Electronic Supplementary Information

Tri-functional TiO_2 photoelectrode: single crystalline nanowires directly grown on nanoparticles for dye-sensitized solar cells

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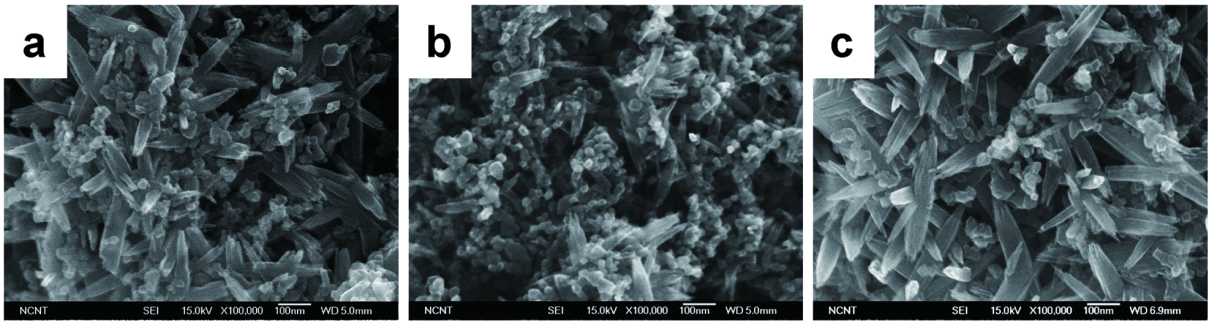

Figure S1. SEM images of the P25NW made by solvothermal treatment with P25 particles of 0.1 g (a**)** and 0.05 g (c), respectively. (b) P25NW of Figure S1a is sonicated.

Firstly, we have altered the precursor P25 content from 0.1 g to 0.05 g in order to see the nanowire-density-dependence on the cell performance [mark as P25NW (0.1 g) and P25NW (0.05 g)]. It was observed in Figures S1a and c that nanowire density was increased as the P25 content was decreased, which seemed to degrade overall surface area of the resultant film. Consequently, J_{sc} and corresponding η of P25NW (0.5 g) DSC was noticeably reduced

due to the increased portion of nanowires with lower surface area (Fig. S2 and Table S1).

As a next step, we have seperated P25 nanoparticles and nanowires by simple sonication method to prepare a crashed version of P25NW particles [mark as Sonicated P25NW (0.1 g) : Figure S1b]. It was shown in the *I-V* curves that both V_{oc} and fill factor was slightly degraded in sonicated sample, resulting in a small decrease in the cell efficiency. We think that this stems from the loss of intimate interconnection between the P25NW particles (Fig. S2 and Table S1).

In conclusion, nanowires directly grown on P25 nanoparticles are more beneficial in terms of the particle interconnection, and there can be an optimized condition for the nanowire-nanoparticle hybrid structure.

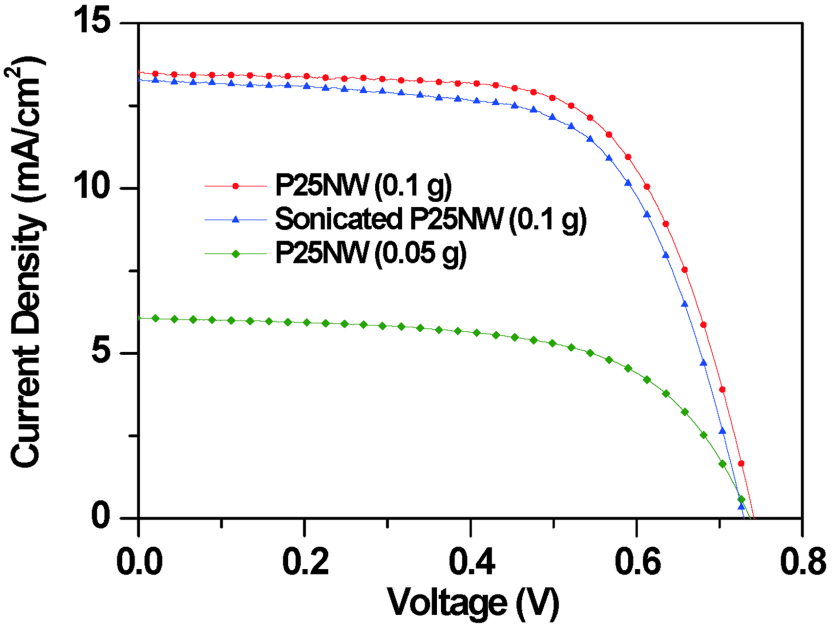

Figure S2. *J-V* characteristics of the P25NW (0.1 g), Sonicated P25NW (0.1 g), and P25NW (0.05 g) DSCs at the film thickness of 16.5 μm.

Table S1. Photovoltaic parameters of the P25NW (0.1 g), Sonicated P25NW (0.1 g), and P25NW (0.05 g) devices at the film thickness of 16.5 μm.

	J_{sc} (mA/cm^2)	V_{oc} (mV)	FF (%)	η (%)
P25NW (0.1 g)	13.5	741.8	66.1	6.6
Sonicated P25NW (0.1 g)	13.3	729.1	64.5	6.2
P25NW (0.05 g)	6.1	736.8	61.1	2.7

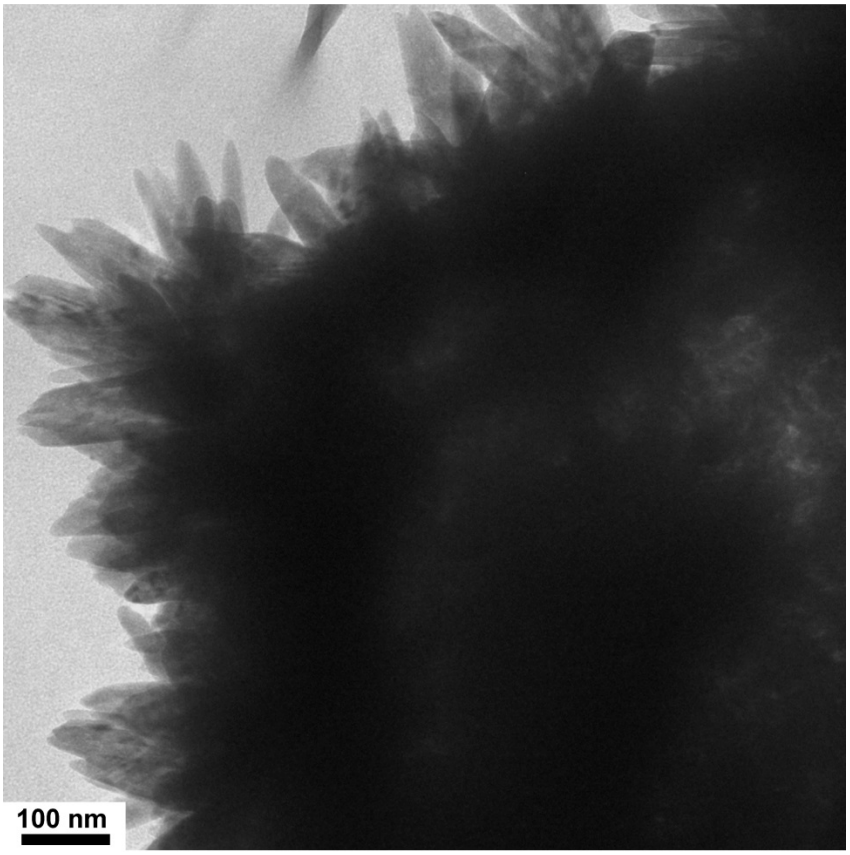

Figure S3. TEM image of the P25NW made by solvothermal treatment with P25 particles.