Supporting Information

Photomodulating Carbon Dots for Spatiotemporal Suppression of Alzheimer’s β-Amyloid Aggregation

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Figure S1. FT-IR spectrum of bare RCDs. The bands in the range 3390, 3160, 3050-2800 cm⁻¹ are assigned to stretching vibrations of O-H, N-H, and C-H bonds, respectively. The bands in the range 1690, 1640-1540, and 1425 cm⁻¹ are assigned to stretching vibrations of C=N and amide C=O, C-C, and aromatic C-N bonds, respectively.

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Figure S2. XPS elemental survey scan spectrum of RCDs and high-resolution deconvoluted spectra of C1s, N1s, and O1s.
**Figure S3.** Zeta potential of bare RCDs and Apta@CDs. After aptamer conjugation, the surface charge was negatively shifted from -26.0 to -35.1 mV. All samples were measured three times for analyses.

**Figure S4.** Optical properties of Apta@CDs. (a) Absorbance spectra of bare RCDs and Apta@CDs. (b) Photoluminescence of Apta@CDs under various excitation wavelengths from 590 to 630 nm. The spectra from Apta@CDs were analogous to those of bare RCDs. (b) The photograph of Apta@CDs under day light (up) and 365 nm UV light (down).
**Figure S5.** Dot-blot assay for examining Apta@CDs’ interaction with Aβ peptides (25 µM) that were pre-incubated for various times from 0 to 8 hours at 37 °C.

**Figure S6.** Singlet oxygen quantum yield calculation of Apta@CDs. (a) Left: Absorption spectra of Apta@CDs and methylene blue and the emission spectrum of 617 nm LED. Right: Equation for calculating the singlet oxygen quantum yield of Apta@CDs. (b) Photodegradation of DPBF in presence of Apta@CDs or MB. (c) Timescale decay curves of DPBF in presence of Apta@CDs or MB. Singlet oxygen generation assay of Apta@CDs was conducted under 617 nm LED irradiation.
Figure S7. EPR-based singlet oxygen measurements by TEMP. EPR (EMXplus, Bruker) spectra of Apta@CDs and 2,2,6,6-tetramethylpiperidine (TEMP) containing solutions were taken after two hours of incubation with (light) or without (dark) 617 nm LED irradiation at Western Seoul Center in KBSI with the following parameters: 9.64 GHz and 3 mW microwave frequency and power with 1G modulation amplitude; 3 scans of 48s sweep time at room temperature. 3 µL of TEMP was added into 100 µL of Apta@CDs solution (25 µg mL⁻¹). EPR spectrum of Apta@CDs in presence of TEMP was taken immediately after mixing and treated as background.

Figure S8. LED power evaluation with mouse brain tissues. (a) Schematic illustration for measuring the intensity of light passing through the mouse brain. (b) Penetration intensity of 617 nm LED (10 mW cm⁻¹) by the thickness of mouse brain.
**Figure S9.** Turbidity assay of Aβ aggregation with or without Apta@CDs under dark or light conditions. Turbidity was measured by the absorption at 405 nm of each Aβ solution (25 μM) using UV-Vis spectrophotometer. Background absorption of Aβ incubation buffer containing 25 μg mL⁻¹ Apta@CDs was subtracted for Apta@CDs-containing Aβ solutions.

**Figure S10.** Circular dichroism spectra of pristine Aβ peptides with or without light irradiation and Aβ peptides coincubated with Apta@CDs under varying light intensities from 0 to 10 mW cm⁻². (a) Circular dichroism spectra of pristine Aβ peptides under dark or light conditions. (b) Circular dichroism spectra of Aβ samples incubated with Apta@CDs (25 μg mL⁻¹) under various light intensities of 617 nm LED. All Aβ samples were incubated for 24 hours at 37 °C.
**Figure S11.** Circular dichroism spectra of Aβ peptides under dark or light conditions with different concentrations of Apta@CDs. (a) Aβ peptides treated by 12.5 µg mL⁻¹, and (b) 37.5 µg mL⁻¹ of Apta@CDs. (c) Circular dichroism spectra of Aβ peptides with different concentration of Apta@CDs under dark condition. (d) Circular dichroism spectra of Aβ peptides with different concentration of Apta@CDs after two-hour irradiation of 617 nm LED (10 mW cm⁻¹).
Figure S12. PC12 cell viability assay with various concentrations of Apta@CDs from 10 to 120 μg mL\(^{-1}\). Statistical analysis was carried out by means of one-way analysis of variance (ANOVA, n = 3, n.s: not significant).

Figure S13. Exemplary fluorescence images of a coronal brain section of 5xFAD mouse after ThS and bare RCDs staining ex vivo. Co-localizations of ThS-positive Aβ species and the bare RCDs are shown in the right merged image (magnified image in the yellow box).
Figure S14. Aβ plaque depositions of 5xFAD mice. (a) An exemplary ThS stained 5xFAD coronal brain section image without any treatments, scale bar: 1 mm. (b) Imaging analyses of ThS-positive Aβ aggregates. The brain section images were separated into half along the midline of the brain, and the regions of interest were selected along the upper cortex and hippocampus regions of the brain. The acquired Aβ plaque information along the “right side” region was normalized with the “left side” region to give "Relative %". For each brain, 3 images (within approximately -1.2 mm to -3.2 mm anterior/posterior direction from the bregma) were taken to give average Aβ plaque information of each brain. A total of 2 independent brains were analyzed to give the average and the standard deviations (error bars).