Supplementary information

Ultrasmall Molybdenum Disulfide Quantum Dots Cage Alzheimer's Amyloid Beta to Restore Membrane Fluidity

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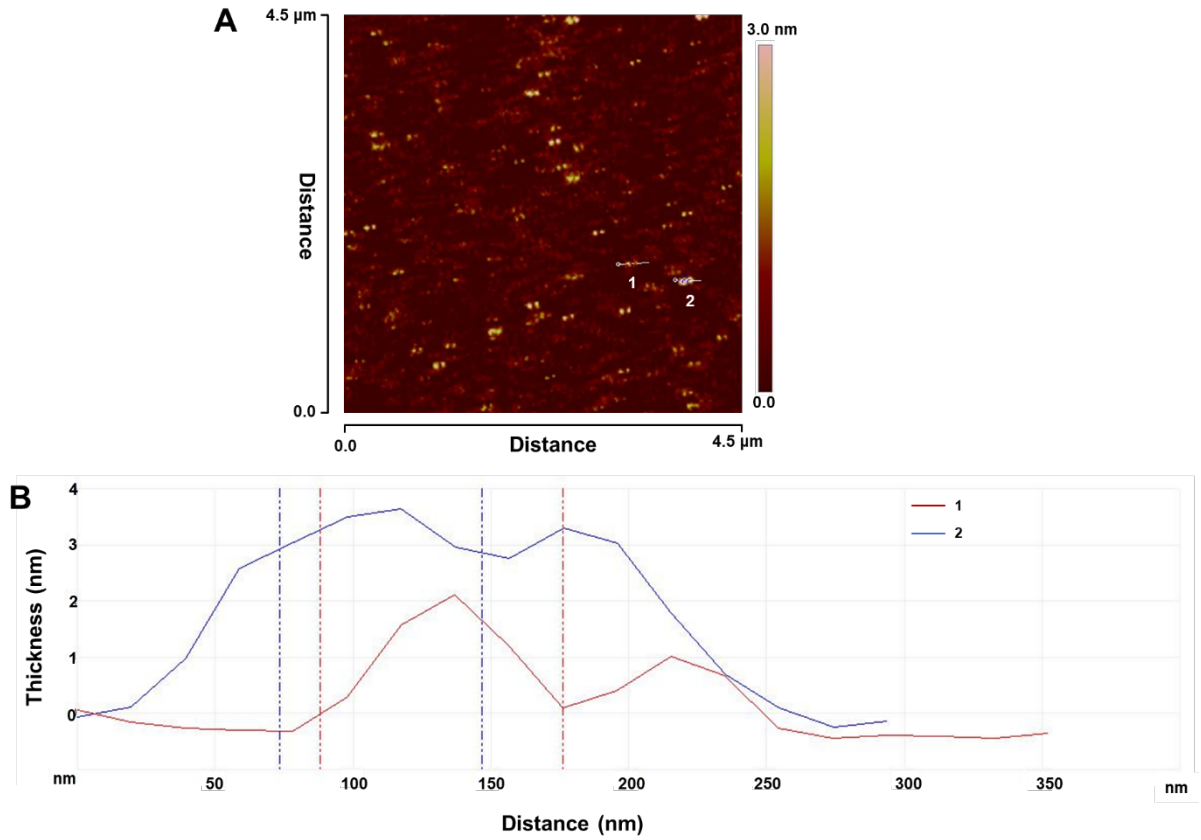

Figure S1. AFM measurement for the thickness of ultrasmall MoS_2 QDs. (A) AFM imaging of ultrasmall MoS_2 QDs. (B) Thickness analysis of ultrasmall MoS_2 QDs for cross-sections 1 and 2 selected from panel A.

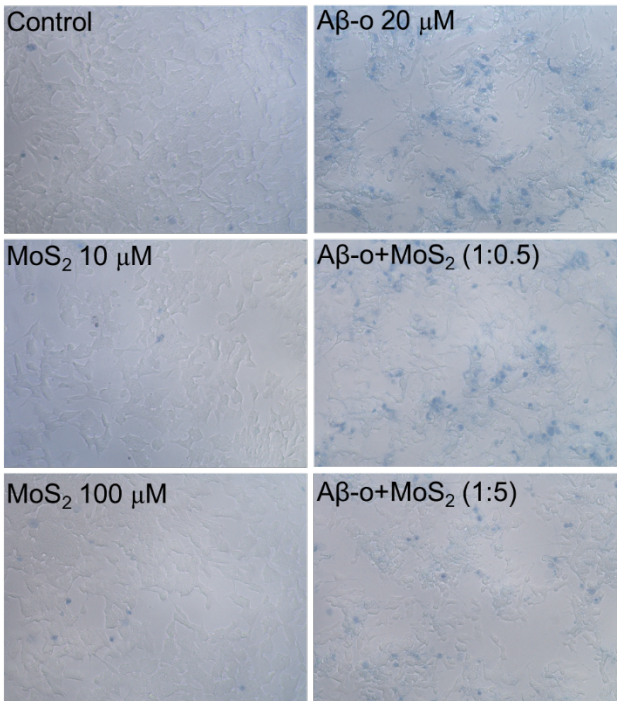

Figure S2. Trypan blue staining of SH-S5Y cells after 48 h treatment by Aβ-o, ultrasmall MoS_2 QDs and the combination of Aβ-o and ultrasmall MoS_2 QDs at the molar ratios of 1:0.5 and 1:5. Aβ was preincubated at 400 μM and 37 °C in MilliQ water for 5 h, and then diluted to 20 μM for the cell viability assay.

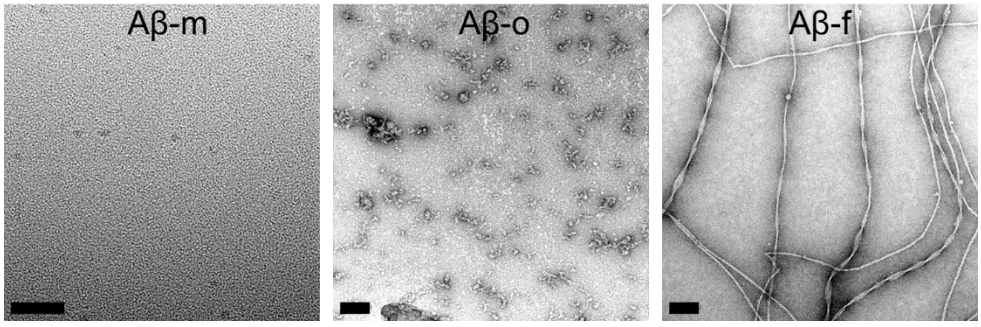

Figure S3. TEM imaging of Aβ aggregation, in the forms of Aβ-m, Aβ-o and Aβ-f. 50 μM of Aβ peptide was incubated at 37 °C for 0 h, 12 h and 30 h. Amyloid protein samples were collected at different time points according to the ThT result presented in Figure 2A and were instantly stained on formvar/carbon-coated copper grids. Scale bars: 50 nm for the image of Aβ-m and 100 nm for the images of Aβ-o and Aβ-f.

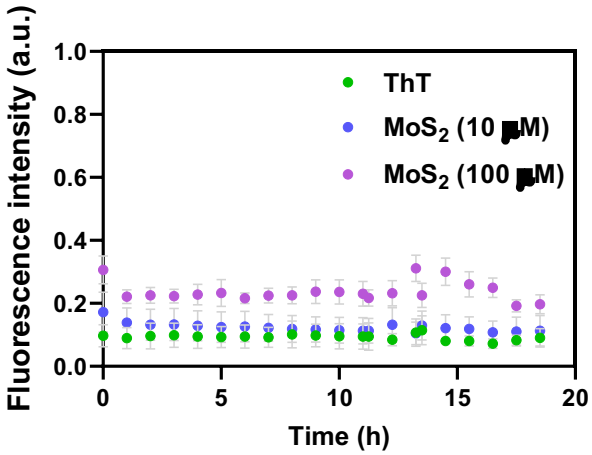

Figure S4. ThT kinetic assay for different concentrations of ultrasmall MoS_2 QDs. The concentration of ThT was 200 μM.

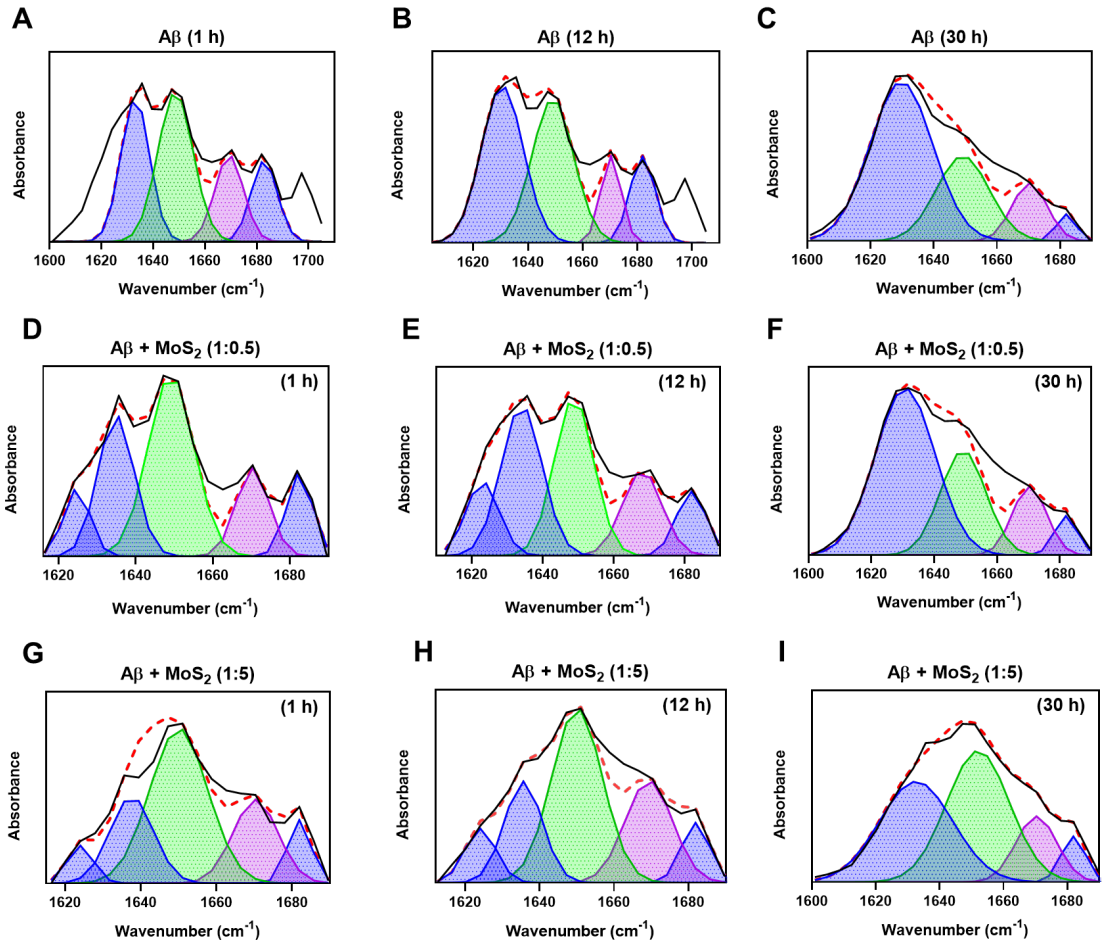

Figure S5. ATR-FTIR amide I band spectra and deconvolution analysis of incubated Aβ samples (50 μM, incubated for 1, 12 and 30 h at 37 °C) with or without ultrasmall MoS_2 QDs at the molar ratios of 1:0.5 and 1:5.

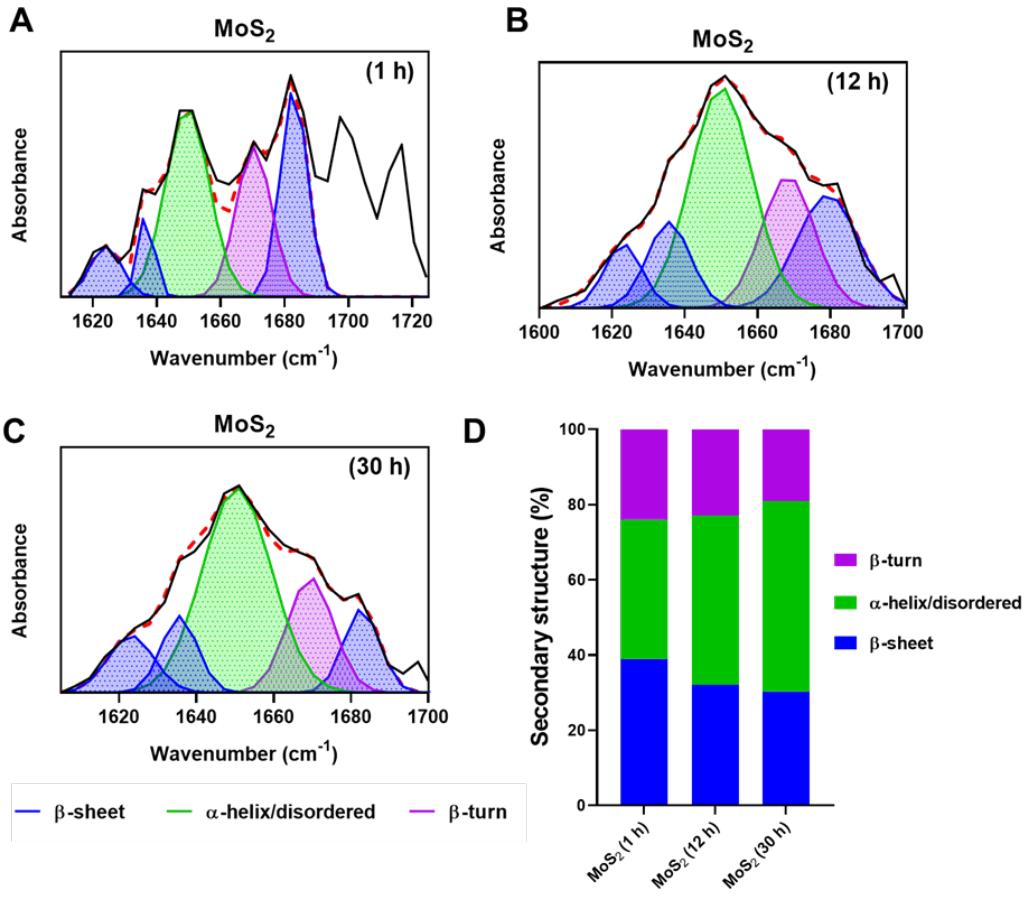

Figure S6. ATR-FTIR amide I band spectra (A, B, C) and the secondary structure distribution (D) of ultrasmall MoS_2 QDs only without Aβ at 1, 12 and 30 h and 37 ^{o}C in water.

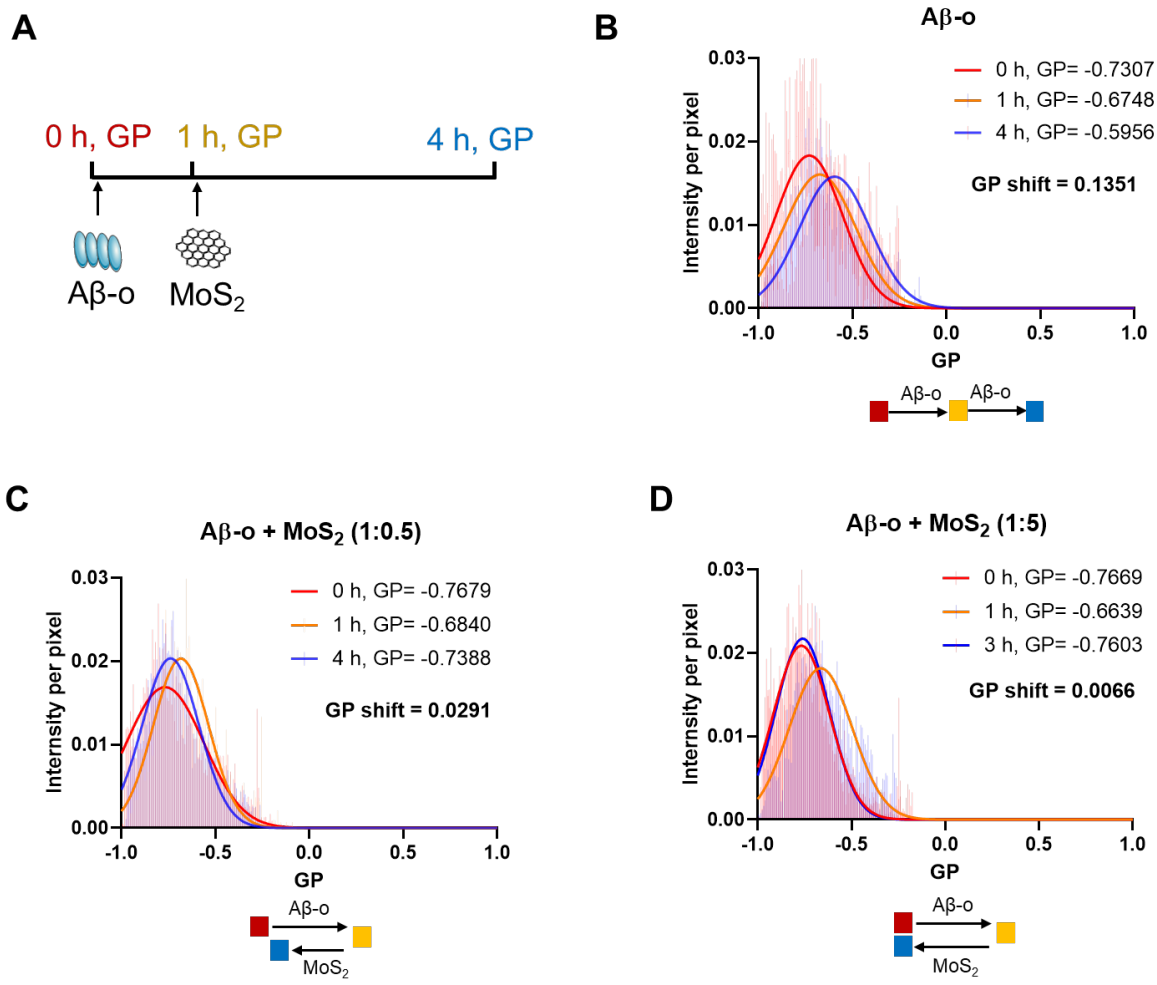

Figure S7. Effects of pre-incubated Aβ-o on the fluidity of SH-SY5Y cell membranes in the presence and absence of ultrasmall MoS_2 QDs. (A) A flowchart illustrates the measurement time points of membrane fluidity and the addition of Aβ-o and ultrasmall MoS_2 QDs. (B-D) GP shifts were recorded after 1 h pre-treatment with Aβ-o (20 μM) followed by another 3 h of incubation in the presence and absence of ultrasmall MoS_2 QDs (10 or 100 μM).

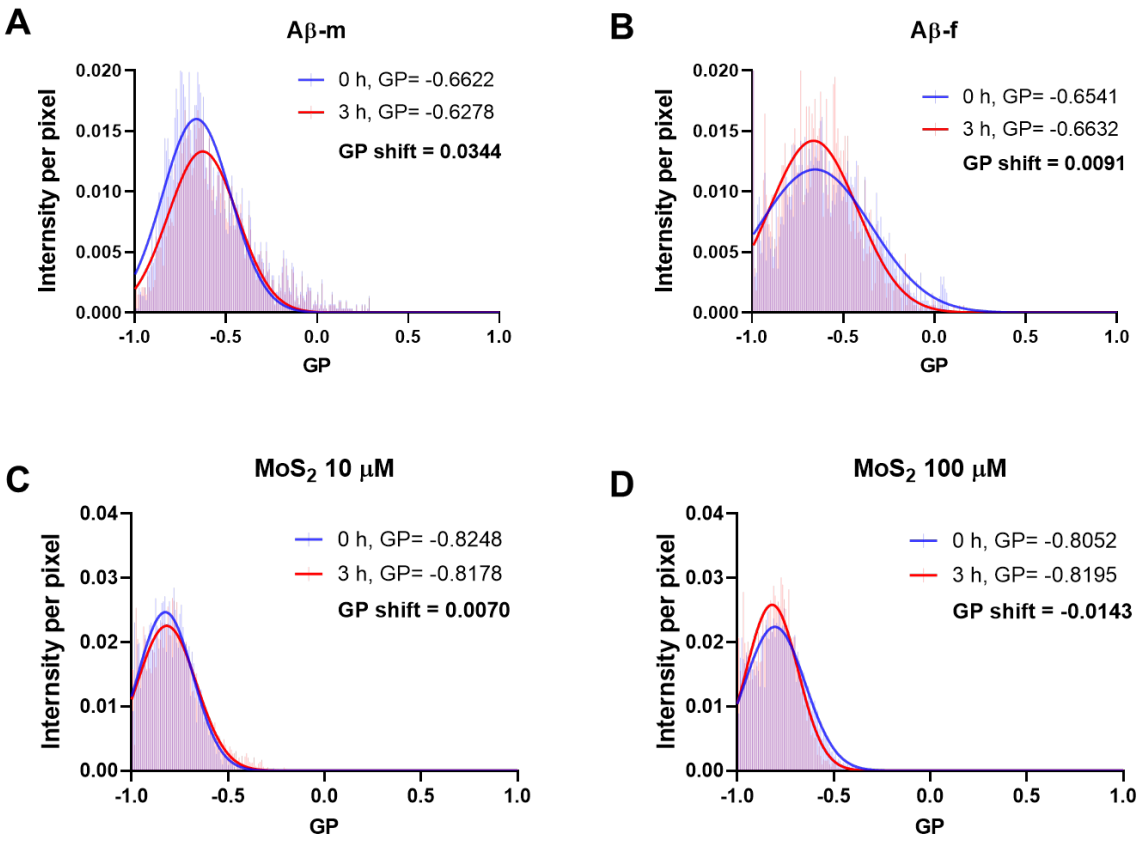

Figure S8. Effects of Aβ-m, Aβ-f and ultrasmall MoS_2 QDs on the membrane fluidity of SH-SY5Y cells. Aβ 400 μM was dissolved in H_2O and incubated at 37 ^oC for 0, 5 and 30 h, representing Aβ-m, Aβ-o and Aβ-f, then was further diluted into cell culture media to reach 20 μM final concentration. After 3 h treatment, GP values and shifts were analyzed.

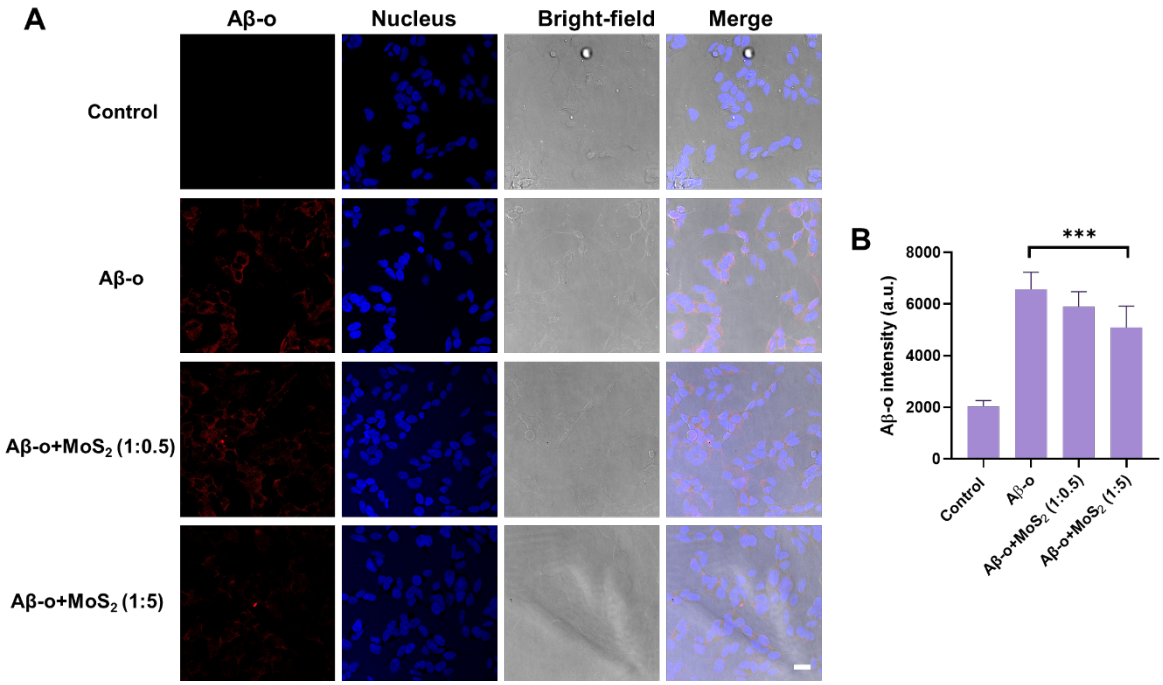

Figure S9. Aβ-o distribution on SH-SY5Y cells in the presence and absence of ultrasmall MoS_2 QDs with the molar ratios of 1:0.5 and 1:5. (A) Confocal images of Aβ-o (concentration: 20 μM) distribution after 3 h treatment, including Aβ-o (red), nucleus (blue), bright-field (gray) and merged images for 3 channels. Scale bar: 20 μm. (B) Corresponding Aβ-o fluorescence intensity of panel A. Data are shown as mean values (n=3) ± SEM, *** $P <$ 0.001.

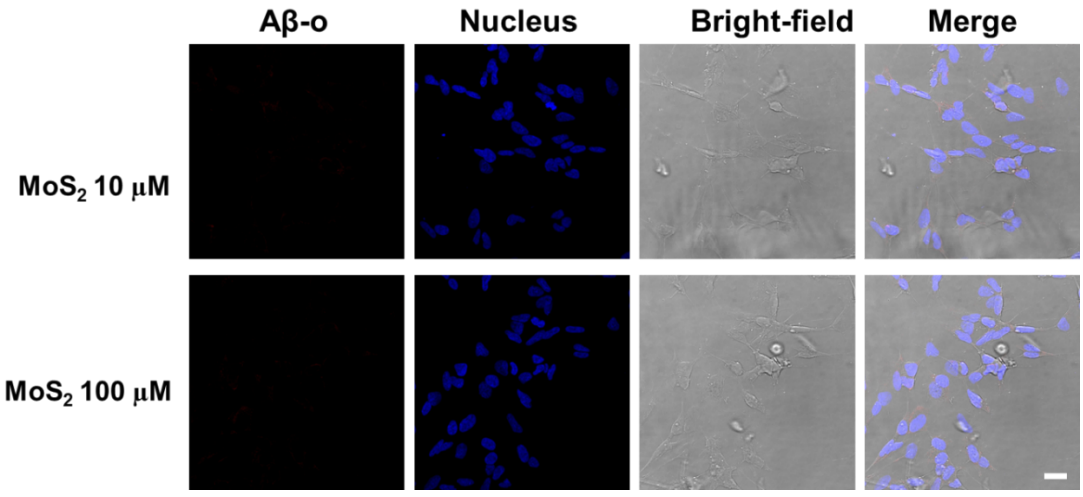

Figure S10. Aβ-o distribution on SH-SY5Y cells treated with 10 and 100 μM of ultrasmall MoS_2 QDs. Aβ-o (red), nucleus (blue), bright-field (gray) and merged images for 3 channels. Scale bar: 20 μm.

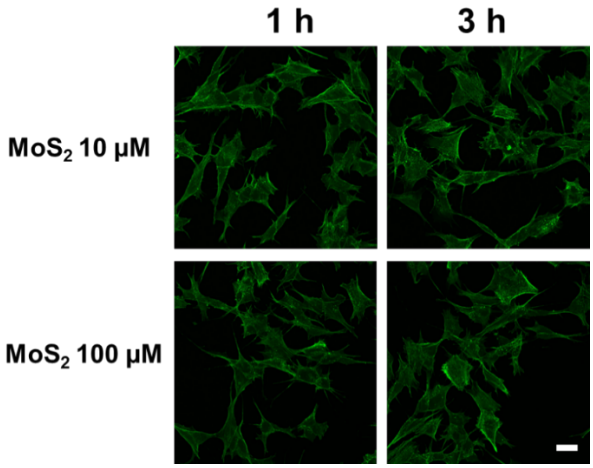

Figure S11. Actin organization in SH-SY5Y cells after 1 h and 3 h treatment by different concentrations of ultrasmall MoS_2 QDs. Actin filaments were stained by phalloidin-iFluor 488 (green). Scale bar: 20 μm.

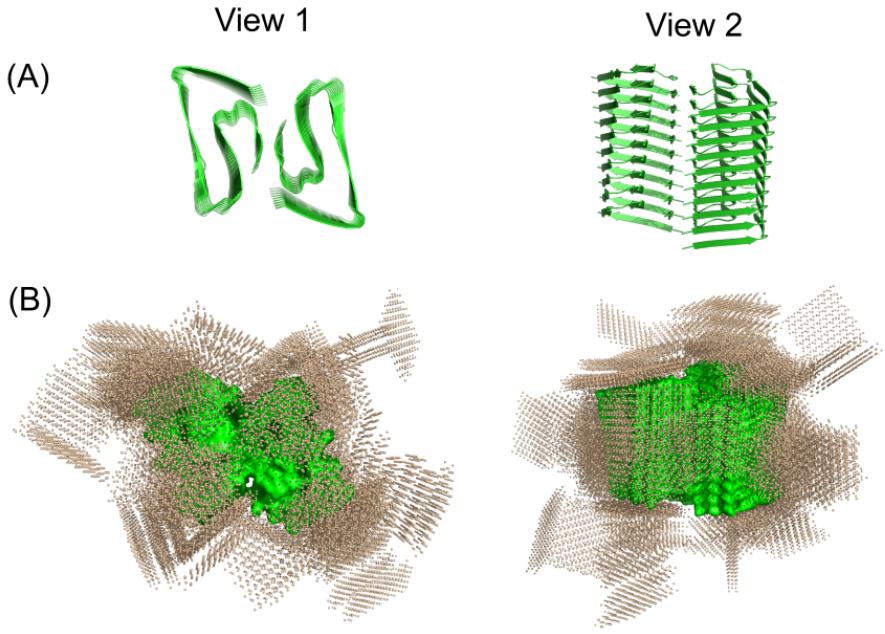

Figure S12. Interactions between Aβ-f and ultrasmall MoS_2 QDs. (A) Structure of the Aβ fibril (Aβ-f). Aβ peptides were shown as cartoons. (B) Overlaying of final snapshots from 30 independent simulations, where preformed Aβ-f were illustrated by their surfaces and MoS_2 atoms were displayed in wheat spheres.

Table S1. Secondary structure distribution of incubated (1, 12 and 30 h) Aβ 50 μM in the presence and absence of ultrasmall MoS_2 QDs. Secondary structure analysis (%) is derived after deconvolution of the respective ATR-FTIR raw spectra presented in **Figures S5&S6** in 4 peak regions (1610~1640 cm^{-1}, 1640~1660 cm^{-1}, 1660~1675 cm^{-1}, and 1675~690 cm^{-1}). Incubation temperature: 37 ºC.

Samples	β-sheet (%)	α-helix/disordered (%)	β-turn (%)
Aβ (1 h)	44.7	37.7	17.6
Aβ (12 h)	52.8	36.4	10.8
Aβ (30 h)	61.6	26.5	11.9
Aβ + MoS_2 (1:0.5, 1 h)	44.3	41.3	14.4
Aβ + MoS_2 (1:0.5, 12 h)	52.2	31.1	16.7
Aβ + MoS_2 (1:0.5, 30 h)	60.4	26.5	13.1
Aβ + MoS_2 (1:5, 1 h)	32.9	47.2	19.9
Aβ + MoS_2 (1:5, 12 h)	34.7	42.2	23.1
Aβ + MoS_2 (1:5, 30 h)	43.6	42.6	13.8
MoS_2 (1 h)	39	37.1	23.9
MoS_2 (12 h)	32.1	45	22.9
MoS_2 (30 h)	30.3	50.7	19