Dye assessment in nanostructured TiO_2 sensitized films by microprobe techniques

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Dye sensitized solar cells (DSCs) have received considerable attention once this technology offers economic and environmental advantages over conventional photovoltaic (PV) devices. The PV performance of a DSC relies on the characteristics of its photoanode, which typically consists of a nanocrystalline porous TiO_2 film, enabled with a large adsorptive surface area. Dye molecules that capture photons from light during device operation are attached to the film nanoparticles. The effective loading of the dye in the TiO_2 electrode is of utmost importance for controlling and optimizing solar cell parameters. Relatively few methods are known today for quantitative evaluation of the total dye adsorbed on the film. In this work, a new approach combining microprobe techniques namely, Ion Beam Analytical (IBA) techniques using a micro-ion beam (Rutherford Backscattering Spectrometry (RBS) and Particle Induced X-ray Emission (PIXE)) and Electron Probe Micro-Analysis (EPMA) was carried out to assess dye distribution and depth profile in TiO_2 films and the dye load based on Ru/Ti mass ratio.

Different 1D nanostructured TiO_2 films were prepared, morphologically characterised by SEM, sensitized and analysed by the referred techniques. Dye load evaluation in different TiO_2 films by three different techniques (PIXE, RBS and EPMA/ wavelength dispersive spectrometry (WDS)) provided similar results of Ru/Ti mass fraction ratio. Moreover, it was possible to assess dye surface distribution and its depth profile, by means of Ru signal, and to visualise the dye distribution in sample cross-section through X-ray mapping by EPMA/ energy dispersive spectrometry (EDS). PIXE maps of Ru and Ti indicated an homogeneous surface distribution. The assessment of ruthenium depth profile by RBS showed that some films have homogeneous Ru depth distribution while others present different Ru concentration in the top layer (2 µm thickness). These results are consistent with the EPMA/EDS maps obtained.

EPMA (WDS and EDS) together with IBA techniques proved to be powerful tools for functional materials characterisation and provided very promising results in the study of nanostructured TiO_2 sensitized films.

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