Supporting Information

Enhancing the device efficiency by filling the traps in photoanode

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Experimental Section

Dye sensitized solar cell fabrication

Commercial Fluorine-doped tin oxide glass (FTO) (TEC-15, 2.2 mm thickness, Solaronix) has been used as transparent conducting electrode, which is cleaned in an ultrasonic bath with detergent, acetone and iso- propyl alcohol (each step resulted for 20 min long). The FTO substrate were immersed into a 40 mM aqueous $TiCl_4$ solution at 70 °C for 30 min and washed with plenty of water and ethanol. later, FTO substrates were sintered at 500°C for 30 min. Subsquently, 7-8 μm thick layer of TiO_2 (Ti-Nanoxide T/SP, Solaronix) with an average particle size of 20 nm was deposited on top of FTO substrate. Then the TiO_2 coated FTO substrate were sintered by gradual heating under air flow at 325°C for 5 min, at 375°C for 5 min, at 450 °C for 15 min, and 500 °C for 15 min. Then, 3-4 μm thick scattering layer (particle size ~400 nm) were deposited over the 20 nm TiO_2 particles. Then, FTO substrate were sintered at gradually under air flow at 325°C for 5 min, at 375°C for 5 min, at 450 °C for 15 min, and 500 °C for 15 min. After that, TiO_2 coated substrate FTO plates were immersed into a 40 mM aqueous $TiCl_4$ solution at 70°C for 30 min and washed with copious amount of water and ethanol, the FTO substrate were sintered at 500 °C for 30min. After cooling to 80 °C, TiO_2 coated FTO substrate were then immersed in a 0.5 mM of N719 dye in of Acetonitrile / t-butanol mixture (volume ratio: 1/1) for 22 h. After anchoring the dye, photoanodes were washed with Acetonitrile / t-butanol (volume ratio: 1/1) solution and dried by air flow. Finally, the electrolyte (AN-50,

Solarnix, Switzerland) solution was introduced into the space between sandwiched photo anodes and Pt coated FTO that was used as a counter electrode.

Hydrazine treatment (Trap filling)

TiO_2 coated FTO substrates were immersed into 100 ml DI water which contains 1.5 mL hydrazine solution. These photoanodes, namely $N_{10\text{-}70}$, $N_{20\text{-}70}$, $N_{30\text{-}70}$ and $N_{40\text{-}70}$, were treated at 70 °C at different time intervals such as 10, 20, 30 and 40 minutes respectively. Subsequently, the devices were heated for 30 more minutes at 70 °C to remove the excess of hydrazine from the photoanode. Furthermore, other set of photoanodes of $N_{10\text{-}70}$, $N_{20\text{-}70}$, $N_{30\text{-}70}$ and $N_{40\text{-}70}$ were sintered at 500°C for different time intervals such as 10, 20, 30 and 40 minutes and named as $N_{10\text{-}500}$, $N_{20\text{-}500}$, $N_{30\text{-}500}$ and $N_{40\text{-}500}$.

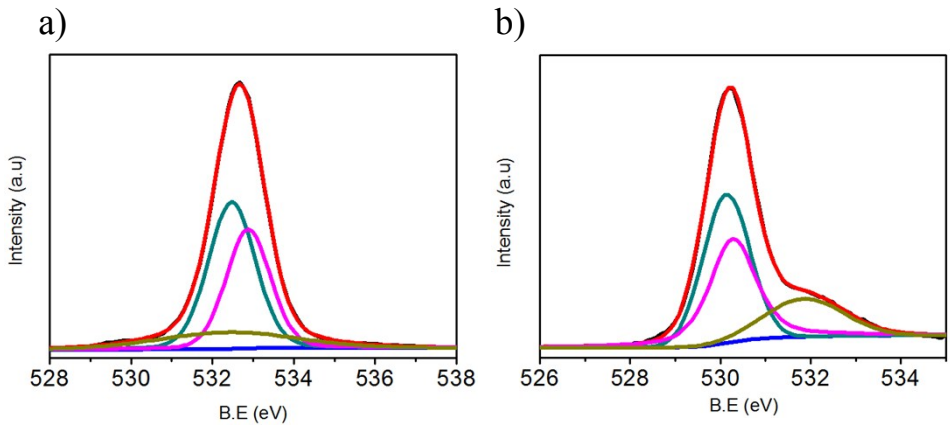

Figure S1. XPS spectra of a) $N_{0\text{-}0}$ and b) $N_{30\text{-}70}$ O 1s peak

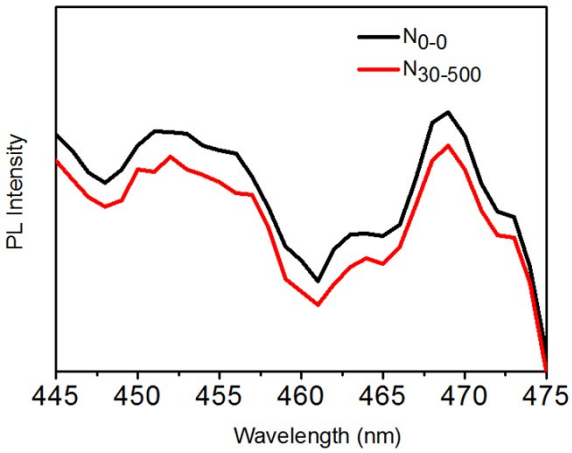

Figure S2. Photoluminescence (PL) curves of the $N_{0\text{-}0}$ and $N_{30\text{-}500}$

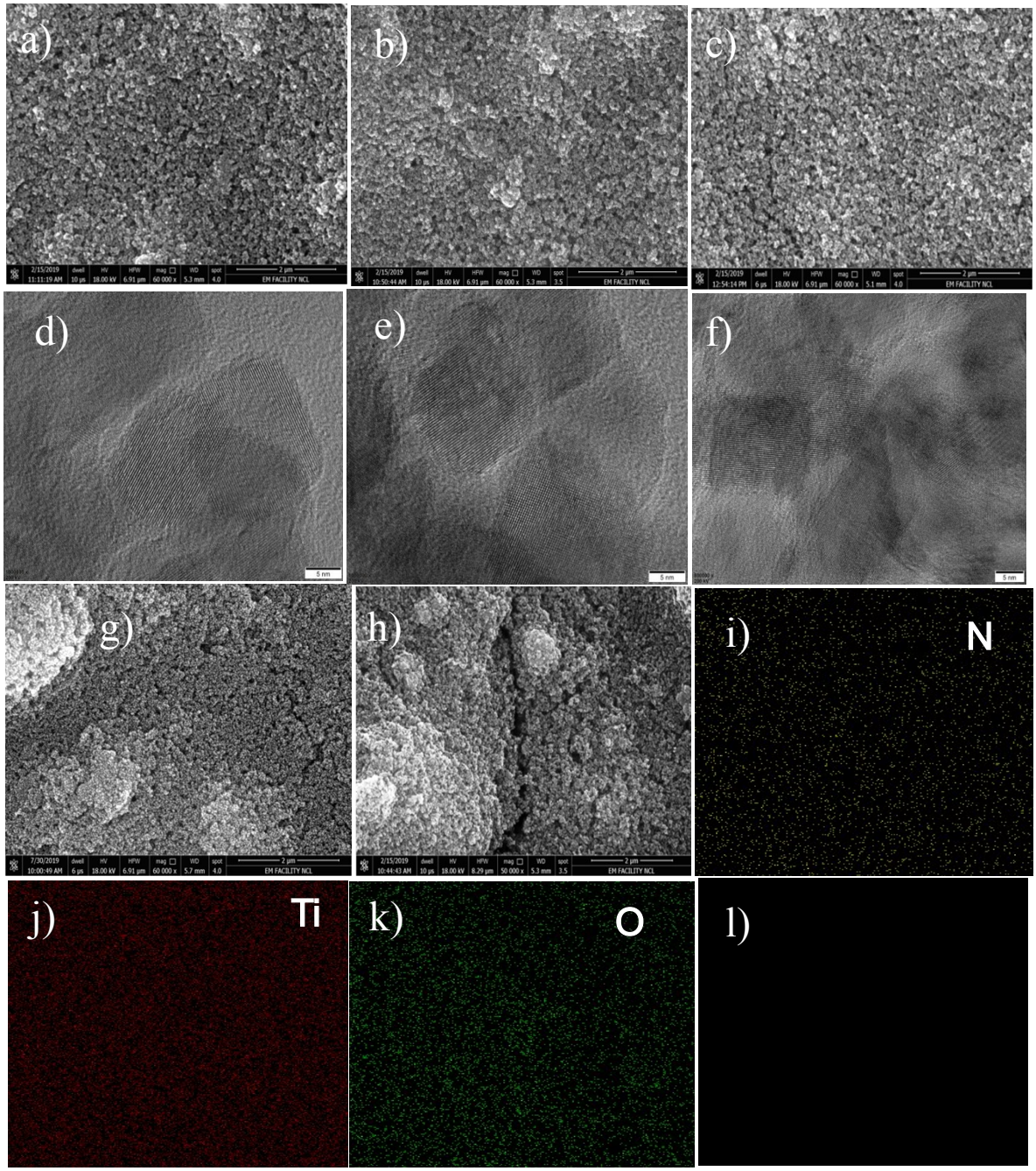

Figure S3. SEM top view image of a) $N_{0\text{-}0}$ b) $N_{30\text{-}70}$ c) $N_{30\text{-}500}$. HRTEM images of d) $N_{0\text{-}0}$ e) $N_{30\text{-}70}$ f) $N_{30\text{-}500}$. SEM images of g) $N_{40\text{-}70}$ h) $N_{40\text{-}500}$ and their elemental mapping results i) N (Yellow) j) Ti (Red) k) O (Green) l) Absence of N in $N_{0\text{-}0}$

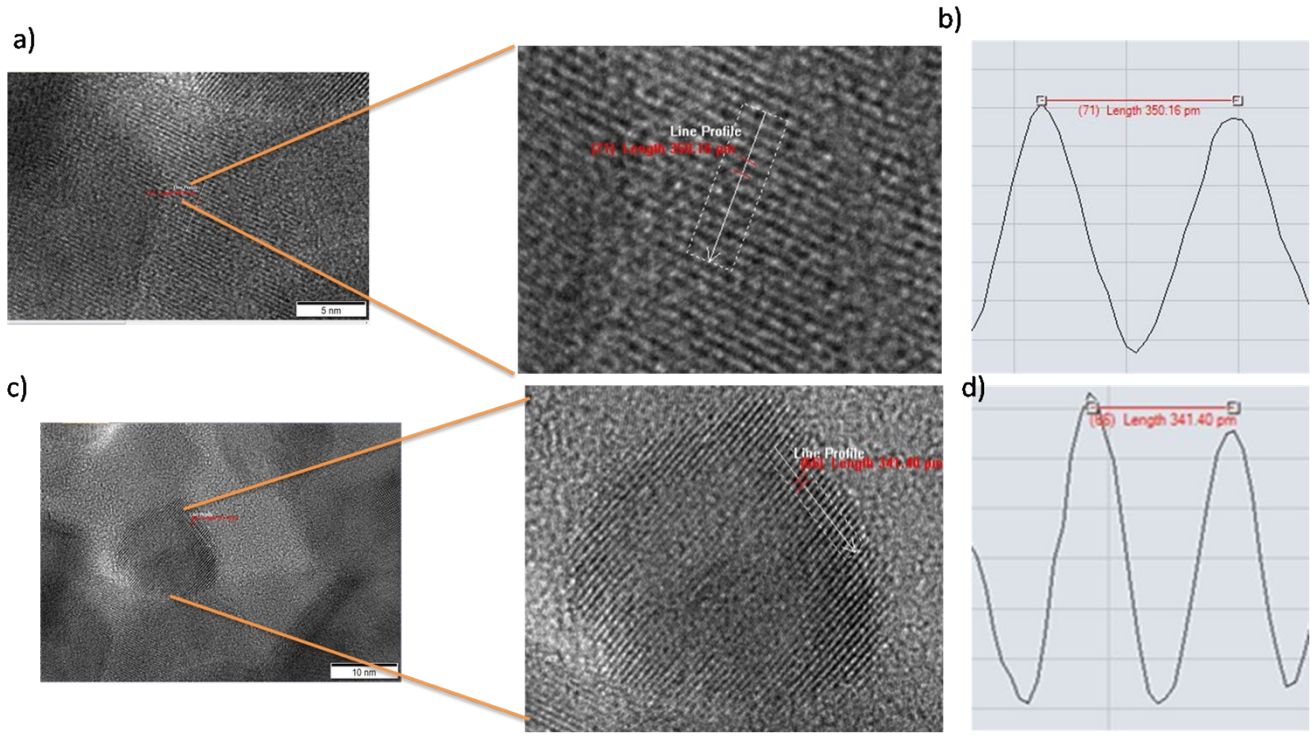

Figure S4. HRTEM images of $N_{0\text{-}0}$ (a) Interplanar space value of $N_{0\text{-}0}$ (b) HRTEM images of $N_{30\text{-}500}$(c) Interplanar space value of $N_{30\text{-}500}$ (d)

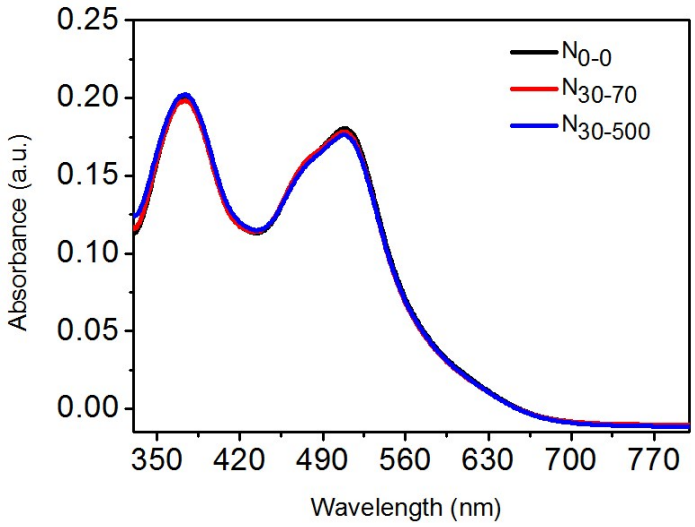

Figure S5. Dye desorption study of $N_{0\text{-}0}$, $N_{30\text{-}70}$ and $N_{30\text{-}500}$

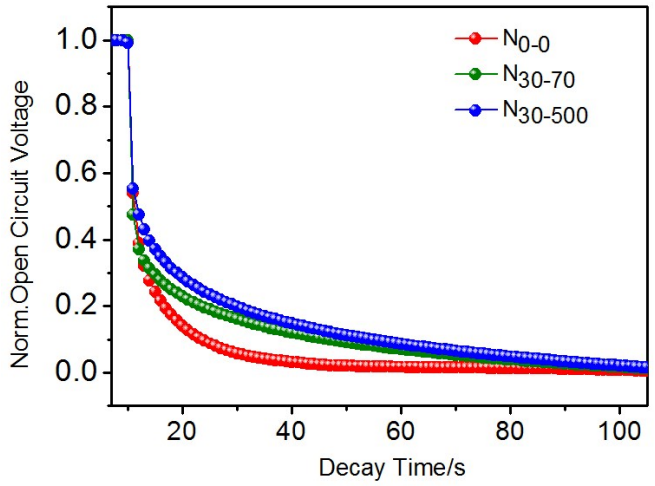

Figure S6. Open-circuit voltage-decay (OCVD) of $N_{0\text{-}0}$, $N_{30\text{-}70}$ and $N_{30\text{-}500}$

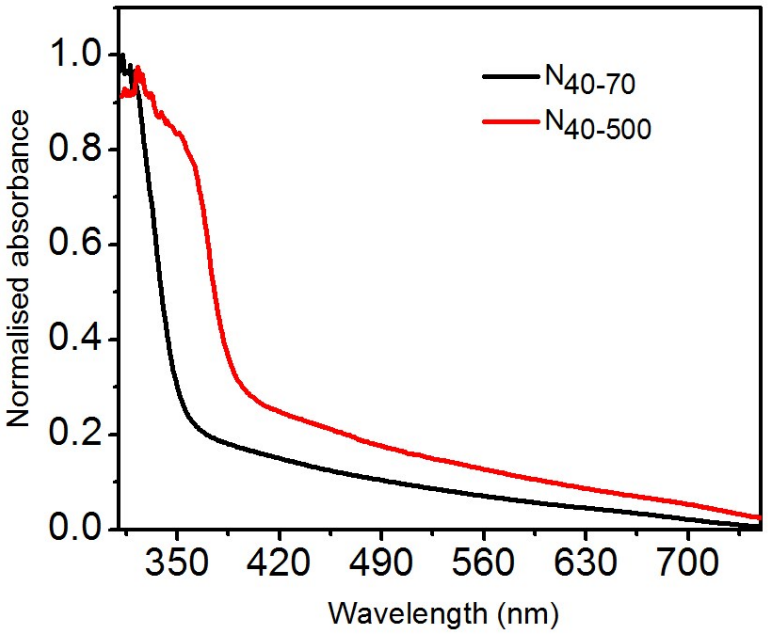

Figure S7. UV-vis spectra of $N_{40\text{-}70}$ and $N_{40\text{-}500}$

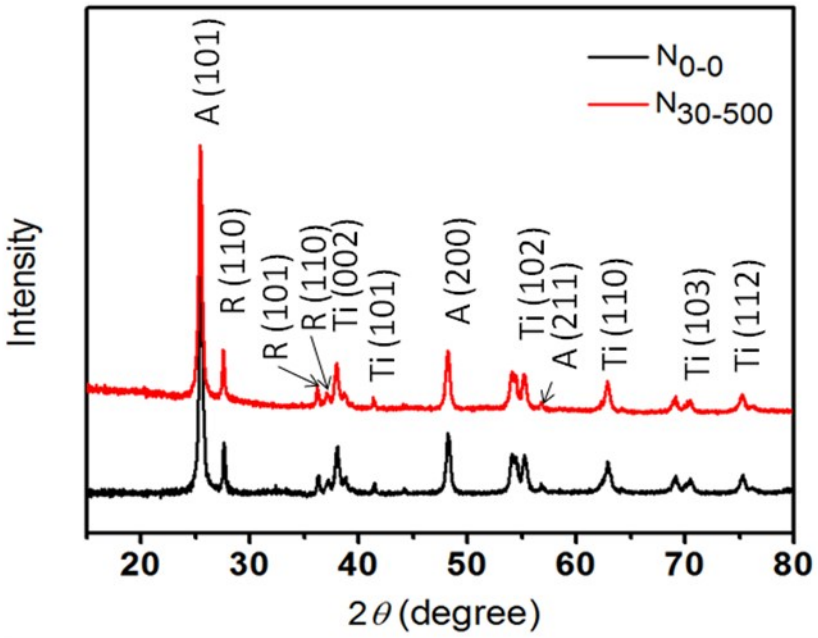

Figure S8. XRD patterns of $N_{0\text{-}0}$ and $N_{30\text{-}500}$

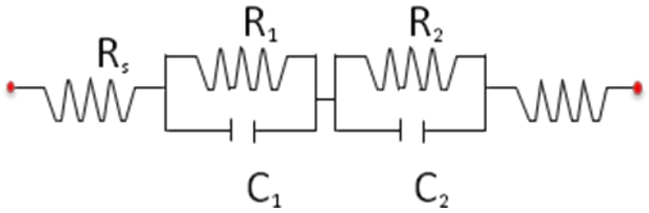

Figure S9. Equivalent circuit used to fit EIS curves

Table S1. Photovoltaic parameters of DSSCs with $N_{0\text{-}0}$, $N_{30\text{-}70}$ and $N_{30\text{-}500}$ measured under 1 sun illumination condition (AM 1.5 G,100 mW cm^{-2}). Active area of the DSSCs (18.75 cm^2).

Sample	V_{oc} (V)	J_{sc} (mA cm^{-2})	$^{INT}J_{sc}$ (mA cm^{-2})	*FF* (%)	η (%)
$N_{0\text{-}0}$	0.705 ± 0.003	12.52±0.11	10.1	62.1 ± 0.1	5.48± 0.15
$N_{30\text{-}70}$	0.721 ± 0.002	13.31±0.12	11.3	71.0 ± 0.2	6.81 ± 0.16
$N_{30\text{-}500}$	0.737 ± 0.002	14.77±0.14	13.2	73.0 ± 0.2	7.94± 0.13

Table S2. EIS Parameters of $N_{0\text{-}0}$ and hydrazine treated TiO_2 based large area (18.75 cm^2) DSSCs at an applied voltage of 0.5 V in the dark condition.

Sample	R_{rec} (Ω)	C_μ (F/cm^2)	τ (ms)
$N_{0\text{-}0}$	9	1.2×10^{-4}	1.1
$N_{30\text{-}70}$	12	1.11×10^{-3}	13.2
$N_{30\text{-}500}$	20	1.6×10^{-3}	32