Supporting Information

Uniform carbon dots@TiO$_2$ nanotube arrays with full spectrum wavelength light activation for efficient dye degradation and overall water splitting

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Figure S1. (a) DLS histogram of CDs. (b) A representative AFM topography image of CDs on mica (with a height profile plot along the line).
Figure S2. (a) C1s XPS spectra of graphite and CDs where the 284.8 eV peak is assigned to C-C is double bonds. (b) Raman spectra ($\lambda_{ex}=633$ nm) of graphite and CDs. Three prominent peaks at 1345, 1570 and 2685 cm$^{-1}$ corresponding to the graphite’s D, G and 2D peaks, respectively, and D and G peaks of CDs are located at 1355 and 1600 cm$^{-1}$. (c) FTIR spectra of graphite and CDs. For graphite, three absorption peaks corresponding to the stretching of the hydroxyl group (3466 cm$^{-1}$), C=C skeletal vibrations bands (1633 cm$^{-1}$) and C-O stretching vibrations (1399 cm$^{-1}$), while for CDs, many strong absorption peaks corresponding to the stretching of the hydroxyl group (3443 cm$^{-1}$), C=O groups in the carbonyl and carboxyl moieties (1724 cm$^{-1}$), C=C skeletal vibrations bands (1420 cm$^{-1}$), C-O stretching vibrations in the epoxy groups (1244 cm$^{-1}$, 1073 cm$^{-1}$). (d) XRD patterns of graphite and CDs.
Figure S3. Top-view (a, c, e, g) and side-view (b, d, f, h) SEM images of CDs/TiO$_2$ NTAs with an electrochemical deposition time of 5, 10, 30 and 40 min, respectively.
Figure S4. FTIR spectra of TiO$_2$ NTAs (a), CDs/TiO$_2$ NTAs with an electrochemical deposition time of 5 (b), 10 (c), 20 (d), 30 (e) and 40 min (f), and CDs (g).

Figure S5. XRD spectra of TiO$_2$ NTAs (a), CDs/TiO$_2$ NTAs with an electrochemical deposition time of 5 (b), 10 (c), 20 (d), 30 (e) and 40 min (f).
Figure S6. Raman spectra of TiO$_2$ NTAs and CDs/TiO$_2$ NTAs with different deposition time of 5, 10, 20, 30 and 40 min.

Figure S7. The time-resolved photoluminescence (TRPL) decay profiles for TiO$_2$ NTAs and CDs/TiO$_2$ NTAs with different deposition time of 5, 10, 20, 30 and 40 min.
Figure S8. Photocurrent densities versus time curves (a) and EIS Nyquist plots (b) of the pristine TiO$_2$ NTAs and CDs/TiO$_2$ NTAs with deposition time of 20 min in 0.1 M Na$_2$SO$_4$ solution under UV ($\lambda < 420$ nm) and visible light ($\lambda > 420$ nm) irradiation.

Table S1. Surface compositional analysis of TiO$_2$ NTAs and CDs/TiO$_2$ NTAs

<table>
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<tr>
<th>Samples</th>
<th>C 1s (Atom%)</th>
<th>O 1s (Atom%)</th>
<th>Ti 2p (Atom%)</th>
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<tbody>
<tr>
<td>TiO$_2$ NTAs</td>
<td>8.87</td>
<td>59.25</td>
<td>31.88</td>
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<tr>
<td>CDs/TiO$_2$ NTAs-5</td>
<td>10.52</td>
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<td>30.61</td>
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<td>57.36</td>
<td>29.03</td>
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<td>53.91</td>
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<td>CDs/TiO$_2$ NTAs-30</td>
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<td>50.54</td>
<td>27.01</td>
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<td>CDs/TiO$_2$ NTAs-40</td>
<td>25.67</td>
<td>48.26</td>
<td>26.07</td>
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Table S2. Kinetic parameters of emission decay analysis of TiO$_2$ NTAs and CDs/TiO$_2$ NTAs deduced from double exponential fits

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<tr>
<th>Sample</th>
<th>$A_1$ (%)</th>
<th>$\tau_1$ (ns)</th>
<th>$A_2$ (%)</th>
<th>$\tau_2$ (ns)</th>
<th>$\tau_{\text{average}}$ (ns)</th>
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<td>33.72</td>
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<td>CDs/TiO$_2$ NTAs-30</td>
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<td>CDs/TiO$_2$ NTAs-40</td>
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<td>44.61</td>
<td>67.33</td>
<td>26.83</td>
<td>34.77</td>
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Figure S9. The kinetic rates of photocatalytic degradation curves for RhB using TiO$_2$ NTAs and CDs/TiO$_2$ NTAs with different deposition time of 5, 10, 20, 30 and 40 min under the simulated solar light illumination (100 mW·cm$^{-2}$).

Figure S10. (a) Photocatalytic degradation curves for RhB and (b) corresponding kinetic rates by using TiO$_2$ NTAs and CDs/TiO$_2$ NTAs with a deposition time of 20 min as catalysts under different irradiation conditions. The UV and visible light denote $\lambda < 420$ nm and $\lambda > 420$ nm, whose power densities are measured to be 2.7 and 100 mW·cm$^{-2}$, respectively.
Figure S11. (a) Photocatalytic phenol degradation by self-degradation, using TiO$_2$ NTAs and CDs/TiO$_2$ NTAs with deposition time of 20 min, respectively. (b) Consecutive photocatalytic degradation of phenol using one CDs/TiO$_2$ NTAs with deposition time of 20 min sample 5 continuous cycles. (c) TOC removal efficiency during photocatalytic degradation using TiO$_2$ NTAs and CDs/TiO$_2$ NTAs with deposition time of 20 min, respectively. (d) TOC removal efficiencies of photocatalytic phenol degradation by using one sample for CDs/TiO$_2$ NTAs with a deposition time of 20 min for continuous 5 consecutive cycles under the same condition. $C_0$, $C_t$ is the initial concentration and concentration after a certain reaction time of phenol, respectively.