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Electronic Supplementary Information

Revisiting the principles of preparing aqueous quantum dots for biological applications: the effects of surface ligands on the physicochemical property of quantum dots

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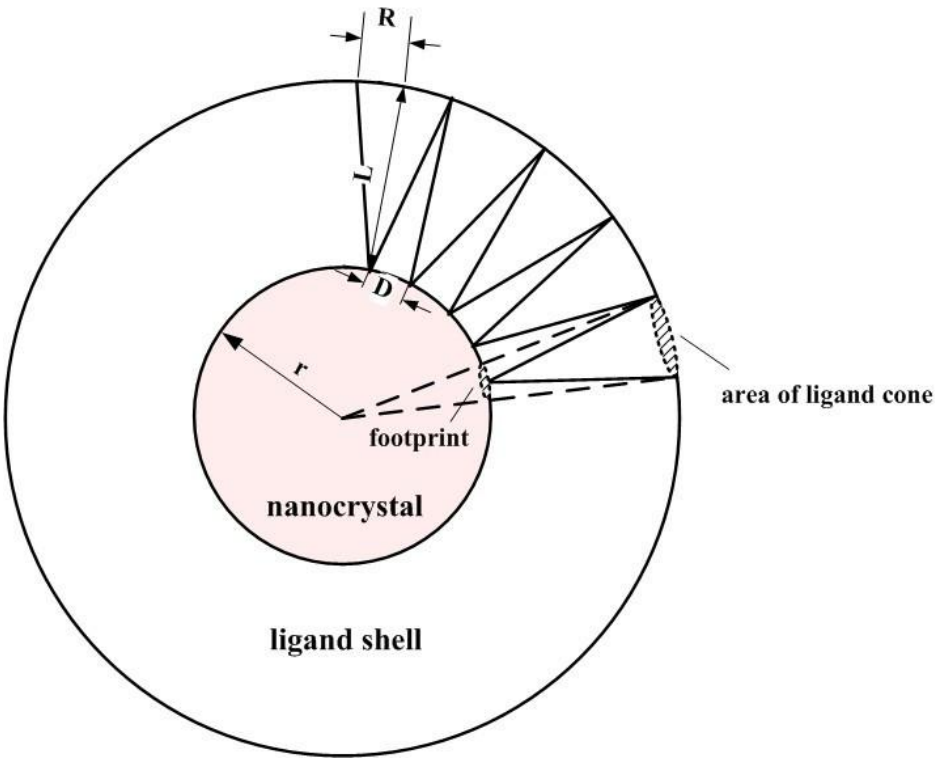

Figure S1. (a) Shematic view of geometric model for estimating maximum ligand grafting density.

Assuming spherical nanocrystals and cone-shaped ligands,

$$Maximum\ ligands\ per\ QD = \frac{4\pi r^2}{footprint} = \frac{4\pi(r+L)^2}{\pi R^2} \qquad (S1)$$

$$footprint = \pi\left(\frac{D}{2}\right)^2 \qquad (S2)$$

where r is the nanocrystal radius, L is the ligand shell thickness, D is the distance between two ligand chains at the particle surface, and R is the radius of ligand cone.

For short chain thiol ligands capped nanocrystals with a diameter of ~6nm, the ligands shell thickness is much smaller than the nanocrystals core ($L \ll r$). Therefore, short-chain thiol area[1] (0.025nm^2) could be used as footprint on our nanoparticles. The calculated theoretical capacity is ~4524 ligands per QD.

For PEG chain ligands, their ligand shell thickness is comparable to the particle size. Under this condition, the dimension (L and R) of the PEG ligand cone on the particle surface should be considered. Given r (4.25 nm), L (11 nm) and D (0.83 nm) in the previous data,[2] the radius R of the PEG cone could be calculated using Equation s1 and s2. Based on the PEG dimensions and our QDs size (~ 6nm), the estimated maximum capacity is ~355 PEG ligands per QD in our condition. The corresponding footprint (0.32 nm^2/ligand) is in good aggrement with the PEG footprint in previous report (0.35 nm^2 /ligand) [3]. (Their footprint of 0.35 nm^2 /ligand was based on the particles with 2.8 nm diameter. According to the ligand cone model, smaller partilces has smaller theoretical footprint [4]. Therefore, it provides a reasonable lower limit for our footprint.)

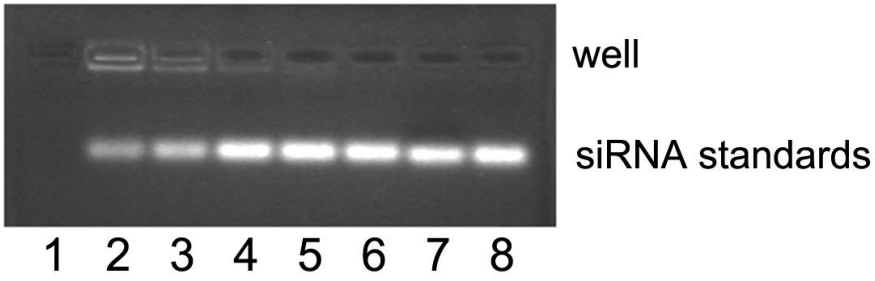

Figure S2. Electrophoretic mobility of siRNA in agarose gel after conjugation with QDs. (1) AET-QDs control. (2-6) siRNA/AET-QD mixture at weight ratios of 1:12 (same amount QDs with lanes 1), 1:6, 1:3, 1:1.5 and 1:0.75. (7) siRNA/MPA-QDs mixture at a weight ratio of 1:12. (8) pure siRNA.

The QD-siRNA complexes provide a multifunctional platform for effectively delivering siRNA while tracking their allocation, which has great potential for gene silencing and disease therapy[5-7]. To demonstrate the QDs potential for biomedical applications after functionalization, we conjugated AET-QDs with small interfering RNA molecules (siRNA). Gel electrophoresis was performed to examine the linking between QDs with siRNA and the result is shown in Figure S2. The fluorescence intensity at siRNA standards decreases gradually with the increase of AET-QDs/siRNA ratio (lane 2-6) while the fluorescence at the well attenuated accordingly. Compared with AET-QDs control (lanes 1), we infer the fluorescence around the well mainly arise from the bounded siRNA on QDs with limited mobility. These results indicate successful conjugation between siRNA and QDs via electrostatic interaction, further certified by the band pattern of MPA-QDs/siRNA (lanes 7). On the basis of this preliminary result, the QD-AET-siRNA^{FAM} complexes were incubated with RAW 246.7 macrophages and demonstrated effective siRNA transfection compared to the unbound siRNA (Figure S3).

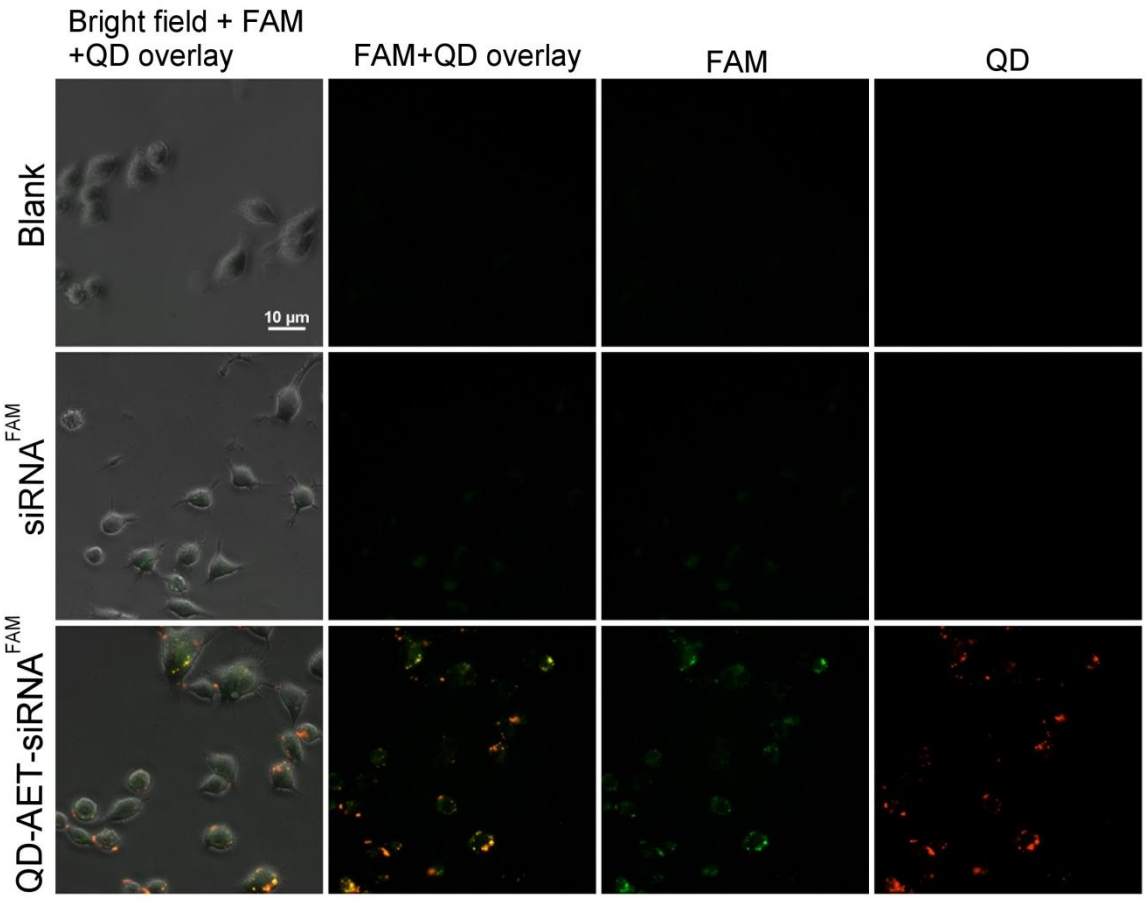

Figure S3. Microscope imaging of RAW246.7 cells incubated with blank, siRNA^{FAM} and AET-QDs-siRNA^{FAM}. FAM channel were excited with blue light and rendered in green. QD channel were excited with green light and rendered in red.

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