_3$ coated electrodes. The photocurrent was converted to incident photon to current efficiency (IPCE). The IPCE spectra of large and small $Bi_2S_3$ nanoparticles are shown in Fig.3. The bandgaps of the particles are 1.50 eV for the large particles and 1.86 eV for the small particles. Clearly indicating that size selection for $Bi_2S_3$ nanoparticles is possible.

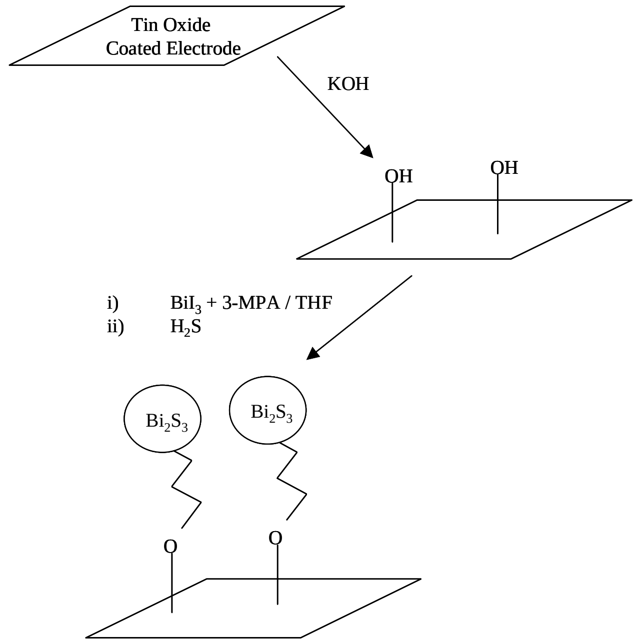


Fig.1 Strategy of preparation of $Bi_2S_3$ nanoparticles

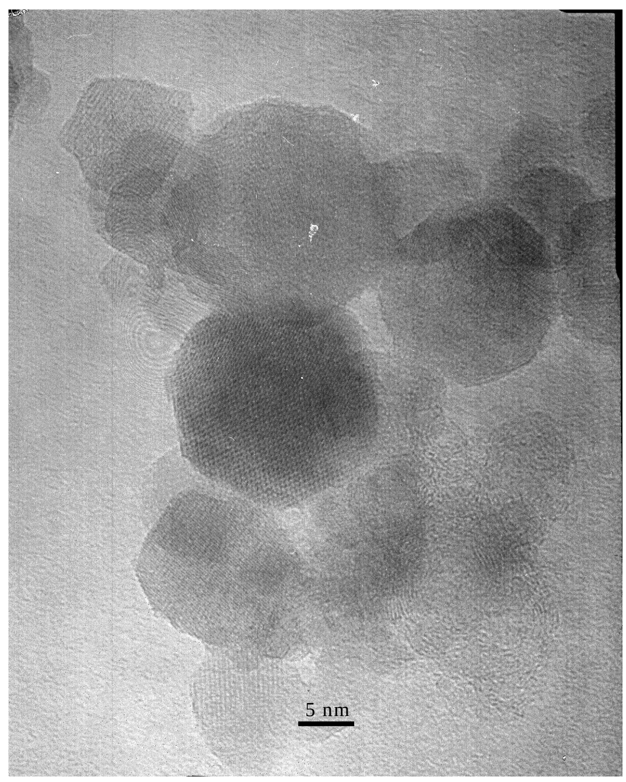


Fig.2 TEM image of large $Bi_2S_3$ nanoparticles.

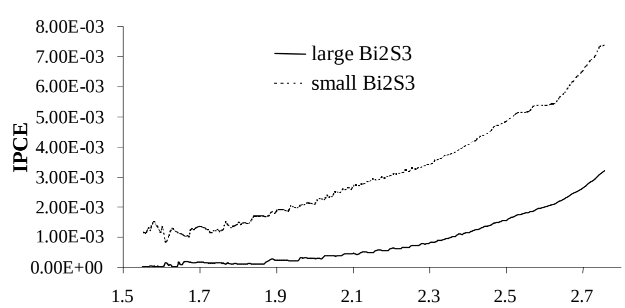


Fig.3 IPCE spectra of $Bi_2S_3$ nanoparticle modified electrodes prepared using a) 0 mol $dm^{-3}$ and b) $5*10^{-4}$ mol $dm^{-3}$ of 3-MPA.

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