Electronic Supplementary Material (ESI) for Nanoscale Advances.

Electronic Supplementary Information

Phosphorescent MoS_2 Quantum Dots as a Temperature Sensor and Security Inks

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Abstract

We included detailed information associated with TEM images, AFM images, absorption spectra, and fluorescence spectra of the FL-MoS_2 QDs, FL-WS_2 QDs, and N, S-doped CDs (Figures S1-S4), FT-IR spectra of the FL-MoS_2 QDs in the absence and presence of PVA matrices (Figure S5), TEM image and air stability of the FL-MoS_2 QD/PVA composites (Figures S6 and S7), phosphorescence of the CD/PVA composites as a function of temperature (Figure S8), and a comparison of the PQY of the FL-MoS_2 QD/PVA composites with previously reported PMs (Table S1).

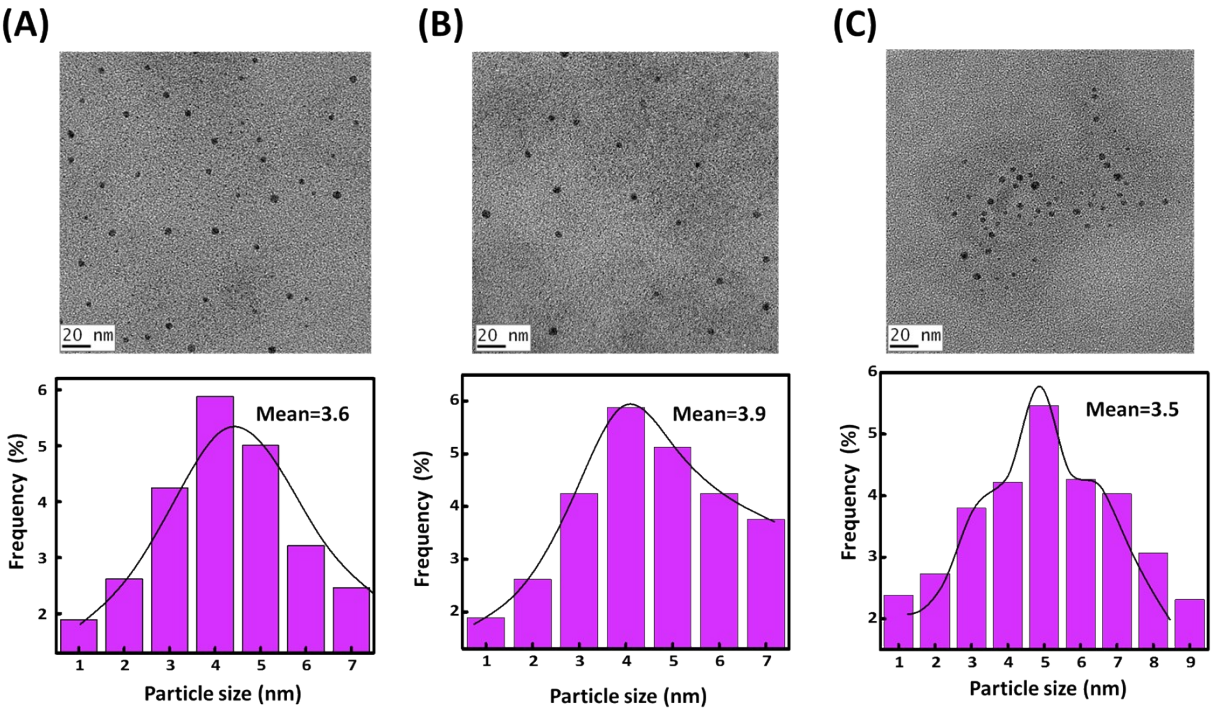

Figure S1. TEM images (top panel) and size distribution (bottom panel) of the (A) FL-MoS_2 QDs, (B) FL-WS_2 QDs, and (C) N, S-doped CDs.

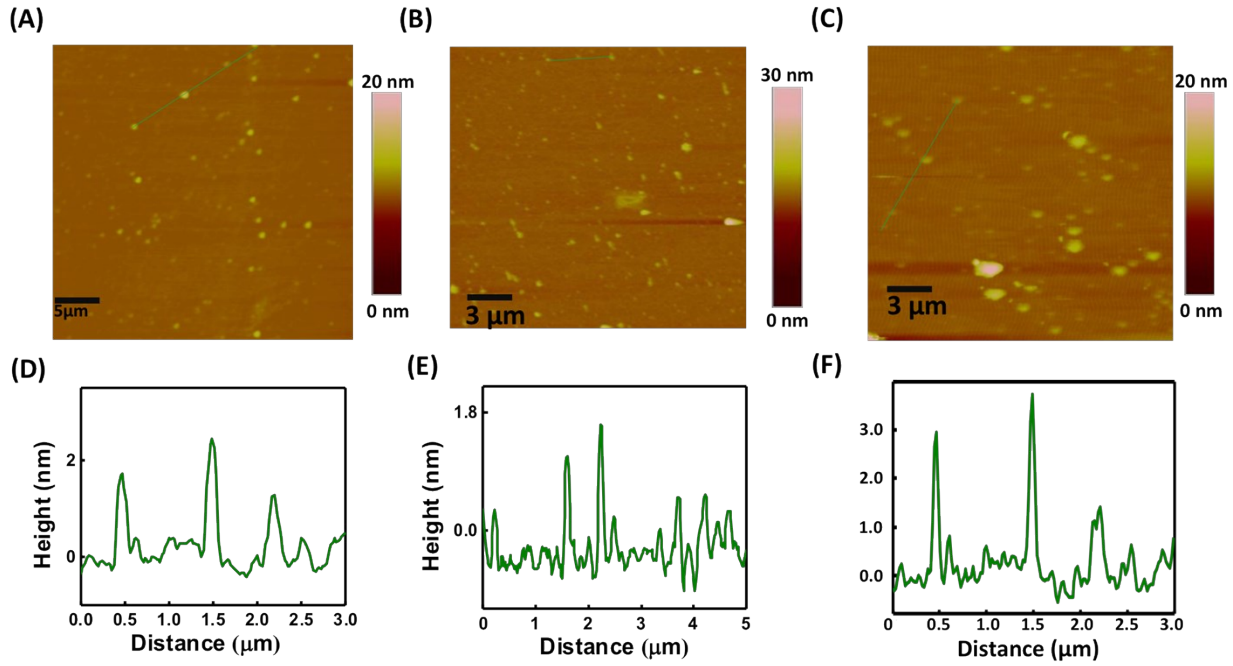

Figure S2. (A, B, C) AFM images and (D, E, F) height profiles of the (A, D) FL-MoS_2 QDs, (B, E) FL-WS_2 QDs, and (C, F) N, S-doped CDs.

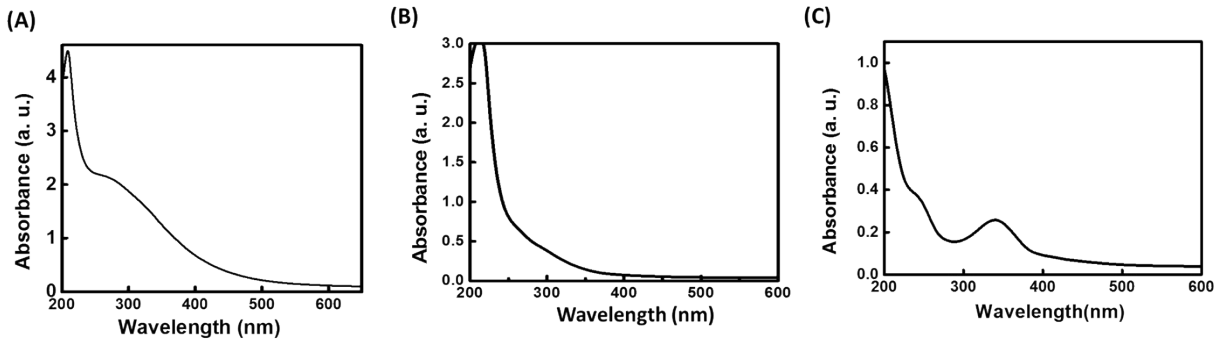

Figure S3. Absorption spectra of the (A) FL-MoS_2 QDs, (B) FL-WS_2 QDs, and (C) N, S-doped CDs.

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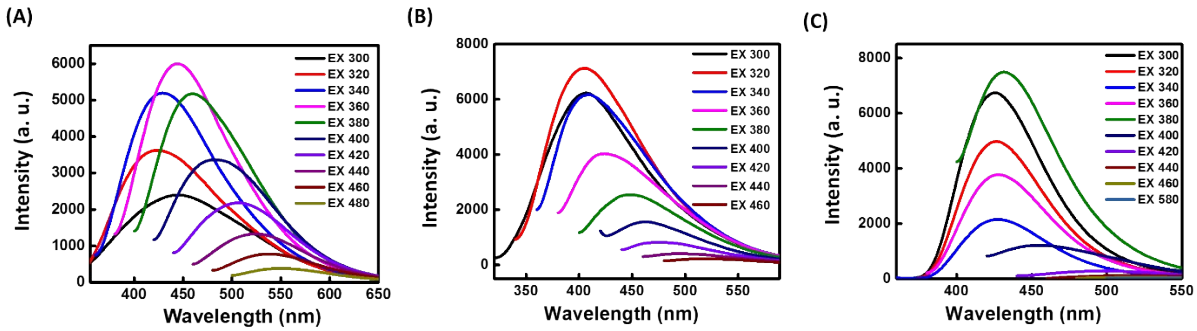

Figure S4. Fluorescence spectra of the (A) FL-MoS_2 QDs, (B) FL-WS_2 QDs, and (C) N, S-doped CDs.

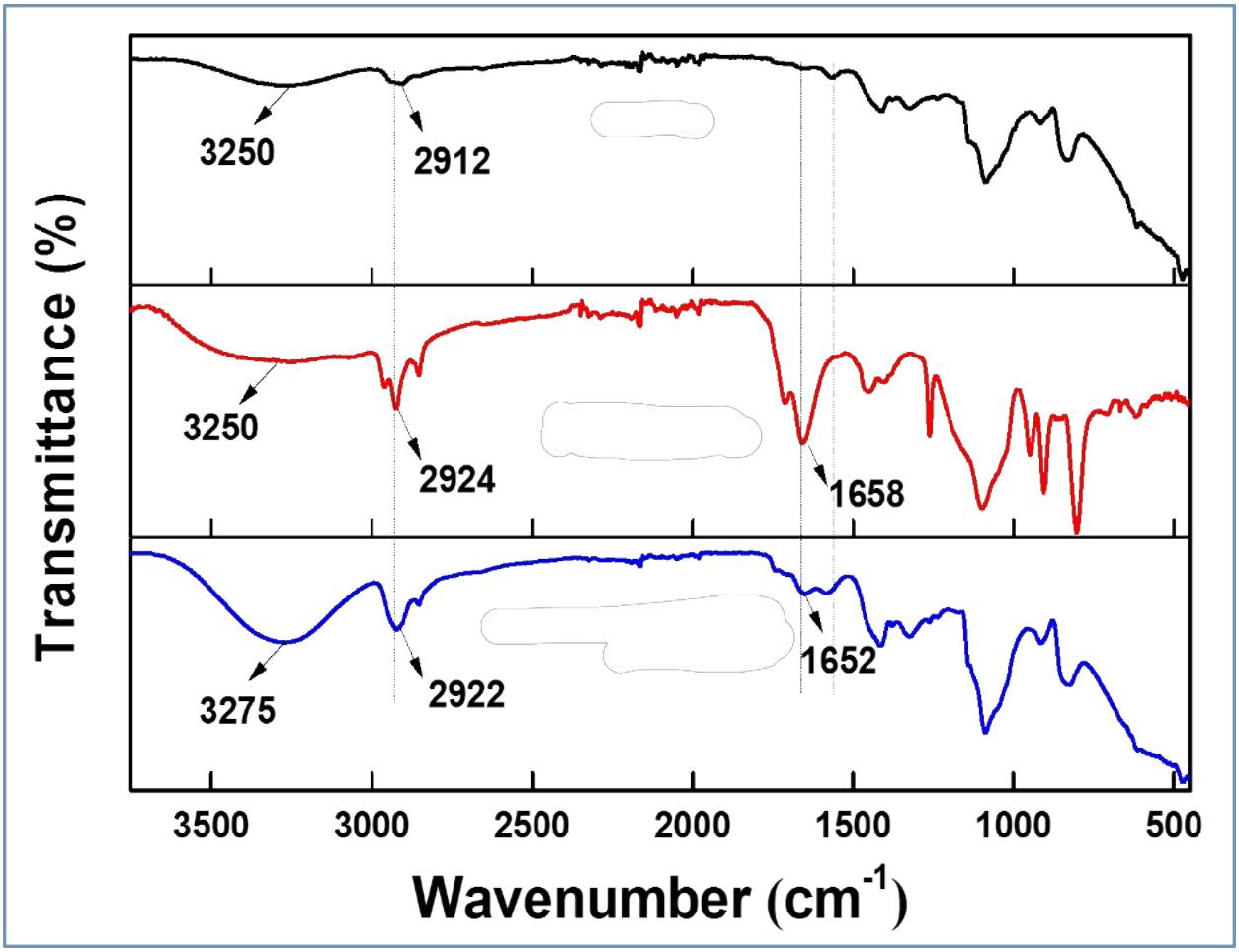

Figure S5. FT-IR spectra of PVA polymers (black line), the FL-MoS_2 QDs (red line), and the FL-MoS_2 QD/PVA composites (blue line).

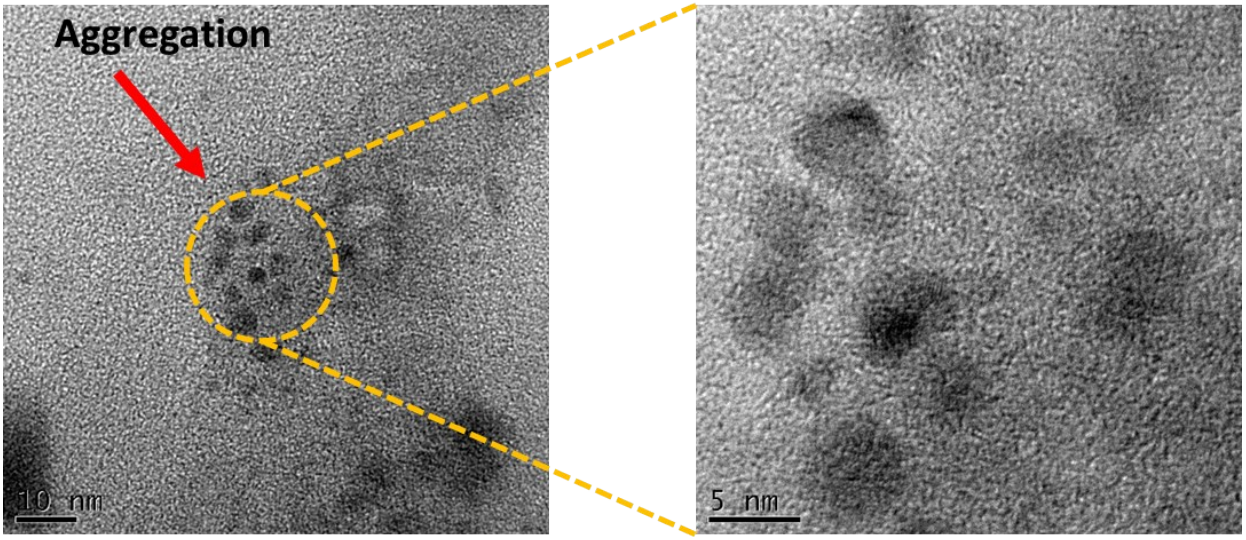

Figure S6. TEM image of the FL-MoS_2 QD/PVA composites. The red arrow indicates the aggregation of the FL-MoS_2 QDs. An enlarged image (right side) of the FL-MoS_2 QD/PVA composites in the yellow circle (left side).

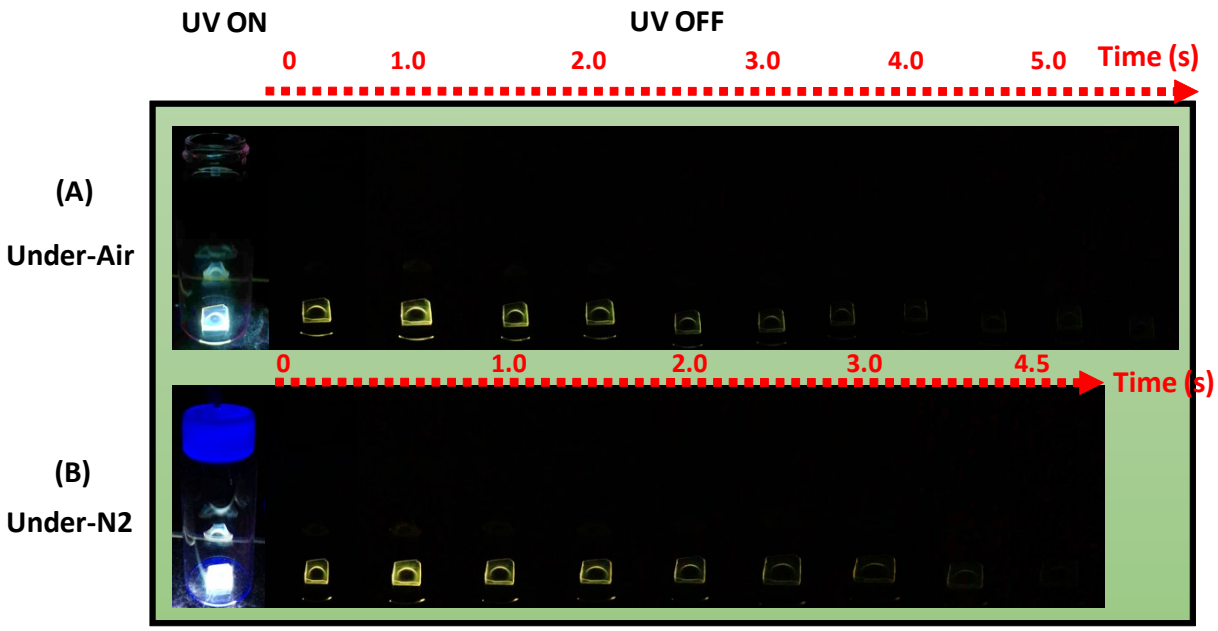

Figure S7. Time-evolution photographs of the FL-MoS_2 QD/PVA composites in (A) ambient air and (B) N_2 gas before and after turning off a UV lamp (365 nm) at ambient temperature.

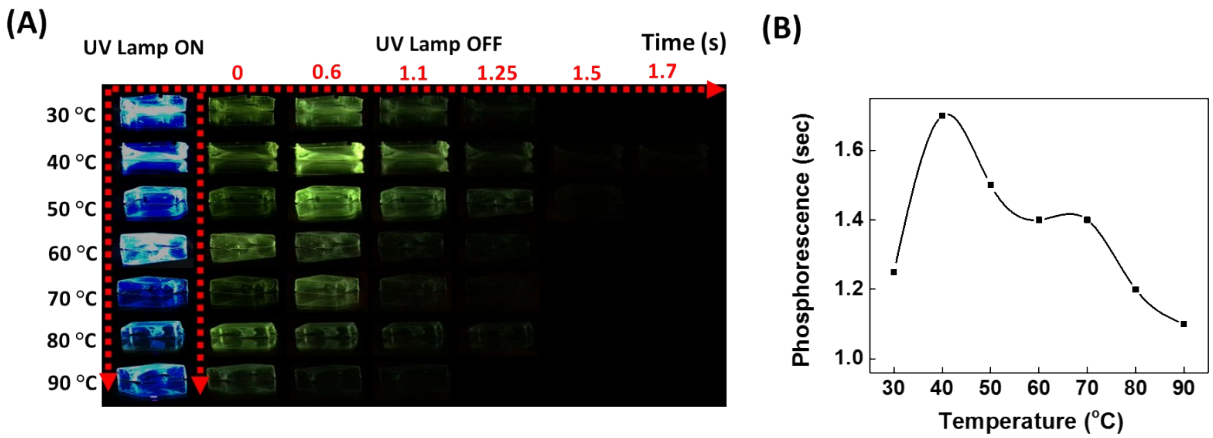

Figure S8. (A) Time-evolution photographs of the CD/PVA composites before and after turning off UV lamp at different temperatures. (B) Phosphorescence lifetime of the CD/PVA composites as a function of temperature from 30 to 90 ˚C

Table S1: Comparison of the present FL-MoS_2 QD/PVA composites with previously reported PMs in terms of QYs.

Materials	Environmental condition	QY (%)	References
Organic nanoparticles	Aqueous solution	1.59	Adv. Mater. 2017, 1606665
Zeolitic imidazolate framework-8	Organic solvent	0.82	Chem. Commun., 2017, 53, 1801–1804
Organic molecules	Organic solvent	20	Angew. Chem. Int. Ed. 2016, 55, 1–7
Organic materials	Aqueous solution	11.23	Sci. Adv. 2018;4: eaas9732
Carbon dots	Aqueous solution	1.3	Nat. Commun. 2019, 10, 206.
Carbon dot@ Zeolite	Aqueous solution	5.7	ACS Cent. Sci. 2019, 5, 349−356
Polymer carbon dots	Aqueous solution	28.77	Angew. Chem. Int. Ed. 2018, 57, 2393 –2398
Organic clusters	N/A	20	Nat. Commun. 2019, 10, 5161.
Organic materials	Aqueous solution	24	Angew. Chem. Int. Ed. 2014, 53, 11177 –11181
Organic materials	Organic solvent	2.9	Nat. Chem., 2011, 3, 205–210.
Organic materials	N/A	13	J. Mater. Chem. C, 2018, 6, 4603–4626
Carbon dots	Aqueous solution	3.45	Adv. Funct. Mater. 2018, 1800791
Layer-by-layer assembly	N/A	2.2	Nano Res. 2017, 10, 3606–3617.
Metal–organic frameworks	Organic solvent	4.76	Chem. Sci., 2016, 7, 4519–4526
Carbon dots	Powder	4.2	Angew. Chem. Int. Ed. 2020, 59, 1263-1269.
Single-conjugated aromatic unit	Solution	2.6	Adv. Optical Mater. 2017, 1600996

Organic molecules	N/A	7.2	Nat. Commun. 2017, 8, 416
Organic materials	Aqueous solution	11.23	Sci. Adv. 2018;4: eaas9732
Organic molecule	crystal	1.4	Angew. Chem. Int. Ed.2019, 58, 12102-12106.
Carbon dots	N/A	7	Chem. Mater. 2016, 28, 8221−8227
Carbon dots	powder	17.41	Nanoscale, 2019, 11, 16036–16042
Organic materials	N/A	9.58	J. Mater. Chem. C, 2019, 7, 230–236
Carbon dots	N/A	14	J. Mater. Chem. C, 2018, 6, 7890–7895
Layer-by-layer assembly	N/A	1.51	J. Mater. Chem. C, 2018, 6, 4444–4449
Polyphosphazenes derivatives	Organic solvent	1.0	Adv. Mater. 2020, 1907355
Carbon dots	Paper stripe	15.85	Carbon 2019, 152, 609–615
Organic dyes	Solid state	1.7	Dyes Pigm. 2012, 95, 161–167
Organic dyes	N/A	0.003	J. Photoch. Photobio. A 2014, 285, 16–20
Organic materials	N/A	11.4	Nano Res. 2020, 13, 875–881
FL-MoS_2 QD/PVA composites	Solid	20	Current work

N/A: Not available.