

Supporting information

Self-doped Carbon Dots Decorated TiO₂ Nanorods: A Novel Synthesis Route for Enhanced Photoelectrochemical Water Splitting

1.1.Characterizations:

The morphology and composition of TiO₂ and TiO₂@NCD4h were studied by field-emission scanning electron microscope (FESEM, S4800 Hitachi, Japan) and field-emission transmission electron microscopy (FETEM, Tecnai G2 F20, USA) with energy dispersive spectrometer (EDS). Absorption spectra were recorded with Cary 5000 UV-Vis-NIR spectrophotometer (Agilent, USA). The crystalline structures were acquired by X-ray diffraction (XRD; X'pert PRO MPD diffractometer, Netherlands) with a PANalytical X'celerator detector, using Cu K α ($\lambda = 0.15406$ nm) source. X-ray photoelectron Spectroscopy (XPS) was performed to investigate the surface elemental compositions and chemical states by a PHI 5600 spectrometer (USA) with a monochromatic Al K α X-ray source. Raman spectra were collected from XploRA PLUS Raman microscope (Horiba Jobin Yvon, UK.)

PEC Experiment setup

PEC tests were performed with an electrochemical workstation, Zive SP1 (WonATech Co., Ltd., Korea) using a three-electrode system with an as-prepared photoanode, a platinum mesh and a 3 M KCl Ag/AgCl electrode in a Luggin capillary as the working electrode, counter electrode and the reference electrode, respectively. The reactor used during the PEC test and other electrochemical measurements was a 50 mm x 50 mm x 20 mm quartz cell (Hellma, HE.700.000.OG20.) The electrolyte was 0.3 M Na₂SO₄ (pH = 7). The linear sweep voltammetry (LSV) curves window from - 0.5 V to 1.3 V vs Ag/AgCl with scan rate of 20 mV s⁻¹. I-t curves were obtained at a bias potential of 1.23 V vs Ag/AgCl for 1 h. Electrochemical impedance spectroscopy (EIS) was carried out under the frequency range of 10⁻² - 10⁵ Hz with amplitude of 5 mV at bias potential of 0 V vs Ag/AgCl under a solar simulator (AM 1.5 G, 100 mW/cm²) irradiation. Mott-Schottky plots were measured with a frequency of 1 kHz under dark. The incident photon-to-current conversion efficiency (IPCE) was carried out at 1.23 V vs Ag/AgCl using a

xenon arc lamp (75 W, Ushio UXL-75XE) filtered by a dual-grating monochromator and individual filters onto the test devices.

2. Result and discussion

$$(Ah\nu)^2 = A (h\nu - E_g) \quad (S1)$$

Where a , h , ν , A and E_g means the absorbance index, Planck constant, frequency, constant and the band gap respectively.

where C represents space charge capacitance, e fundamental electron charge ($1.6 \times 10^{-19}\text{C}$); ϵ semiconductor relative permittivity of the (35 for TiO_2); ϵ_0 permittivity of vacuum (8.86×10^{-12} F/m); N_D carrier density; V applied potential, K_B Boltzmann constant and T is the absolute temperature.

$$\frac{1}{C^2} = \left(\frac{2}{e\epsilon\epsilon_0 N_D} \right) \left[V - V_{FB} - \frac{K_B T}{e} \right] \quad (S2)$$

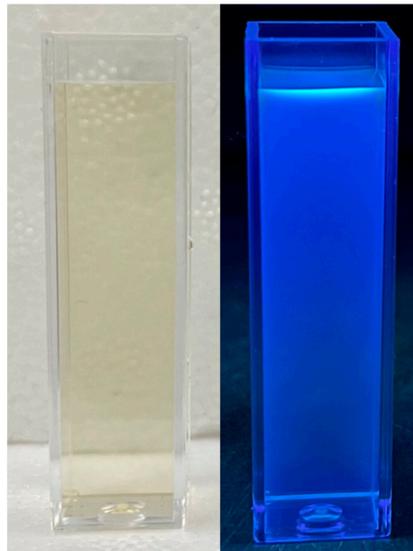


Figure S1. Imagies of NCDs' solution under natural and UV light

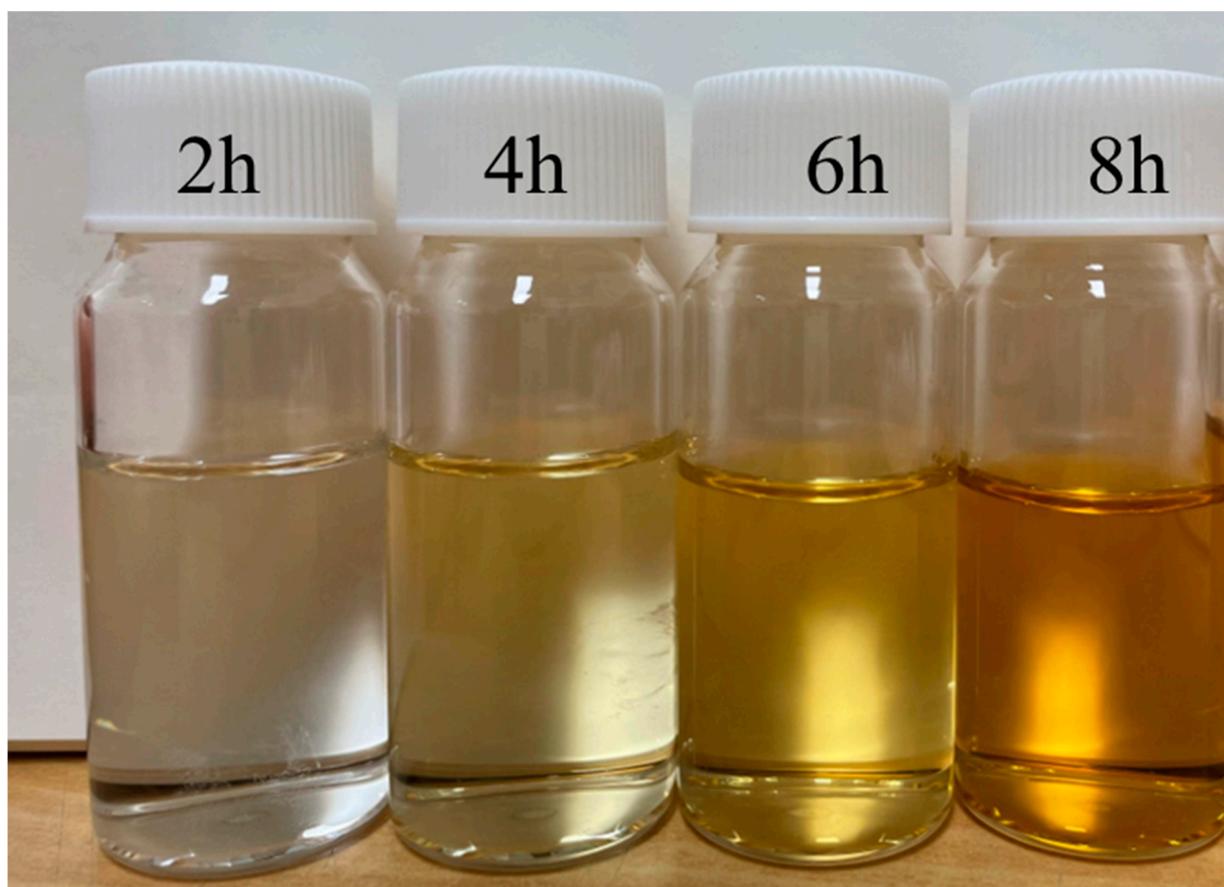


Figure S2. NCDs solution based on the reaction time

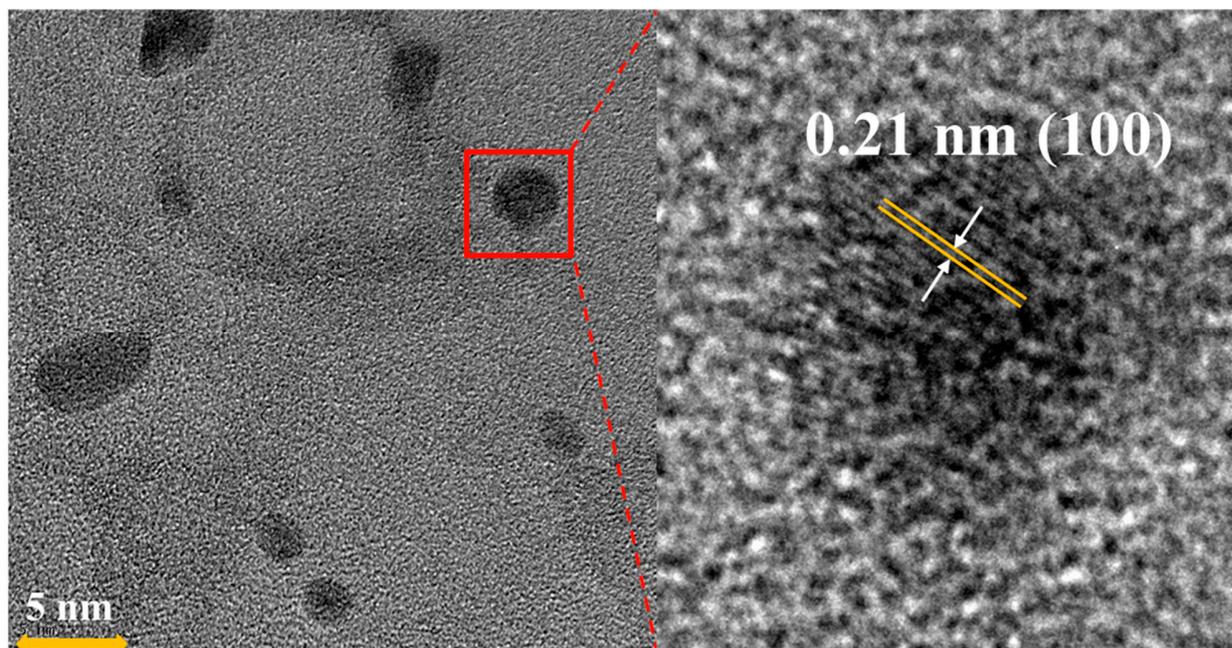


Figure S3. TEM of NCD

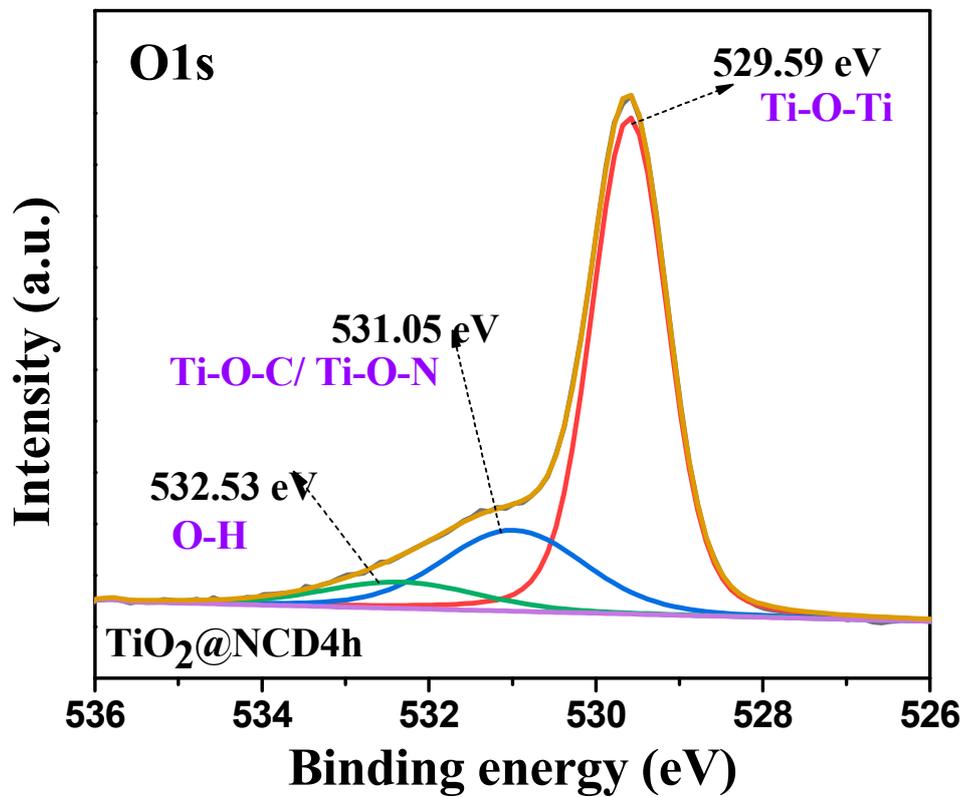


Figure S4. XPS O 1s spectra of TiO₂@NCDs4h

Table. S1. EIS Data of TiO₂ and NCD decorated TiO₂ photoanodes \

Photoanode	R _s (Ohm)	R _{ct} (Ohm)
TiO ₂	75	376
TiO ₂ @NCDs2h	50.4	273.6
TiO ₂ @NCDs4h	50.8	248.3
TiO ₂ @NCDs6h	60	277.2
TiO ₂ @NCDs8h	76.6	297.4

Table S2. The photocurrent densities of the TiO₂ and TiO₂@NCDs photoanodes

Photoanode	Photocurrent Density (mA.cm⁻²) at 1.23 V vs Ag/AgCl
TiO ₂	0.73
TiO ₂ @NCD2h	2.33
TiO ₂ @NCD4h	2.51
TiO ₂ @NCD6h	1.99
TiO ₂ @NCD8h	1.85