Supplementary information-Exploring smartphone-based environmental sensors through applying perovskite quantum dots

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Materials and instruments

Cs_2CO_3 (99.9%), octadecene (ODE, 90%), oleylamine (OLA, 70%), oleic acid (OA, 90%) and $PbBr_2$ (99.999%) were purchased from Shanghai Aladdin Biochemical Technology Co., Ltd. (Shanghai, China). Toluene, *n*-hexane and ethyl acetate were obtained from Beijing Chemical Reagent Ltd. (Beijing, China). Potassium hydrogen phthalate (KHP, 99.99%) was purchased from the Beijing Institute of Chemical Reagents (Beijing, China).

Characterization of the $CsPbBr_3$ QDs was performed with a spectrometer (U-3900H, Hitachi), a spectrofluorometer (Fluorolog-3, Horiba Jobin-Yvon) and a transmission electron microscope (Tecnai F20, Philips). A smartphone (STK-AL00, Huawei Technologies Co., Ltd.) with a 1/2-inch complementary metal-oxide-semiconductor image sensor as the main camera (Sony Corporation, IMX586) was used as the smartphone platform for sensor development.

For UV-sensor development, to selectively transmit UV radiation in the UVA, UVB, and UVC regions, three band-pass filters with centre wavelengths of 370, 300 and 254 nm (#86-982, #12-093 and #39-312, Edmund Optics) were used in UV

sensor I. The bandwidths of these filters were 36, 50 and 10 nm, respectively. In the sensor-calibration experiment, an UV radiometer (LS125, Shenzhen Linshang Technology Co., Ltd.) containing three probe accessories (UVA-X1, UVB-X0 and UVC-X0) was used to obtain the reference UV-radiation values. The smartphone and probe accessory were synchronously fixed on a tripod with automatic rotation and balance functions (QADOU-s5B, Shanghai Lingchen Trading Co., Ltd.). Through Bluetooth wireless communication, a control was connected to the smartphone and remotely controlled the camera shutter. For COD-sensor development, an UV LED with a centre wavelength of 254 nm and power of 0.5 mW (SMD, Everlight Electronics, Ltd.) was used to measure the water COD.

$CsPbBr_3$ perovskite QDs preparation and characterization

The $CsPbBr_3$ QDs were synthesized based on a reported method with slight modification[1,2]. The caesium oleate solution was prepared by dissolving Cs_2CO_3 (0.814 g) in ODE (40 mL) and OA (2.5 mL), which was then loaded in a 100 mL three-neck flask and dried at 120 ℃ for 1 h. The mixed solution was then heated to 150 ℃ under blowing nitrogen until all of Cs_2CO_3 reacted with OA. After obtaining the reaction product, ODE (5 mL) and $PbBr_2$ (0.069 g) were loaded into a 25 mL three-neck flask and dried under vacuum at 120 ℃ for 1 h. Subsequently, OLA (0.5 mL) and OA (0.5 mL) were injected into the flask at 120 ℃ under blowing nitrogen. After complete dissolution of $PbBr_2$, the temperature was increased to 180 ℃ and caesium oleate solution (0.4 mL) was rapidly injected into the flask. The reaction mixture was cooled in an ice-water bath for 5 s. The $CsPbBr_3$ QDs were extracted from the crude solution after reaction by centrifugation at 10,000 rpm for 10 min. After centrifugation, the supernatant was discarded and the particles were washed twice with ethyl acetate. Finally, the $CsPbBr_3$ QDs were dispersed in toluene to form a long-term stable colloidal solution (Figure S1a). With regard to characterization of the $CsPbBr_3$ QDs, ultraviolet–visible (UV–vis) absorption spectroscopy with resolution of 0.5 nm was performed with an U-3900H UV–vis spectrophotometer and photoluminescence measurements were performed with a Fluorolog-3 spectrofluorometer equipped with an integrating sphere (Figure S1b and d). The transmission electron microscopy images were recorded with a Tecnai F20 microscope operated at 200 kV (Figure S1c).

References:

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2 Protesescu, L. *et al.* Nanocrystals of Cesium Lead Halide Perovskites (CsPbX3, X = Cl, Br, and I): Novel Optoelectronic Materials Showing Bright Emission with Wide Color Gamut. *Nano Lett.* **15**, 3692-3696, doi:10.1021/nl5048779 (2015).