Supporting Information

Graphene quantum dots for detecting monomeric amyloid peptide

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Experiments

Materials and sample preparation: $A\beta_{1-42}$ peptide was obtained from Science Peptide Biological Technology Co. (Shanghai, China). The purity of the peptide (>98%) has been verified by high-performance liquid chromatography (HPLC) and mass spectrum analyses.

Synthesis of graphene quantum dots: GQDs were synthesized by incision of natural graphite with oxidation reactions. Graphite (1.0 g) was first mixed with concentrated sulfuric acid (100 mL) and $NaNO_3$ (43.0 g). The mixture was subsequently cooled to 0 ^oC. After that, $KMnO_4$ (3.0 g) was added slowly to keep the temperature under 20 ^oC with vigorous agitation. Then, the mixture was reacted under 40 ^oC (water bath) for about 60 min. The resultant was heated to 120 ^oC and stirred for another 16 h. After the reaction, it was cooled to room temperature and diluted with deionized water (500 mL). The pH value of the diluted solution was adjusted to 3 with Na_2CO_3 solution. The supernatant was filtered through a 0.22 μm microporous membrane to remove the big particles. Then the solution was centrifuged at 10,000 rpm for 30 minutes to further remove residual particles. Finally, the solution was dialyzed in a dialysis bag (cut-off molecular weight: 1000 Da) for 3 days. To measure the concentration of resulted GQDs solution, certain volume of GQDs solution was dried at 50 ^oC in vacuum and then the weight of solid GQDs was recorded. The concentration was calculated from the mass of the solid GQDs divided by the solution volume. According to the concentration and total volume of GQDs solution, the average mass of GQDs that obtained in different parallel experiments was calculated to be 600 mg. Thus, the yield of GQDs by this method is as high as 60 % (by weight, wt%).

Sample pre-treatment for Aβ peptide: $A\beta_{1-42}$ powder was dissolved in 1,1,1,3,3,3-hexafluoro-2-propanol (HFIP) at 1 mg/mL, and incubated at 37 ^oC for 6 hour. The HFIP acts as a hydrogen-bond breaker and is used for eliminating pre-existing structural heterogeneities in the Aβ. Then, $A\beta_{1-42}$ solution was separated into 100 μL

with sterile microcentrifuge tubes, stored at 4 ^{o}C as stock solution of $A\beta_{1-42}$ monomers.

Structure and property characterizations: Transmission electron microscopy (TEM) was performed on an FEI Tecnai 20 transmission electron microscope at acceleration voltage of 200 KV. Tapping mode atomic force microscopy (AFM) were performed on a Dimension 3100 system (Bruker Nano, USA) under ambient conditions using silicon cantilevers with nominal resonance frequency of 330 kHz and nominal spring constant 35 N/m. PL spectra were recorded on an F-4600 fluorescence spectrometer (Hitachi, Japan) at room temperature.

GQDs as probe: $A\beta_{1-42}$ monomer stock solutions were dried under nitrogen gas, dispersed by Milli-Q water containing 1% dimethyl sulphoxide (DMSO) as solubilizer and incubated at 37 ^{o}C. At set intervals, 100 μL of incubated $A\beta_{1-42}$ was taken out and added into black fluorescence 96-well plate for fibrillization analysis. After that, 100 μL GQDs (1.2 mg/mL) was introduced as the monitoring probe for fibrillization process, followed by fluorescence detection with excitation at 400 nm and emission at 500 nm.

ThT fluorescent measurement: 100 μL stock solution of $A\beta_{1-42}$ monomer was taken out and dried under nitrogen gas. Then, the dried samples were re-dissolved into Milli-Q 665 μL water with 10 μL DMSO. Thereafter, a certain amount of ThT solution was added to the mixture to reach the final concentrations of peptide and ThT at 50 μM and 10 μM respectively. All the tests were performed in black fluorescence 96-well plate and each sample was tested in 3 pores as repeated trials.

Characterizations

X-ray photoelectron spectroscopy (XPS) was performed on an ESCALab220i-XL electron spectrometer (VG Scientific Ltd., U.K.) with a high-performance Al

monochromatic source operated at 15 kV. X-ray diffraction (XRD) data were collected with a Philips X'Pert PRO X-ray diffraction instrument using monochromatic Cu Kα1 radiation (λ=1.5406) at 50 kV and 200 mA. The diffraction patterns were optimized with a step length of 0.02°(2θ) over an angular range 4-80°(2θ) with a scanning speed of 4°/min. Raman spectra of GQDs were measured by irradiating with laser light at 514 nm in a Renishaw in Via Raman spectrometer (Renishaw plc, U.K.). Fourier transform infrared (FTIR) spectroscopy was performed on a Perkin−Elmer FTIR spectrometer between 400 and 4000 cm^{-1}, pellet made by the mixture of samples and KBr were prepared for the test.

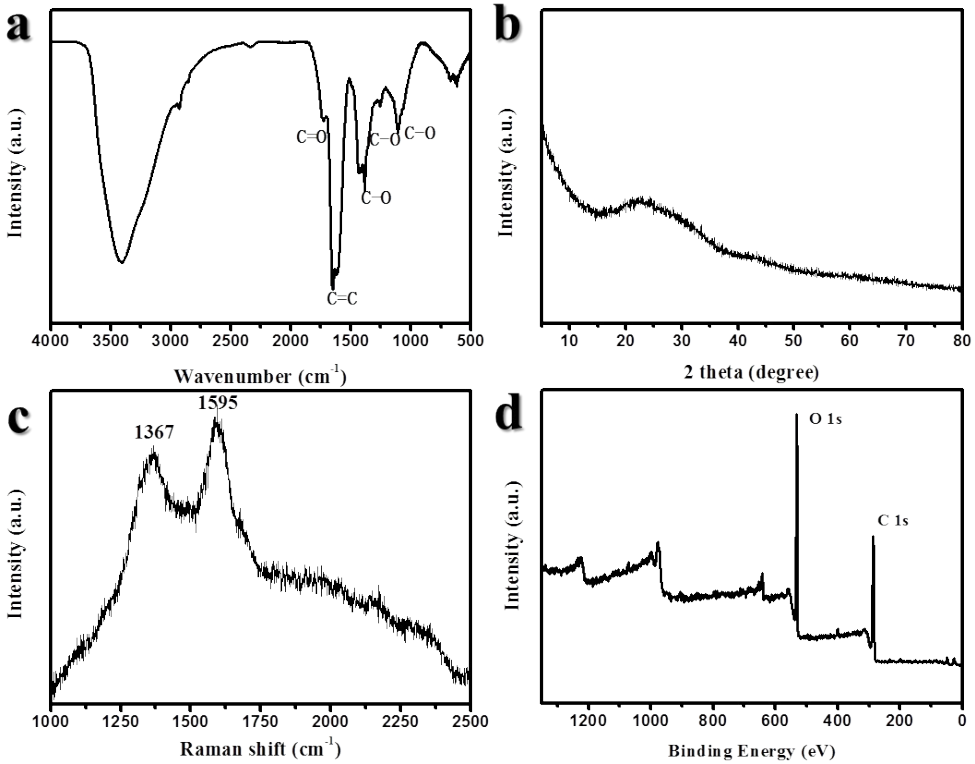

Figure S1. Spectral characterization of GQDs. (a) FT-IR, (b) XRD, (c) Raman, (d) XPS. FT-IR demonstrates that as-prepared GQDs contain plenty of oxygen containing functional groups. XRD shows typical peaks of GQDs at 23° which demonstrated the lamellar structure of synthesized GQDs. D and G peaks in Raman spectrum suggest that GQDs possess a similar structure with graphene oxide. XPS test indicate that the oxygen content of as-prepared GQDs is up to 34 at. %.

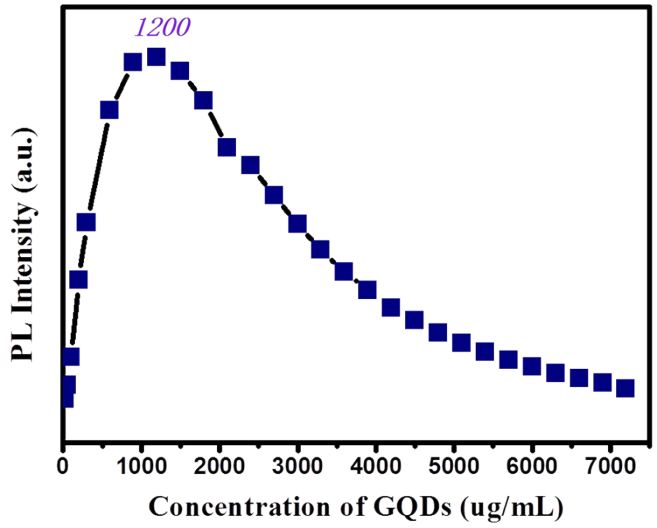

Figure S2. Concentration dependent PL spectrum of GQDs. The PL intensity of GQDs shows linear positive correlation with the concentration of GQDs below 1200 μg/mL. In contrast, the PL intensity of GQDs shows negative correlation with the concentration of GQDs above 1200 μg/mL.

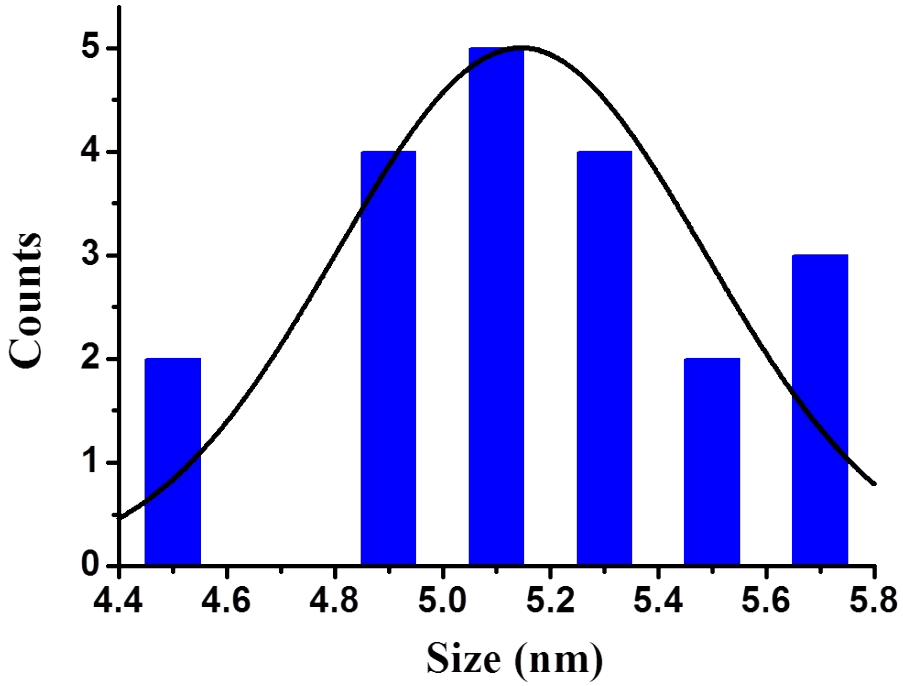

Figure S3. Size distribution of as-prepared GQDs obtained by measuring the TEM images of GQDs at high resolution. The range of the size distribution is between 4.4 nm and 5.8 nm with a peak at 5.1 nm.