Structure control of hierarchial TiO_2 nanowire arrays for solid-state dye-sensitized solar cells

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We report a facile synthesis of highly dense, vertically aligned, and thornbush-like anatase TiO_2 nanowires (TBWs) on transparent conducting oxide glasses. The aspect ratio, length, and density of TBW arrays of 9 ㎛ in length are controllable and generated through a one-step hydrothermal reaction at 200°C over 11 h using potassium titanium oxide oxalate dehydrate, diethylene glycol (DEG), and water. TBW diameters gradually reduces from 600 (TBW600) to 400 (TBW400) to 200 nm (TBW200) and structures transform from nanoplates to nanorods as the content of DEG increases. TBWs are utilized as photoanodes for quasi-solidstate dye-sensitized solar cells (qssDSSCs) and solid-state DSSCs (ssDSSCs). The energy-conversion efficiency of qssDSSCs is in the order: TBW200 (5.2%)>TBW400 (4.5%)>TBW600 (3.4%) because of the different surface areas, light-scattering effects, and charge transport rates. TBW200 is further treated with a graft-copolymer-directed mesoporous TiO_2 to increase the surface area and interconnectivity of TBWs and reaches the maximum efficiency, *i.e.* 6.7% at 100 mW cm^{-2}.