PREPARATION AND MICROSTRUCTURE OF TiO_2-NANOWIRE DISPERSED COMPOSITE ELECTRODE FOR DYE-SENSITIZED SOLAR CELLS

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TiO_2 powders are widely used for industrial applications, such as pigments, cosmetics, electronic devises, photocatalysts, catalyst supports, dye-sensitized solar cells, and so on. In order to improve various functions of TiO_2 powders, phase, size and morphology controlling have been extensively studied. Since the innovative work by Kasuga et al. in 1998-99 [1,2], TiO_2-derived one-dimensional (1-D) nanomaterials synthesized by the hydrothermal alkali treatment method, such as nanotubes, nanowires, and nanofibers, have attracted much attention because of their unique microstructure and promising energy-related applications. *e.g*., lithium ion batteries, hydrogen storage, and dye-sensitized solar cells (DSCs) [3-5].

Since O'Regan and Grätzel firstly reported DSCs using nanocrystalline porous TiO_2 electrode in 1991 [6], a variety of semiconductor electrode have been investigated. Targeting on preparing efficient electron transfer paths through the electrode of DSCs, porous film electrodes composed of various 1-D nanomaterials have been fabricated. Using 1-D TiO_2 nanomaterials (as well as hydrogen titanates, which transform into TiO_2 at high temperatures) is a straightforward way to realize the "electron expressway concept [3]" (Fig. 1). An example of TiO_2-nanowire dispersed composite electrode is shown in Fig. 2.

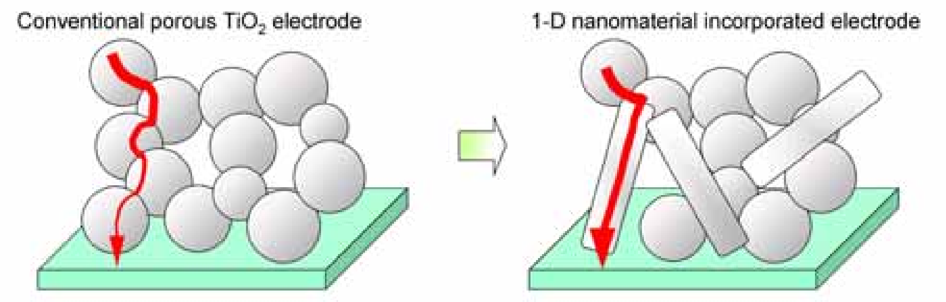

Fig. 1 "Electron expressway concept" by the incorporation of 1-D nanomaterials for DSC electrode. Arrow through particles means the electron transfer [3].

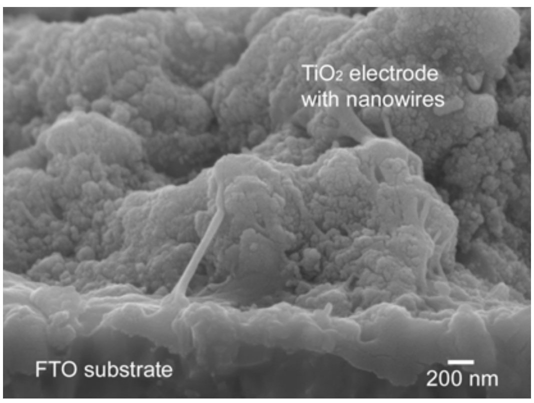

Fig. 2 An example of TiO_2-nanowire dispersed composite electrode prepared by a middle-stage (i.e., incomplete) hydrothermal treatment [3].

To harmonize the 1-D nanostructure and the high surface area of the electrode, we have attempted to fabricate partially nanowire-structured TiO_2, via a modified hydrothermal process, and to apply it for DSCs [3-5]. The idea is an analogy with "a road network system" where truck lines and narrow paths are combined for efficient mass transportation. To prepare the TiO_2 1-D nanomaterial/TiO_2 nanoparticle composite structure, several routes can be available:

(a) Simple mixing of pure 1-D nanomaterial and pure nanoparticles (similarly to the carbon nanotubes addition to TiO_2 powder in the literatures)
(b) Preparing 1-D nanomaterial/nanoparticle mixed (or composite) powder by using chemical fragmentation of 1-D nanomaterials in acid solution at low pH (pH ~ 0)
(c) Preparing 1-D nanomaterial/nanoparticle mixed (or composite) powder by using middle-stage (i.e., incomplete) hydrothermal treatment in rather short period
(d) Preparing nanowire/nanoparticle mixed (or composite) powder by using thermal fragmentation of thermally unstable 1-D nanomaterials (e.g., titania nanotubes), or *in situ* thermal fragmentation during the sintering process for DSC devices.

In this work, we report the preparation and microstructure of TiO_2-nanowire dispersed composite electrode for high-performance dye-sensitized solar cells in various preparation methods. Crystal structure, device structure and cell performances will be discussed in detail.

References:

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