Nano-channeled, Porous TiO_2 Photoanode for High Electrolyte Accessibility Using Micro-fibrillated Cellulose as a Sacrificial Template in Dye-Sensitized Solar Cells

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Dye-sensitized solar cells (DSSCs) differ from traditional p-n junction photovoltaics in that the light absorption and charge transport steps occur separately. [1] This unique property makes the DSSC a cost-effective alternative since there is no requirement for high grade semiconductor material as in a silicon cell, and the materials used are environmentally friendly. What's more, DSSCs maintain good performance under standard conditions, and are stable during thermal changes.

But, the efficiency is still relatively low compared to the first and second generation solar cells. [2] The structural optimization of the photoanode is believed to offer opportunities for improvement in not only the adsorption quantity of dyes, transport of electrons, and diffusion of electrolytes but also the suppression of recombination.

A novel method of fabricating a nano-channeled porous titania photoanode has been developed by using micro-fibrillated cellulose as a template for formation of a sol-gel TiO_2 precursor to enhance the electrolyte penetration. The cellulose is homogenized and consists of microfibers with a 30nm-diameter and several microns in length uniformly suspended in either water or isopropanol, depending on the fabricating method. The cellulose fibers are silane-treated to manipulate the surface energy by reacting them with cellulose surface hydroxyls during the sol-gel reaction.

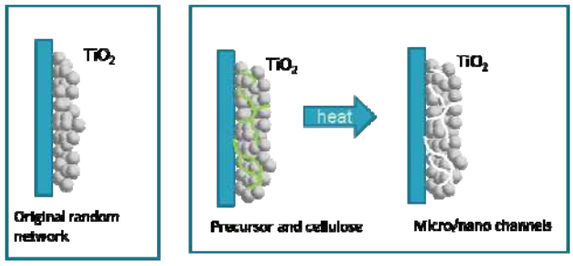

Figure 1. Sacrificial template method to fabricate micro/nano-channeled TiO_2 network as photoanode

In the non-aqueous environment, hydrolysis and condensation rates are greatly reduced and an ultra thin film around 500nm could be prepared on the ITO glass substrate. For the aqueous solution, a super-critically dried cellulose paper scaffold with nano pores is immersed into a liquid phase for deposition of the sol-gel titania precursor on its surface. In both cases, the cellulose is completely removed by decomposition as the assembly undergoes calcination to 450C resulting in the formation of the porous, channeled structure. Scanning electron microscopic images of focused ion beam sections confirm the ordered porous, channeled structure. Analysis with Raman spectroscopy, X-ray diffraction, and UV-Vis spectroscopy, verify the anatase phase and the surface properties of the photoanode. Performance of the titania phototanode and the influence of nano-channeled, porous structure on the current density, voltage and cell efficiency will be discussed.

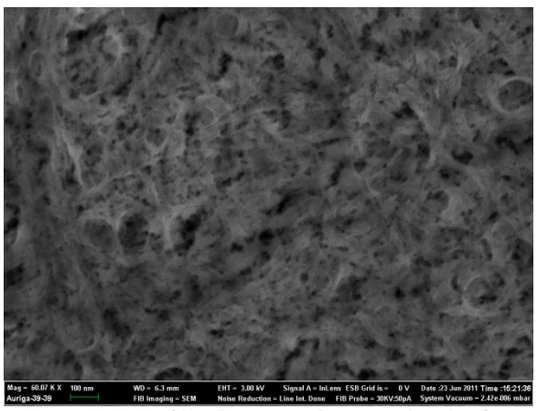

Figure 2. TiO_2 film drop casted on an Al stub after two-stage calcination

References

1. Oregan, B.; Gratzel, M., A Low-Cost, High-Efficiency Solar-Cell Based on Dye-Sensitized Colloidal Tio2 Films. *Nature* **1991,** *353* (6346), 737-740

2. Goncalves, L. M.; Bermudez, V. D.; Ribeiro, H. A.; Mendes, A. M., Dye-sensitized solar cells: A safe bet for the future. *Energ Environ Sci* **2008,** *1* (6), 655-667.