Supporting Information

Amplified light harvesting for enhancing Italian lettuce photosynthesis using water soluble silicon quantum dots as artificial antennas

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1. Materials and methods

N-(2-aminoethyl)-3-aminopropyltrimethoxysilane (DAMO) (95%), trisodium citrate dihydrate (≥ 99.0%), quinine sulphate (98%) and 2,6-dichlorophenolindophenol (DCPIP) were purchased from Macklin (Shanghai, China). SOD and MDA assay kits were purchased from Nanjing Jiancheng Bioengineering Institute (Nanjing, China). 100 μg/mL SiO_2 was purchased from national standard research center of PRC. All chemicals and reagents were used without any additional purification. The solutions were prepared using deionized water. The morphology of the SiQDs was examined using a JEM-2100 ultrahigh scanning transmission electron microscope (HRTEM, Tokto, Japan). The chemical structure and composition were confirmed by X-ray powder diffraction (XRD) using a Persee XD-2X/M4600 and X ray photoelectron spectrometer (Axis Ultra DLD, Kratos). The functional groups on SiQDs were identified by Fourier-transform infrared (FTIR) spectroscopy on Nicolet Avatar 360 FTIR spectrophotometer (Columbus, USA). For the studies of optical properties and mechanism of action, UV-2550 Shimadzu Spectrophotometer and F-700 Hitachi Fluorescence Spectrophotometer were used. The photoluminescence-quantum yield (PLQY) were measured against freshly prepared using quinine sulphate in 0.1 M H_2SO_4 (literature quantum yield: 58%) as a reference standard. The distributions of SiQDs in Italian lettuce seedlings were analysed by Zeiss laser scanning confocal microscopy 710.

2. Growth parameter estimation

After harvesting, the root length and seedling height of Italian lettuce were measured by ruler. To measure the dry matters of Italian lettuce, the fresh Italian lettuce was put in the oven until the dry matter reached constant weight. The dry matters of Italian lettuce were weighed by sensitive balance.

3. Physiological parameter estimation

The fresh leaves were harvested and stored in a subzero-80 degrees cryogenic refrigerator for future analysis after 15 days treatment. Chlorophyll content was assessed by colorimetric method according to Hesheng Li[1]. Total soluble sugar

content was accessed by anthrone colorimetry method according to Hesheng Li[1]. The SOD activity and MDA content were measured using assay kits obtained from Nanjing Jiancheng Bioengineering Institute.

4. Determination of Silicon content

Silicon content of Italian lettuce seedling was determined by the molybdenum blue colorimetric method as described by Van der Vorm.[2] Briefly, 300 mg dry plant materials were put into porcelain crucibles and burn it to ash in a muffle oven at 300 °C for 3 h. Then the temperature of the muffle oven was turned to 550°C for 4 h until the plant material turns grey. The ashes were dissolved in 40% HF and oscillated for 1h. The content of silicon was determined by the molybdenum-blue colorimetric method at 811 nm. The 100 μg/mL SiO_2 were served as standard solution of silicon.

5. Statistical analysis

Statistical analysis software SPSS 20.0 was used to analyze all the data of the experiment. A one-way analysis of variance (ANOVA) and LSD were conducted for the difference significant test (P=0.05). Drawing figures use Origin 9.1 and Microsoft excel 2010.

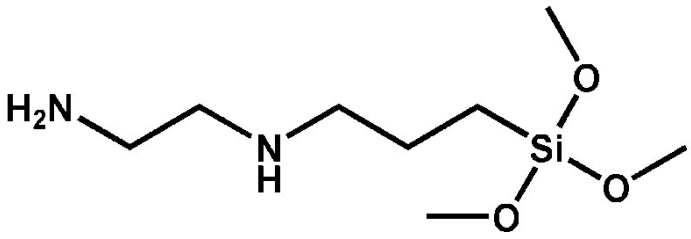

Fig. S1 Molecular structure of DAMO.

Table S1. Quantum yield of SiQDs. Relative quantum yield of fluorescent SiQDs.

Sample	Gradient A, (R^2)	Quantum yield at 364 nm (%)
Quinine sulphate	5.25×10^6 (0.995)	54
SiQDs	6.22×10^6 (0.996)	81

The obtained PL quantum yield is the result of baseline correction.

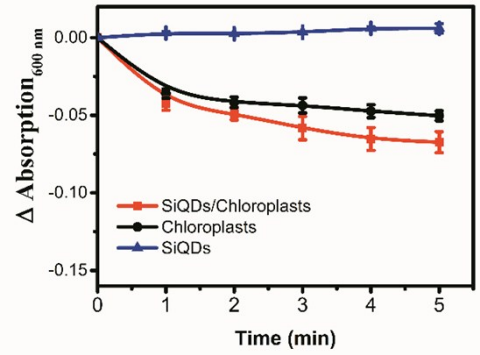

Figure S2. Hill reaction under UV light. The changes in absorption of DCPIP at 600 nm mixing with SiQDs, chloroplast and chloroplast/SiQDs complex under UV lamp irradiation.

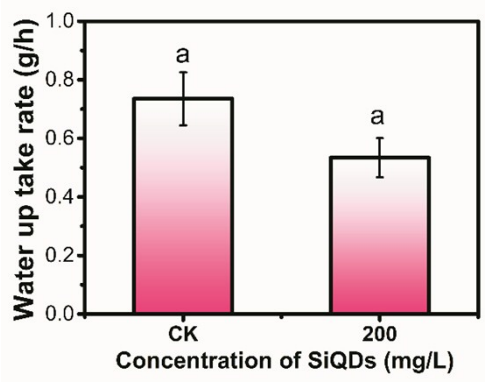

Figure S3. SiQDs effects on water up take rate. The water up take rate of Italian lettuce seedling cultivated with growth medium containing SiQDs at 200 mg/L and the control group without SiQDs (CK).

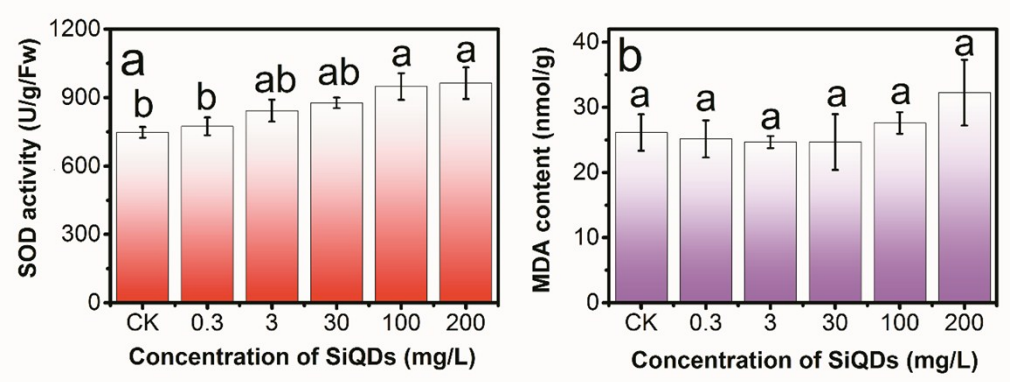

Figure S4. SiQDs effects on SOD and MDA. SOD activity and MDA content of Italian lettuce treated with different concentrations of SiQDs solution.

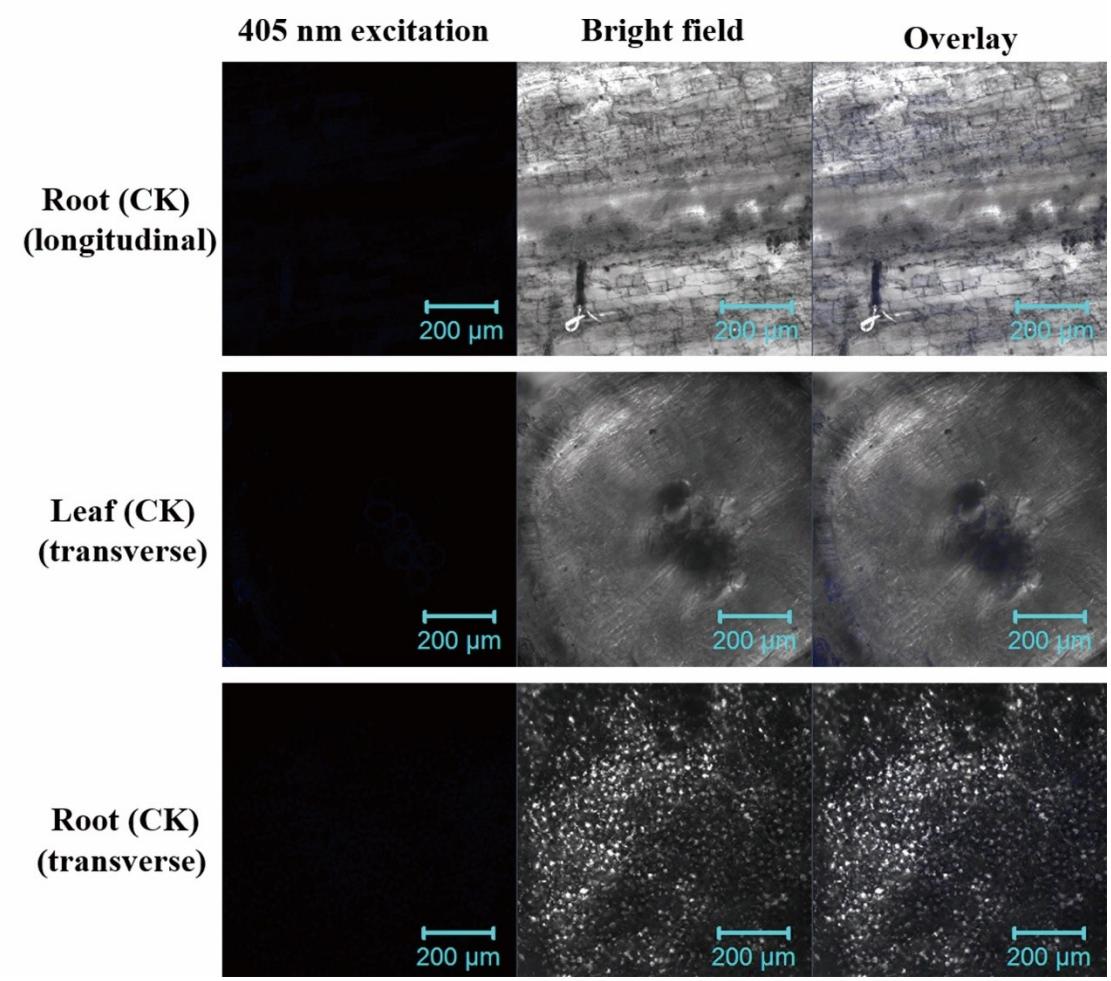

Figure S5. Uptake and distribution without SiQDs. From top to bottom, LSM images of longitudinal sections of root, transverse section of root and leaf without SiQDs as control groups (CK). All images were taken under same exposure conditions.

References

1. H. Li, Beijing: Higher Education Press, 2000.

2. P. D. J. V. D. Vorm, *Commun. in Soil Sci. Plant Anal.*1987, **18**, 1181-1189.