# Supporting Information

# Exceptionally Stable Quantum Dot/Siloxane Hybrid Encapsulation Material for White Light-Emitting Diode with Wide Color Gamut

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## Experimental

### Thermal and Chemical Stability Test

For the thermal stability test, the TSE-QD, PSE-QD, and QD/Acrylate were placed in chambers at 120 ℃ / 5 % relative humidity (RH) and 85 ℃ / 85 % RH. The QD composite films were soaked in ethanol, acetone, 0.1 M sodium hydroxide, and 0.1 M hydrochloric acid to test their chemical stability.

### Characterization

PLQY was measured using an absolute PLQY spectrometer, Quantaurus-QY C11347 series (Hamamatsu Photovics K.K., Japan) with a Xenon light source (150 W). PL decay curves were recorded using a fluorescence lifetime spectrometer, FL920 (Edinburgh Instruments, England) using 470 nm laser as an excitation source. The FT-IR spectra were obtained from an FT-IR 680 plus (JASCO, U.S.A.). TGA profiles were obtained using a TGA Q50 (TA Instruments, U.S.A.) with a ramp of 10 °C $min^{-1}$ under $N_2$ gas. The NMR spectrum for $^{29}Si$ was recorded by a DMX600 FT 600 MHz (Bruker Biospin, Australia) (pulse width: 16025.641 Hz, delay: 5 sec., number of scan: 3072). Absorbance spectra were collected using a UV−vis−NIR spectrometer, SolidSpec-3700 (Shimadzu, Japan). PL spectra were recorded from a DARSA PRO 5100 PL system (PSI Trading Co., Ltd., Korea) using a xenon light source (500 W) as an incident beam. The 3-D images of TOF-SIMS were obtained using a TOF-SIMS5 (ION-TOF GmbH, Germany). The 2-D images of dispersive-Raman PL spectrometery were collected using an ARAMIS (Horiba Jobin Yvon, France). TEM images were obtained using a JEMARM200F (JEOL, Japan) prepared by FIB, Nova-200 (FEI Company, Netherlands).

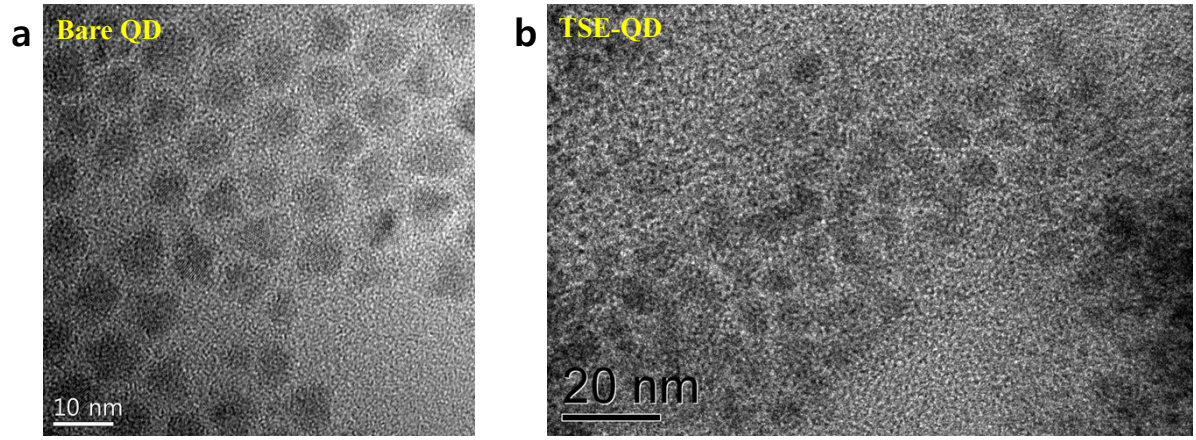


**Fig. S1. Comparison of transmission electron microscope (TEM) images (a) before and (b) after fabrication. The average size is about 8 nm of both samples.**

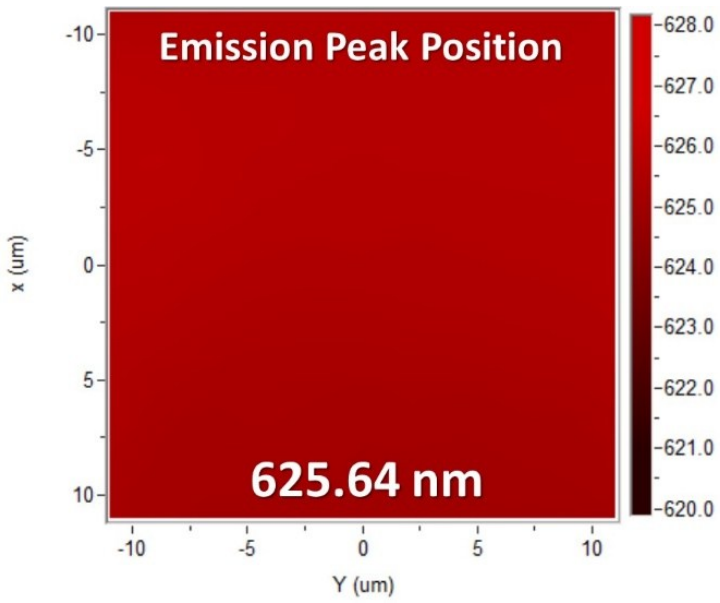


**Fig. S2. 2-D images of the emission peak position of TSE-QD in the area of 400 $\mu m^2$ obtained from Raman PL analysis**

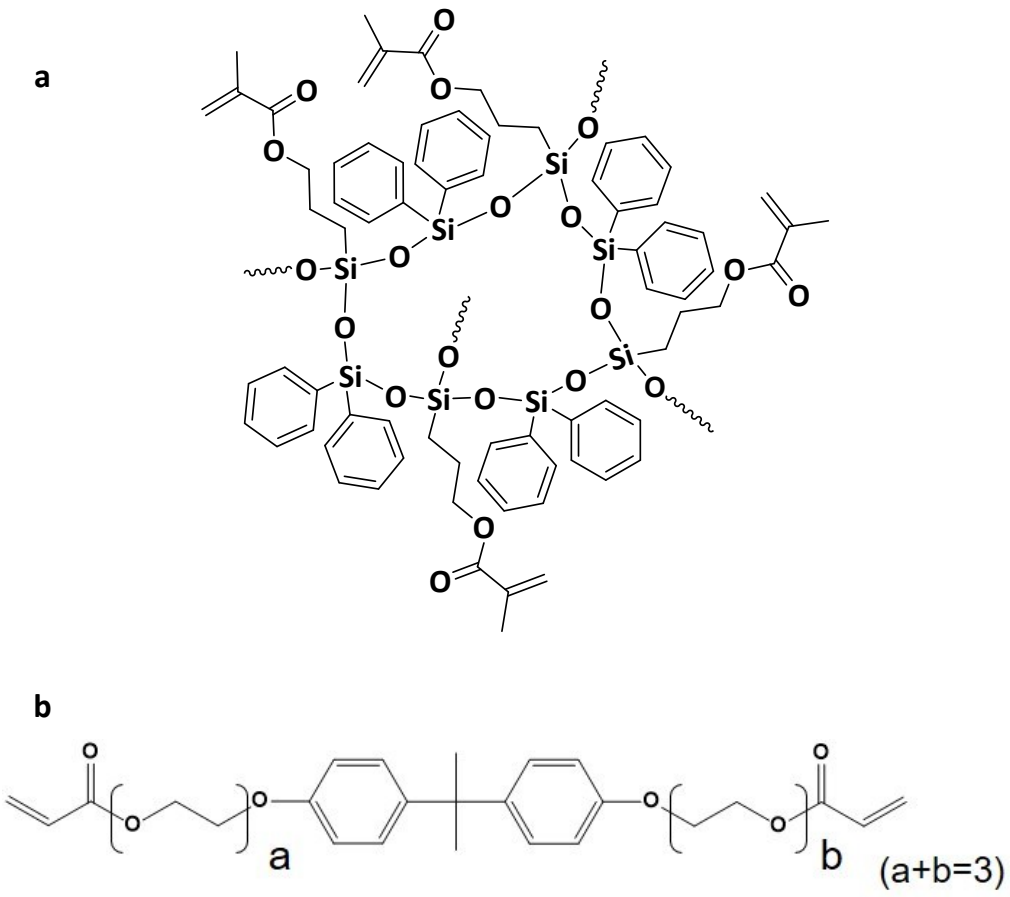


**Fig. S3. Chemical structure of (a) Siloxane matrix of PSE-QD and (b) Hydrocarbon-based diacrylate polymer.**

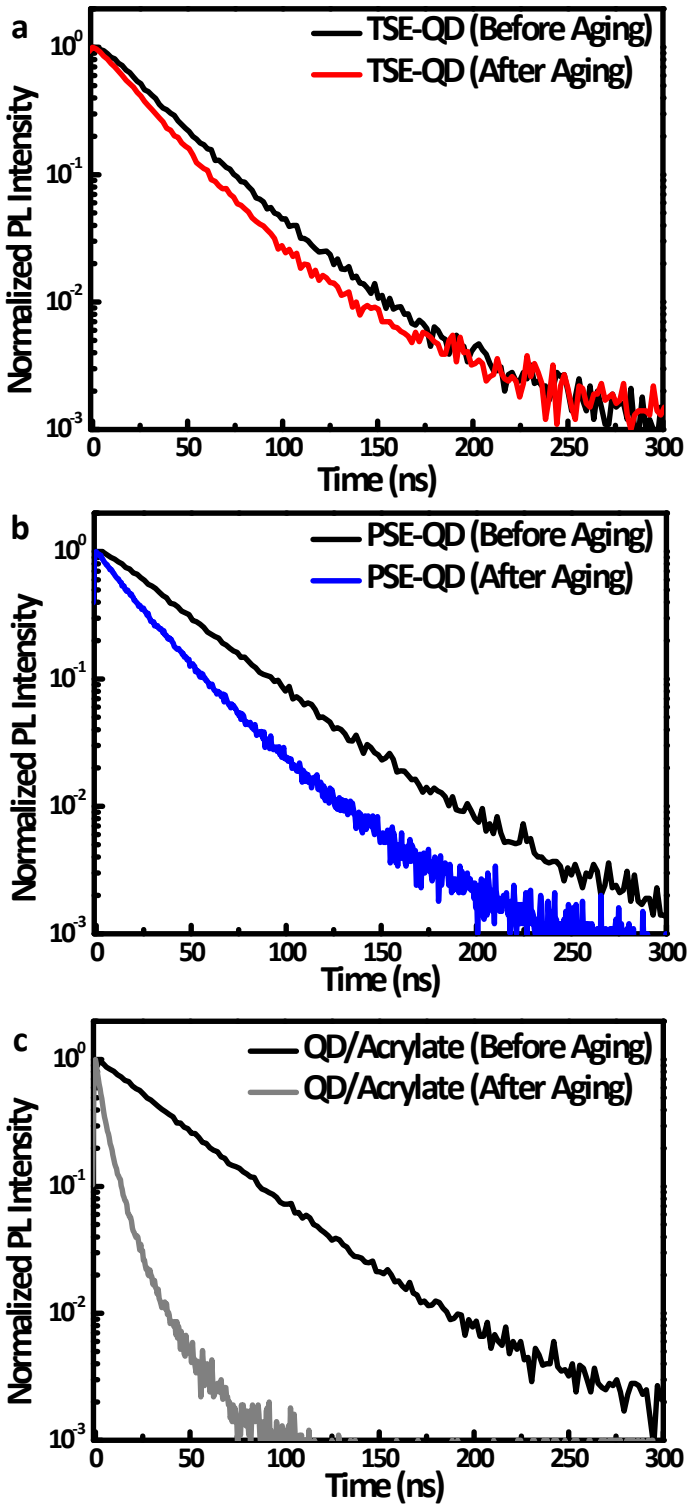


**Fig. S4. Change of PL decay curve of (a) TSE-QD, (b) PSE-QD, and (c) QD/Acrylate before and after high temperature aging**

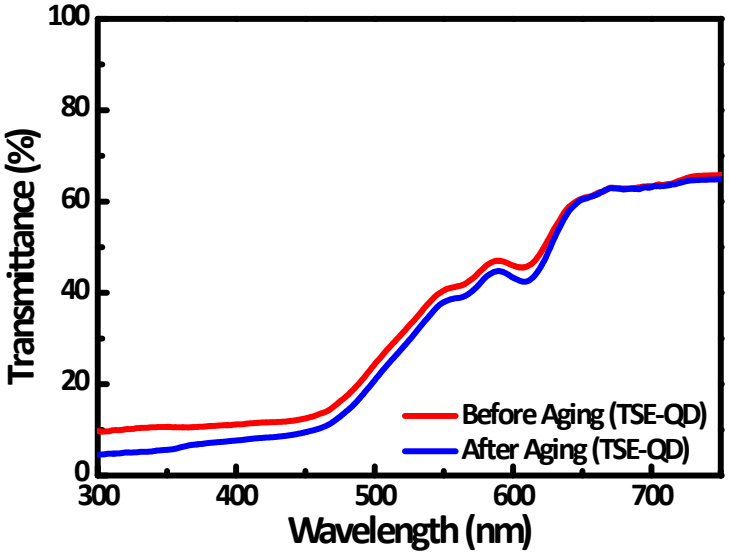


**Fig. S5. Transmittance of TSE-QD before and after aging at 120 ℃ in ambient air**

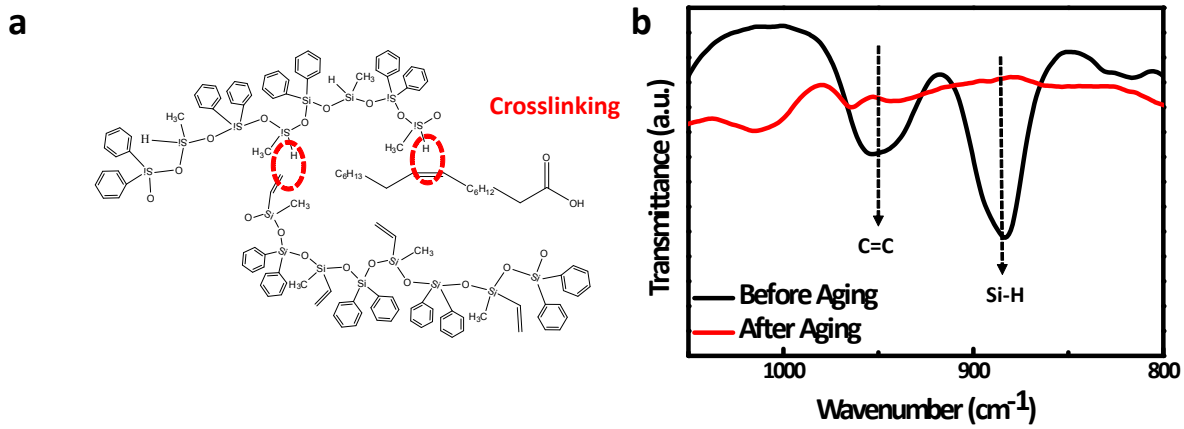


**Fig. S6. (a) Chemical diagram of the reaction between oleic acid and the siloxane matrix. (b) Comparison of the FT-IR spectra of oleic acid and DEMS before (black) and after (red) thermal aging**

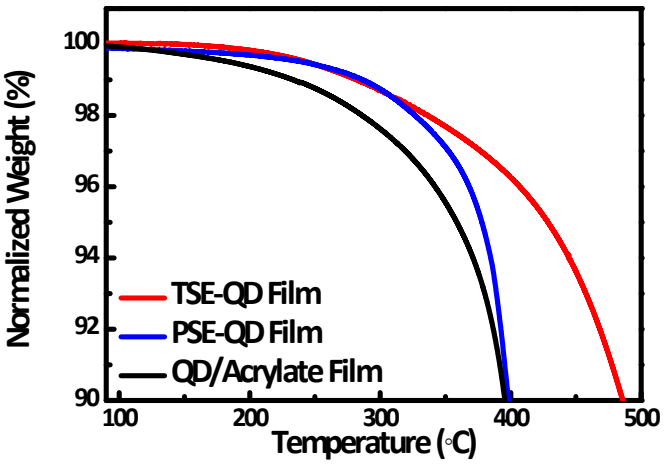


**Fig. S7. TGA profiles of TSE-QD (red), PSE-QD (blue), and QD/Acrylate (black)**

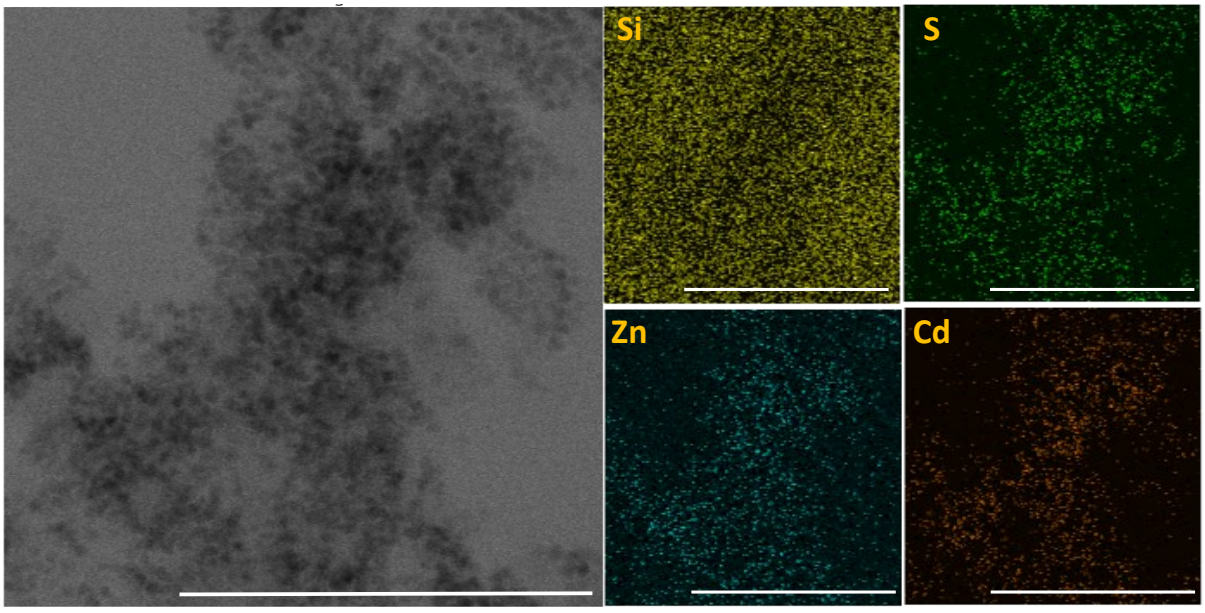


**Fig. S8. Transmission electron microscopy (TEM) image of TSE-QD (left) and energy-dispersive X-ray spectroscopy (EDS) results (right). The selected elements are Si (matrix), Cd (core), Zn (shell) and S (shell). The scale bars in images are 250 nm.**

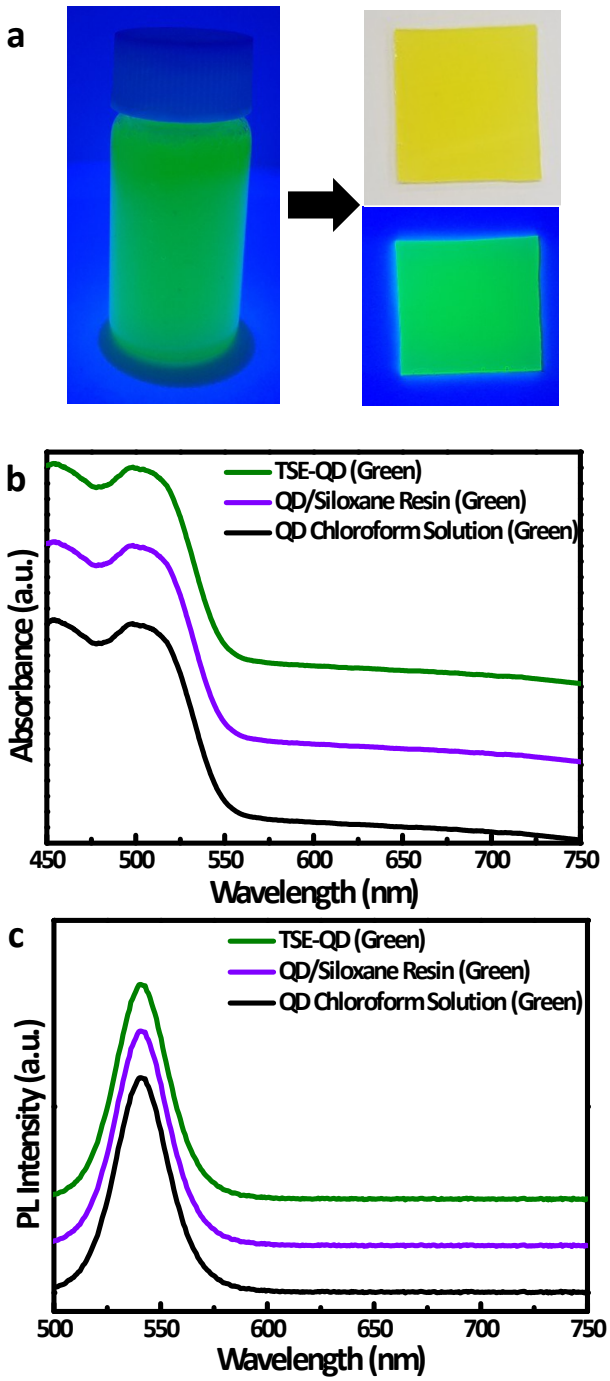


**Fig. S9. Photographs of (a) Green emitting QD/Siloxane resin and TSE-QD, (b) Absorbance and (c) PL spectra of green emitting QD dispersed in chloroform solution (black), QD/Siloxane resin (purple), and TSE-QD (green)**

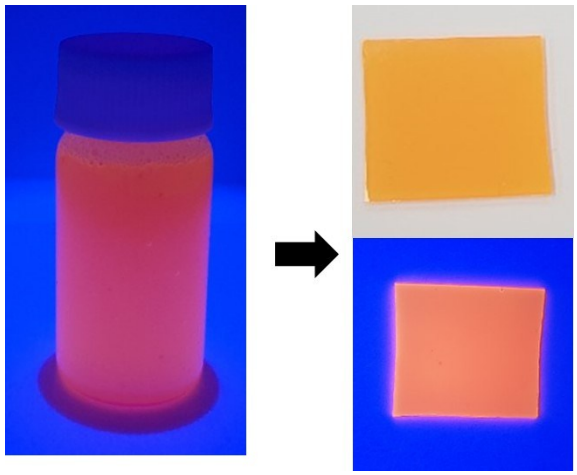

**Fig. S10. Yellow emitting QD-Siloxane resin and TSE-QD**

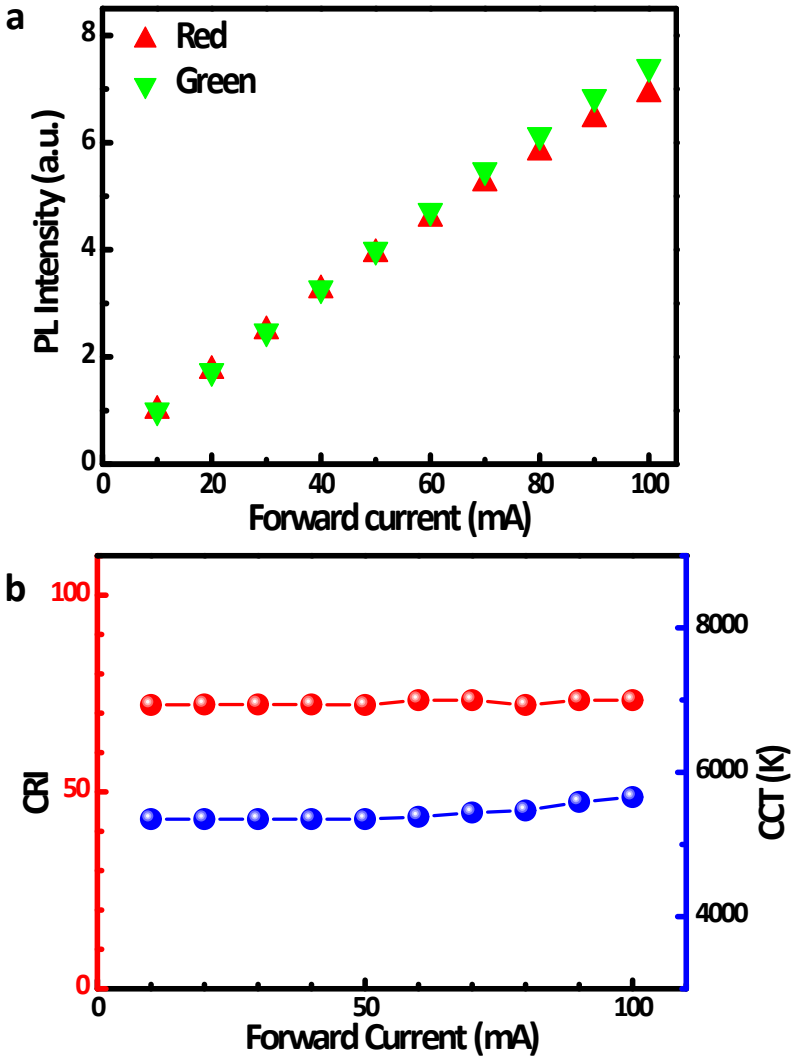


**Fig. S11. (a) Red and green PL intensity change, (b) CRI (red) and CCT (blue) of a TSE-**

**QD-based white LED as a function of forward bias current from 10 to 100 mA.**

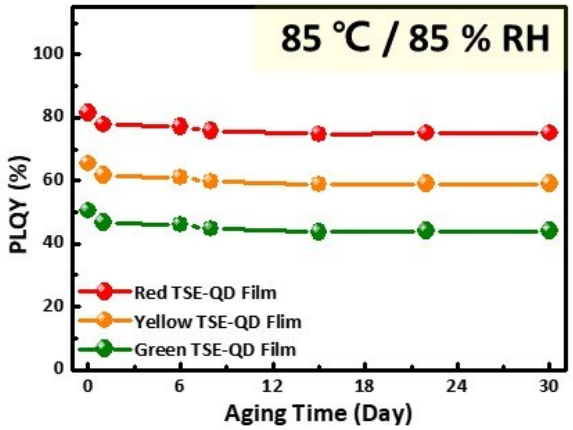


**Fig. S12. Trace of PLQY of red TSE-QD (red), yellow TSE-QD (yellow), and green TSE-QD (green) during aging at 85 ℃ / 85 % RH.**

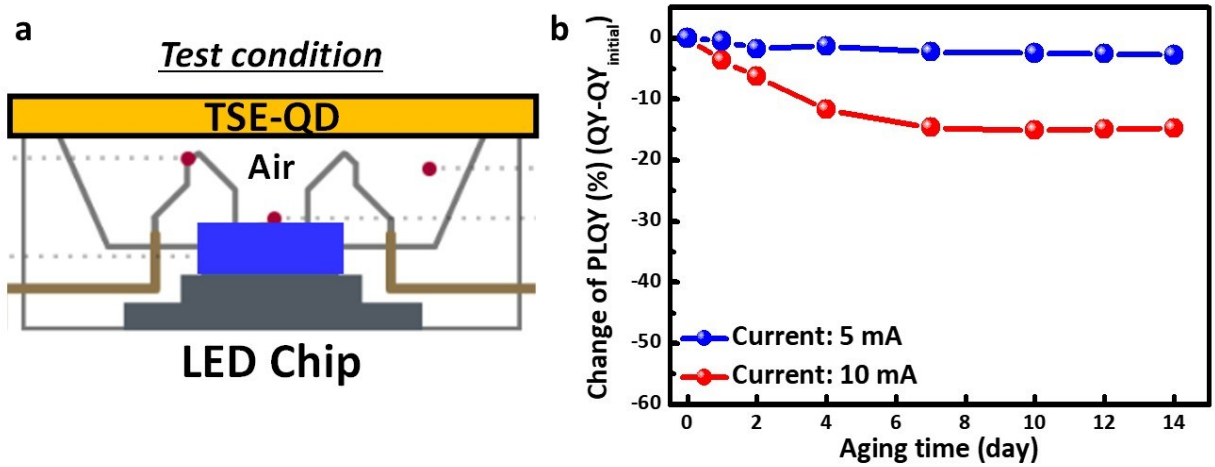


**Fig. S13. The results of photostability of TSE-QD under continuous blue light irradiation. (a) Test condition for photostability. (b) The change of PLQY of TSE-QD under continuous blue light irradiation according to LED power; 5 mA / 2.7 V (blue) and 10 mA / 2.7 V (red).**

**Table S1. PLQY of diluted samples (elimination of reabsorption of QDs) of QD chloroform solution and QD/Siloxane resin**

| Sample | PLQY (%) |
|---|---|
| Diluted QD Chloroform Solution | 90 |
| Diluted QD/Siloxane Resin | 90 |

**Table S2. The 1s peak wavelength (nm), emission peak wavelength (nm) and FWHM of QD chloroform solution, QD/Siloxane resin, and TSE-QD**

| Sample | 1s Peak Wavelength (nm) | Emission Peak Wavelengh (nm) | FWHM (nm) |
|---|---|---|---|
| TSE-QD | 605 | 625 | 35 |
| QD/Siloxane Resin | 605 | 626 | 34 |
| QD Chloroform Solution | 605 | 625 | 34 |

**Table S3. Chemical shift and peak area of Si atoms according to bond states of QD/Siloxane resin with the formula for calculation of DOC**

| Species | $D^0$ (DEMS) | $D^1$ | $D^2$ | $D^0$ (DPSD) | $D^1$ | $D^2$ |
|---|---|---|---|---|---|---|
| Chemical Shift (ppm) | -16 ~ -17 | -22 ~ -26 | -33 ~ -36 | -29 ~ -34 | -36 ~ -38 | -42 ~ -47 |
| Peak Area | 0 | 0.232 | 7.802 | 0 | 3.073 | 12.642 |

$$DOC = \frac{D^1 + 2D^2 + D^1 + 2D^2}{2(D^0 + D^1 + D^2) + 2(D^0 + D^1 + D^2)}$$

**Table S4. Chemical shift and peak area of Si atoms according to bond states of vinyl-based siloxane cross-linker and formula for calculation of DOC**

| Species | $D^0$ (DMVMS) | $D^1$ | $D^2$ | $D^0$ (DPSD) | $D^1$ | $D^2$ |
|---|---|---|---|---|---|---|
| Chemical Shift (ppm) | -26 ~ -28 | -30 ~ -32 | -33 ~ -36 | -29 ~ -34 | -36 ~ -38 | -42 ~ -47 |
| Peak Area | 0 | 1.082 | 9.492 | 0 | 1.021 | 10.161 |