Microsphere Assembly of TiO₂ with Tube-in-Tube Nanostructures: Anisotropic Etching and Photovoltaic Enhancement

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Figure S1. (A) A SEM image showing the overview of the TiO$_2$ microsphere (R) sample. (B) A SEM image of an individual TiO$_2$ microsphere. (C) A magnified SEM image showing the surface of the microsphere. (D) XRD patterns of the TiO$_2$ microsphere (R) sample.
Figure S2. (A-D) FESEM images emphasizing the tubular structures of the TiO$_2$ microsphere (T) sample. Blues dashed circles in (A, B, and C) indicate that the wall of these nanotubes also have tubular structures, the so-called tube-in-tube structures. (D) magnified images of the region in red dashed circle in (C).
Figure S3. (A, B, and C) TEM images of TiO$_2$ nanotubes. (D) A magnified TEM image of the same nanotube as shown in (C). Red dashed lines in all images illustrate the V-shaped spaces inside the nanotubes, while the arrows point to the open ends of the nanotubes.
Figure S4. Characteristic photocurrent-voltage (IV) curves of dye-sensitized solar cells assembled by using the TiO$_2$ nanorod as the middle layer of the sandwiched photoanode (DSSC-R).

We make an addition work that replaces the middle layer of tubular TiO$_2$ with TiO$_2$ nanorod and get a $J_{sc} = 13.64$ mA/cm$^2$, $V_{oc} = 0.74$ V, FF = 0.68 and $\eta = 6.86$ %. The conversion efficiency is lower than that of DSSC-2 using TiO$_2$ nanotube as sandwiched layer.