Supplementary Material (ESI) for Journal of Materials Chemistry

Supporting Information

Flexible Ultrathin Free-standing Fluorescent Composite Films of $CdSe_xS_{1-x}$/ZnS Nanocrystalline and Protein

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1. Crystal structure and surface properties of cadmium hydroxide nanostrands

The crystal structure of cadmium hydroxide nanostrand has been characterized in detail and reported in our previous paper (*J. Am. Chem. Soc.* **2004**, 126, 7162). As shown in Figure S1, the nanostrand has one-dimensional structure where hexagonal cadmium hydroxide plates with a chemical composition of $[Cd_{37}(OH)_{68}(OH_2)_{n+4}]^{6+}$ are assembled along the <001> direction, shifting one unit cell to *x* (or *y*) axis. The distance between the two plates, the length of the *c* axis, is presumed to be the same as that of cadmium hydroxide (0.4702 nm). The surface charge density was estimate from the titration experiments with negatively charged dyes. It has been found that 1/6 cadmium atoms of the cadmium hydroxide nanostrand were positively charged.

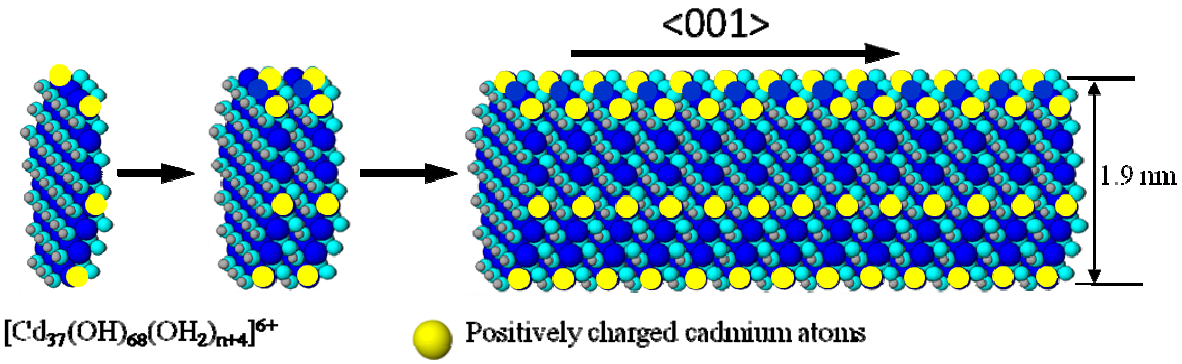

Figure S1 Presumed structure of cadmium hydroxide nanostrand

2. Free-standing films transferred onto solid substrate

The cross-linked films after removing cadmium hydroxide nanostrands were free-standing, and could be peeled off from polycarbonate (PC) membrane, and further transferred onto solid substrate. Figure S2 shows the photo images of two red emission films with a thickness of 80 nm and 40 nm, respectively. They were flexible and robust, and could be transferred onto solid substrate. Figure S2-b is the photo image of the 40 nm thick film after transferred onto a quartz plate. All the films were transparent and uniform in color.

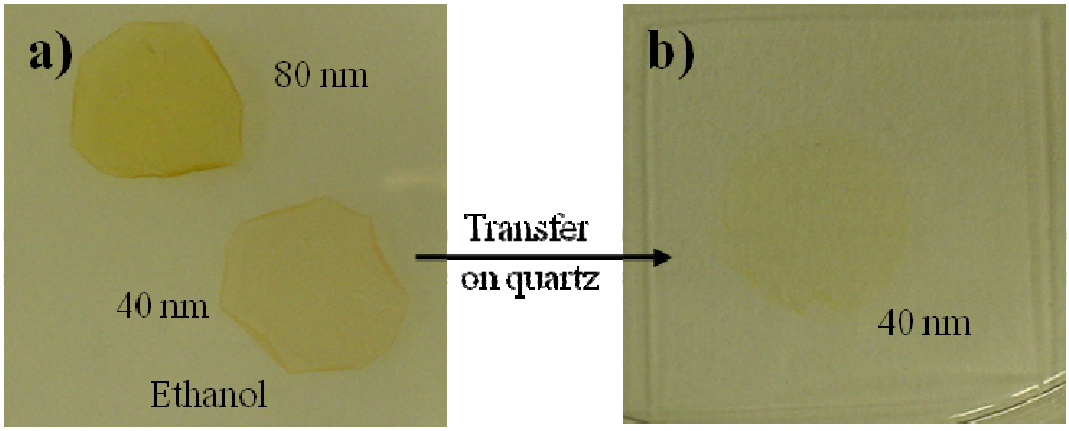

Figure S2 Photo images of (a) two red films of 40 nm and 80 nm in thickness and (b) 40 nm thick film after transferring on a quartz plate.

3. Weight and volume ratio of nanocrystals

The weight and volume ratio of nanocrystals in the composite films were calculated from the following parameters: 1.27 g/cm^3 density of apoferritin (*Crystal Growth & Design* **2007**, *7*, 569), and 5.816 g/cm^3 density of CdS_xSe_{1-x}/ZnS. For an example, as for 80 nm thick film prepared from the mixture (1 ml) of 2mg/ml CdS_xSe_{1-x}/ZnS (0.1 ml), 0.38mg/ml apoferritin (0.75 ml), and cadmium hydroxide solution (10 ml), the weight percent of CdS_xSe_{1-x}/ZnS in the film was calculated after removing away the nanostrands, as follows:

$$CdS_xSe_{1-x}/ZnS\ wt\% = 0.1\times2/(0.1\times2+0.75\times0.38)$$
$$\approx 41\ wt\%$$

The volume present of CdS_xSe_{1-x}/ZnS was calculated as follow:

$$CdS_xSe_{1-x}/ZnS\ vol\% = (0.1\times2/5.815) / [(0.1\times2/5.815)+(0.75\times0.38/1.27)]$$
$$\approx 13\ vol\%$$

The CdS_xSe_{1-x}/ZnS in final fluorescent film is 41 wt% in weight and only 13 vol% in volume, respectively.

4. Uv-vis absorption of the original nanocrystals

Figure S3 shows UV-vis absorption spectra of G-type (green) nanocrystals, Y-type (yellow) nanocrystals and R-type nanocrystals original curves.

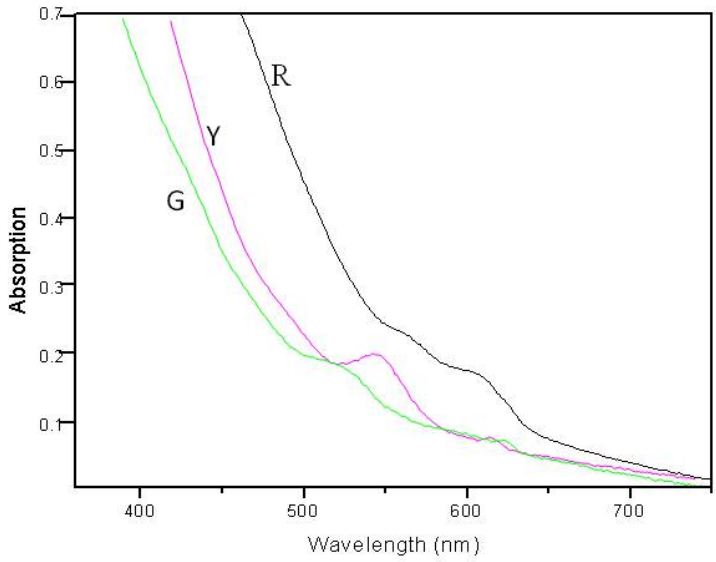

Figure S3 UV-vis absorption spectra of G-type (green), Y-type (yellow) and R-type original nanocrystals solution.

5. Multi-color fluorescent film

Figure S3 shows the PL spectra of another multi-color fluorescent film (100 nm) prepared with different ratio of the three fluorescent nanocrystals. The ratio of G-type, Y-type, and R-type nanocrystals was 1:1:2, where 0.025 ml, 0.025 ml, and 0.05 ml of the corresponding nanocrystal solutions were added into the mixture. The red emission at 618 nm increased with the excitation wavelength similar to the film shown in Figure 5c in the main manuscript.

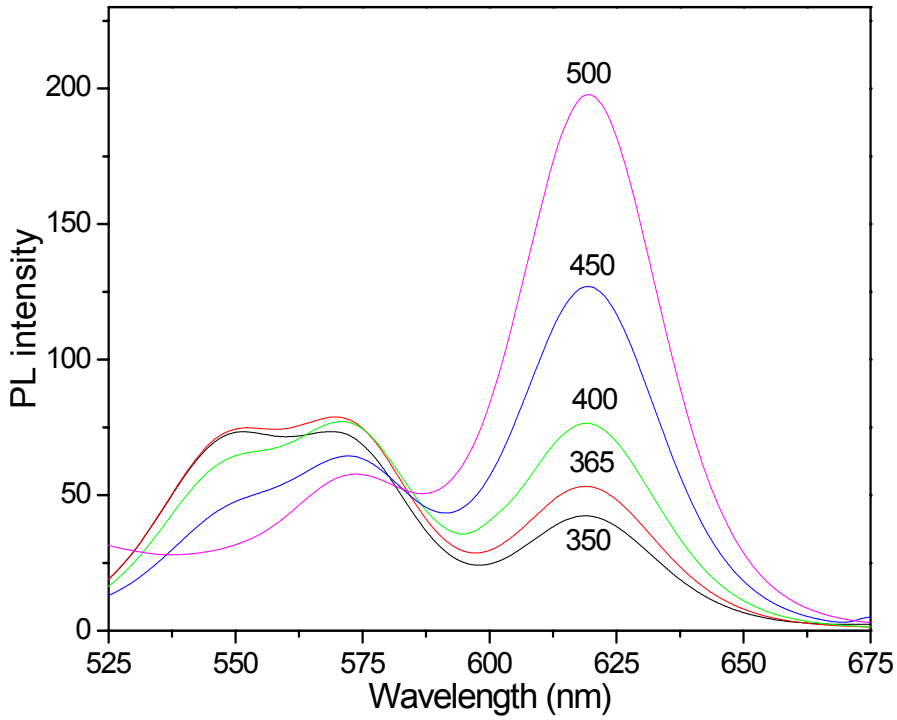

Figure S4 PL spectra of the film prepared from the weight ratio of 1:1:2 for G-type, Y-type, and R-type fluorescent nanocrystals. Excitation wavelength is shown on the peak tops at 618 mm.