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Construction of Hierarchically Structured TiO_2 Nanotube Arrays for Efficient Dye-Sensitized Solar Cells

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One-dimensional (1D) or quasi-1D nanostructures (i.e., nanowires, nanorods, nanotubes and nanofibers) are considered as alternative structures and have attracted great worldwide interest mainly because of their direct pathways for photogenerated electrons and smaller amounts of grain boundaries, which could efficiently enhance electron transport rate and then remarkably improve the charge collection efficiency. However, the efficiencies of 1D nanostructure-based DSSCs are still dissatisfactory on account of their insufficient surface area from the large diameter of 1D nanostructures and considerable free spaces between 1D nanostructures, leading to a poor dye adsorption capacity.

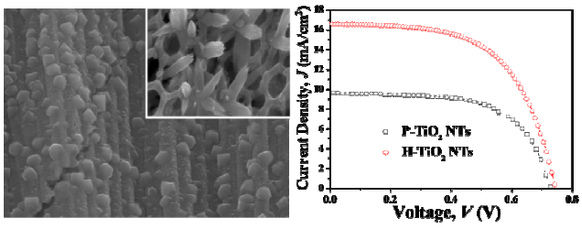

Fig.1 Hierarchical TiO_2 nanotube arrays grown on Ti foils were fine developed via a combination of electrochemical anodization and subsequent hydrothermal processing. Upon the DSSC application, such novel structure-based photoanodes exhibited superior performance compared to pure TiO_2 nanotube arrays.

In this study, hierarchical TiO_2 nanotube arrays composed of rutile nanocrystals on rough anatase nanotube walls and rutile flower-like layer on top were synthesized by capitalizing on hydrothermal processing. Such nanotubes were then exploited as the photoanode to produce DSSCs, exhibiting a highest efficiency of 7.24 %. The efficiency increase is mainly ascribed to the greatly enhanced surface area for higher dye loading and improved light harvesting from the efficient light scattering, and also due to the fast charge separation by providing heterojunctions between anatase and rutile phase. Such hydrothermal processing may be highly noticeable as a promising modification strategy to impart hierarchical structures on 1D semiconductor nanomaterials for use in DSSCs with markedly enhanced performance.