Supporting Information

Investigating a simple and sustainable photoluminescence improvement approach for a highly applicable perovskite-ZIF-8 hybrid material by using water

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Table S1. Water temperature monitoring during stirring PZ material in the water for 24 hours.

Water	0 h	4 h	8 h	12 h	16 h	20 h	24 h
19.2 °C	20.2 °C	23.3 °C	21.1 °C	21.1 °C	21.4 °C	21.2 °C	21.2 °C

Table S2. Water pH value monitoring during stirring PZ material in the water for 24 hours.

Water	0 h	4 h	8 h	12 h	16 h	20 h	24 h
7.00	6.98	6.69	6.66	6.79	6.79	6.79	6.79

Table S3. EDS elemental distribution table of PZ hybrid material before and after stirred in the water.

Element	Before	After
Zn	20.47%	48.34%
Cs	52.00%	33.08%
Pb	4.64%	4.56%
Br	22.89%	14.02%

Table S4. The fitting parameters of PL decay plots of $CsPbBr_3$ and PZ hybrid material before and after (BW and AW) stirred in the water using an emission wavelength of 522 nm (λ_{ex} = 360 nm).

Sample	$\tau_{average}$ (ns)
$CsPbBr_3$ BW	34.29
PZ BW	82.79
$CsPbBr_3$ AW	52.71
PZ AW	109.28

Table S5. The fitting parameters of PL decay plots of ZIF-8+Ligands and PZ hybrid material before and after (BW and AW) stirred in the water using an emission wavelength of 428 nm (λ_{ex} = 360 nm).

Sample	$\tau_{average}$ (ns)
ZIF-8+Ligands BW	7.73
PZ BW	5.77
ZIF-8+Ligands AW	7.76
PZ AW	6.06

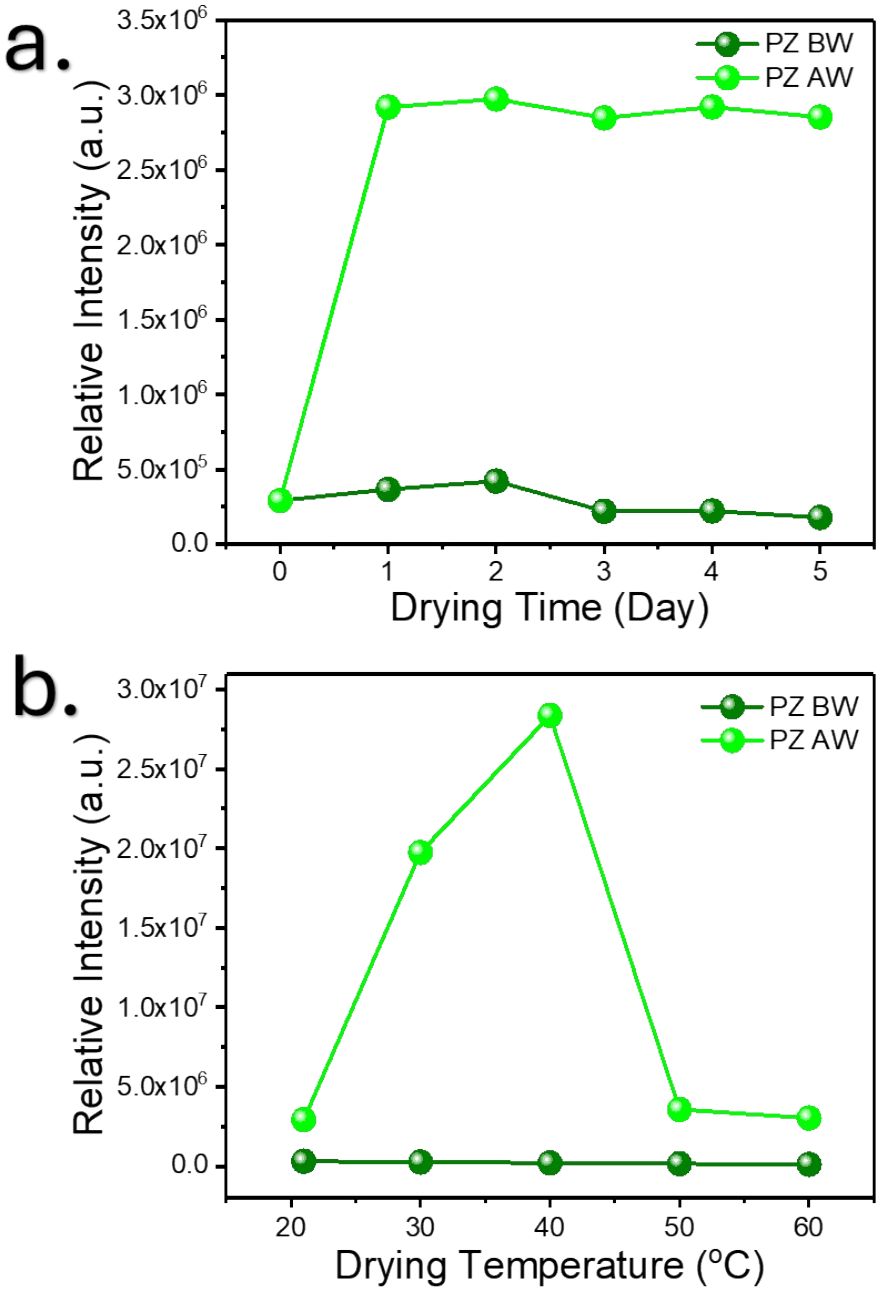


Figure S1. PL intensity op PZ hybrid material comparison for different vacuum drying process; (a) different vacuum drying time (room temperature, 21 °C) and (b) different vacuum drying temperature (for 24 hours).

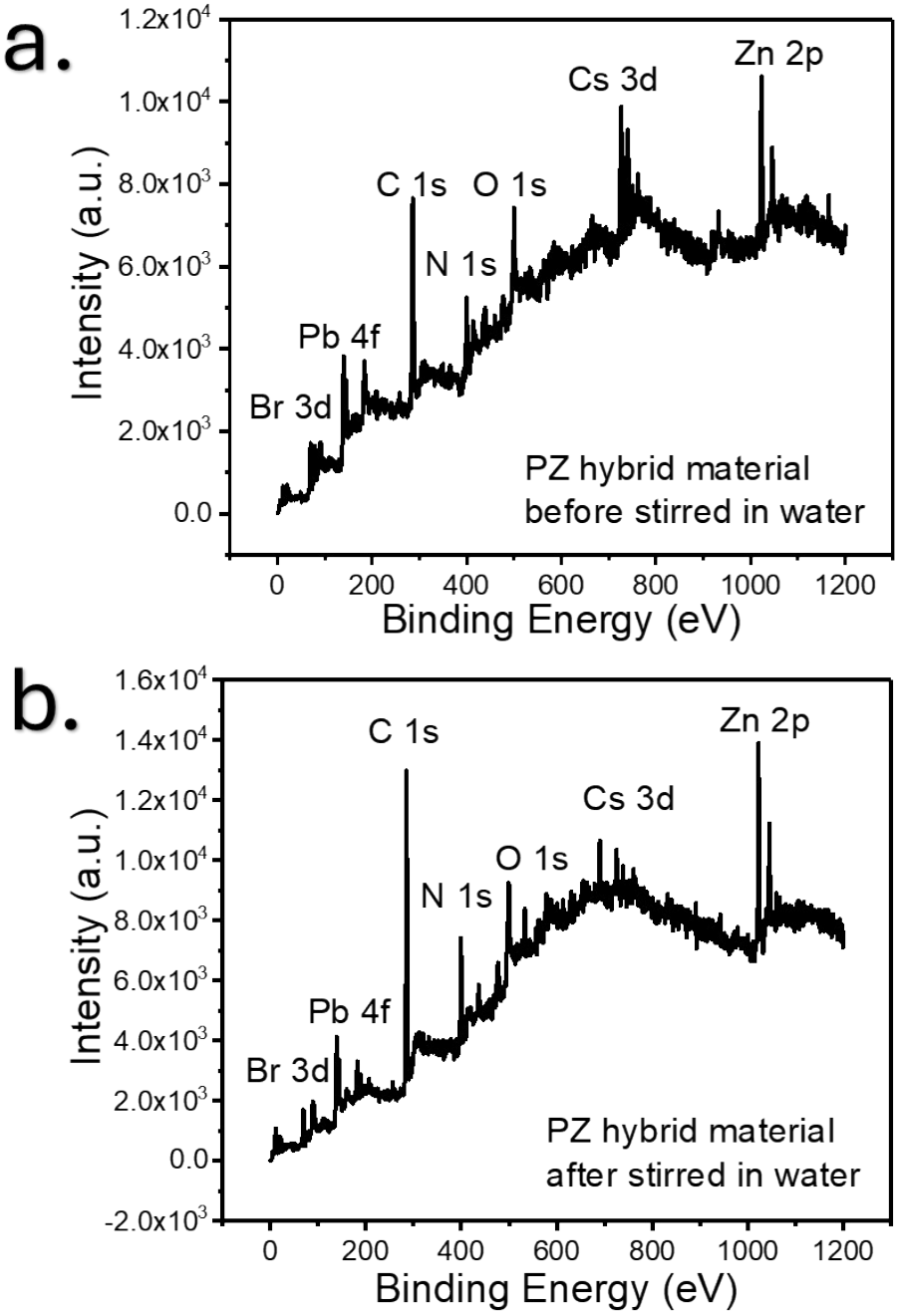


Figure S2. Full XPS spectra of PZ hybrid materials (a) before and (b) after stirred in the water.

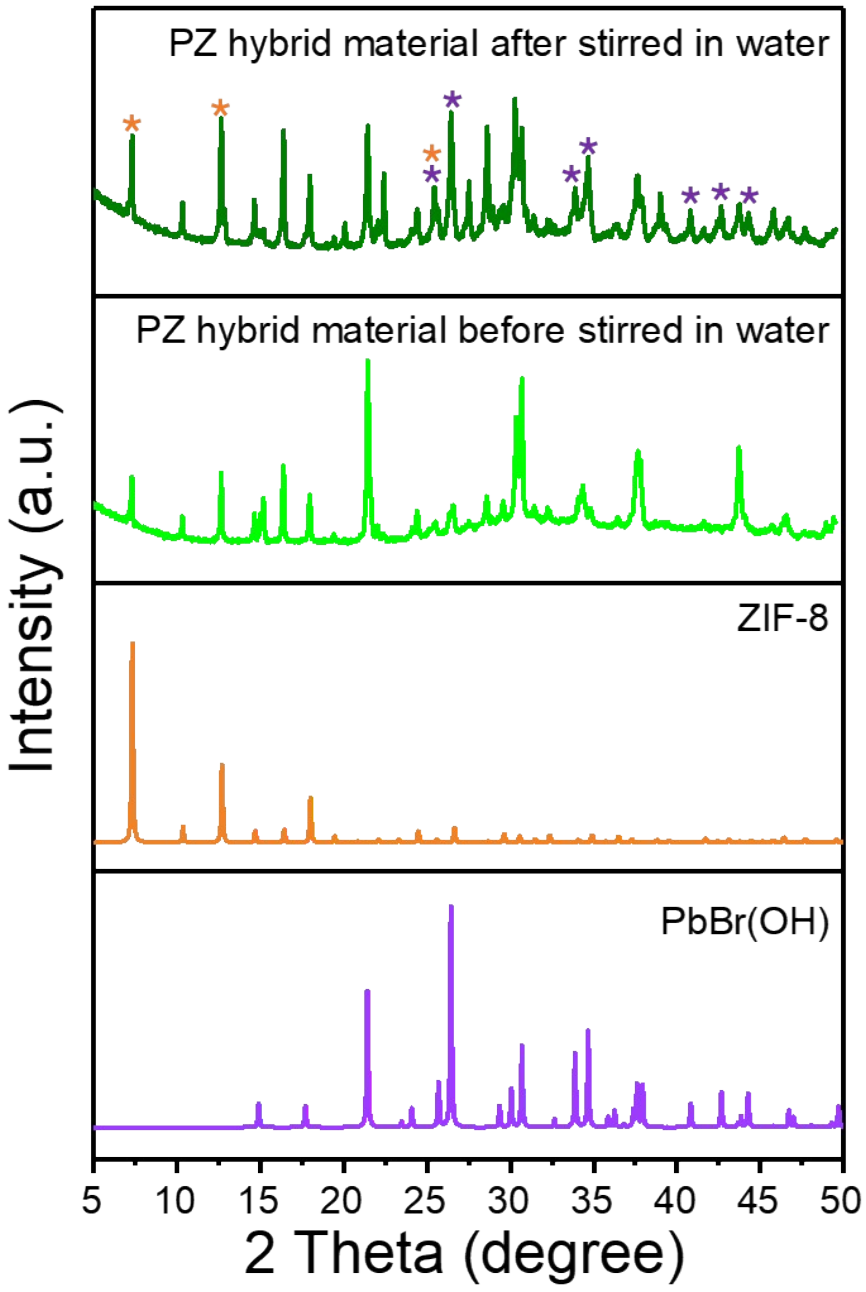


Figure S3. XRD patterns of the PZ hybrid materials before and after stirring in the water matched with the PbBr(OH) reference pattern signed by purple colour stars "*", and ZIF-8 and Pb-ZIF-8 references pattern signed by orange colour stars "*" mean the significant increased peaks in the PZ hybrid material after stirring in the water.

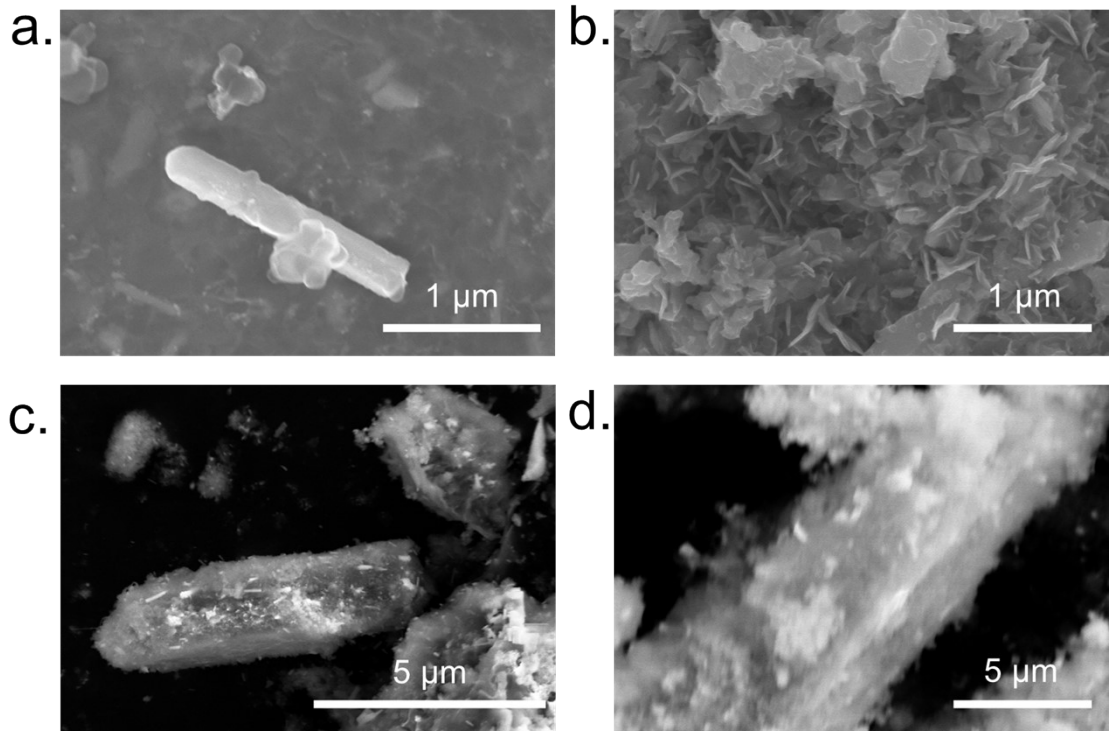


Figure S4. HR-SEM images of (a) rod and (b) micro flower morphology that we believed PbBr(OH). (c-d) HR-SEM image of a bigger needle-shaped crystal in PZ hybrid material after stirring in water that we assumed was a Pb-ZIF-8 crystal.

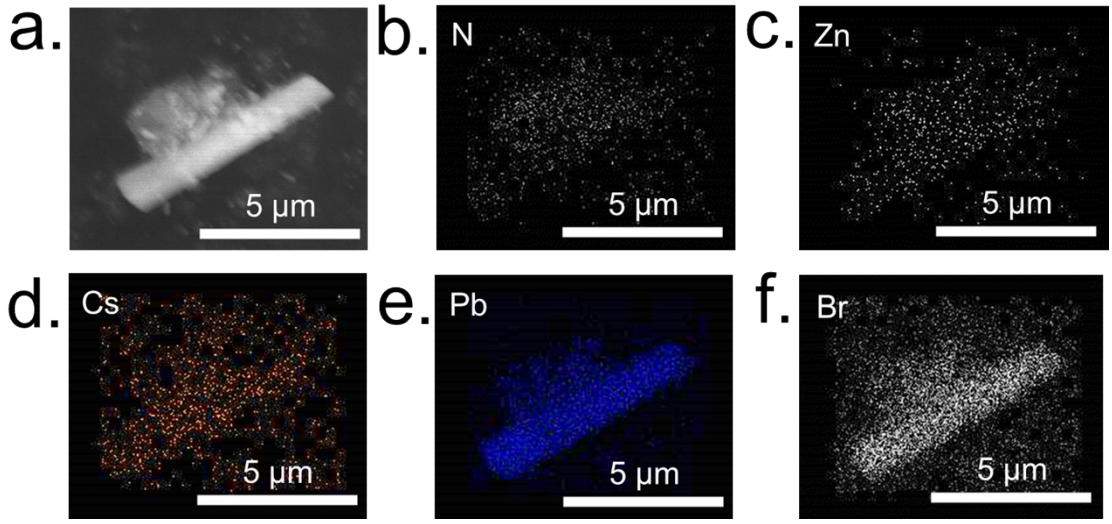


Figure S5. (a) HR-SEM images of needle-like crystal in PZ hybrid material after stirring in the water that assumed as rod PbBr(OH) with its (b-f) EDS elemental mapping for each element N, Zn, Cs, Pb, and Br.

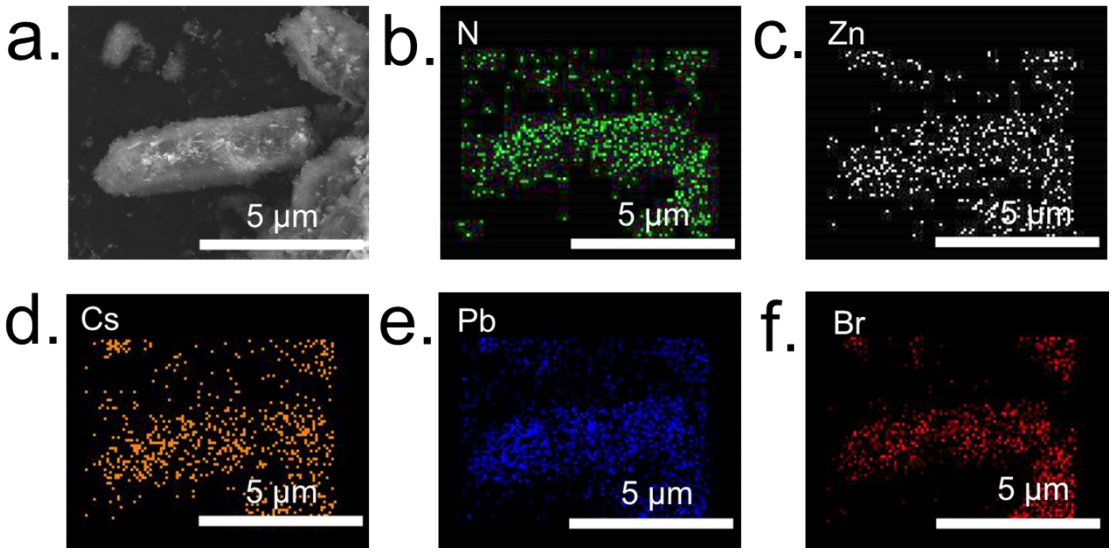


Figure S6. (a) HR-SEM images of needle-like crystal in PZ hybrid material after stirring in the water that assumed as Pb-ZIF-8 with its (b-f) EDS elemental mapping for each element N, Zn, Cs, Pb, and Br.

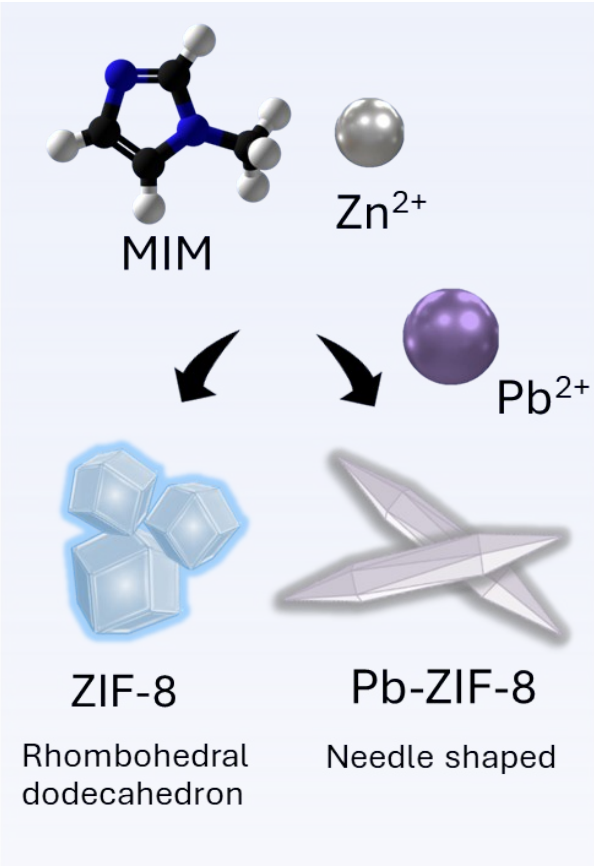
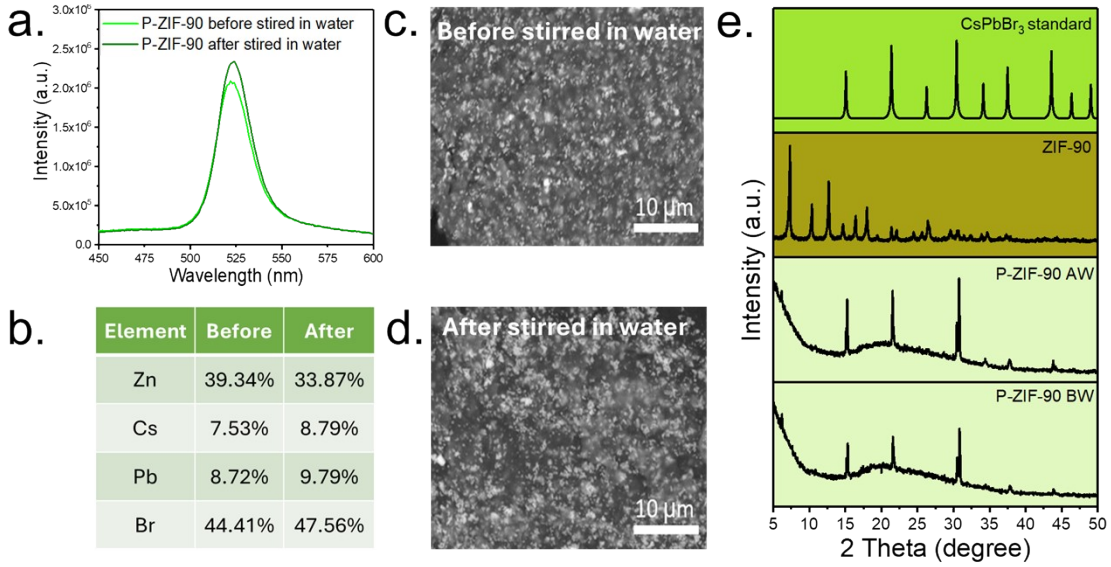


Figure S7. The scheme of difference morphology of ZIF-8 and Pb-ZIF-8.



Element	Before	After
Zn	39.34%	33.87%
Cs	7.53%	8.79%
Pb	8.72%	9.79%
Br	44.41%	47.56%

Figure S8. Perovskite-ZIF-90 composite characterization using the same method as PZ hybrid material (with ZIF-8). (a) P-ZIF-90 PL spectra before (BW) and after (AW) stirred in water, (b) EDS atomic distribution percentage in the P-ZIF-90, (c-d) SEM images, and (e) XRD patterns of P-ZIF-90 material.

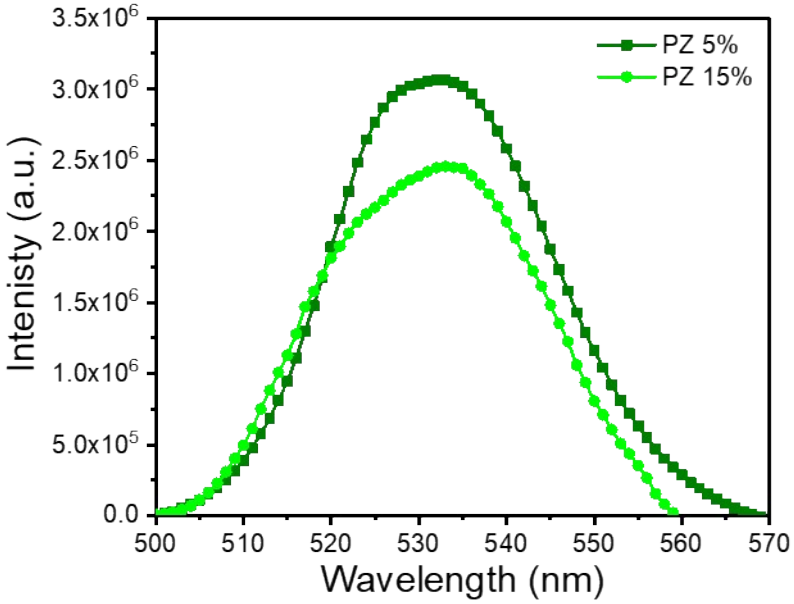


Figure S9. PL intensity comparison of LED device from PZ BW material with different concentration.

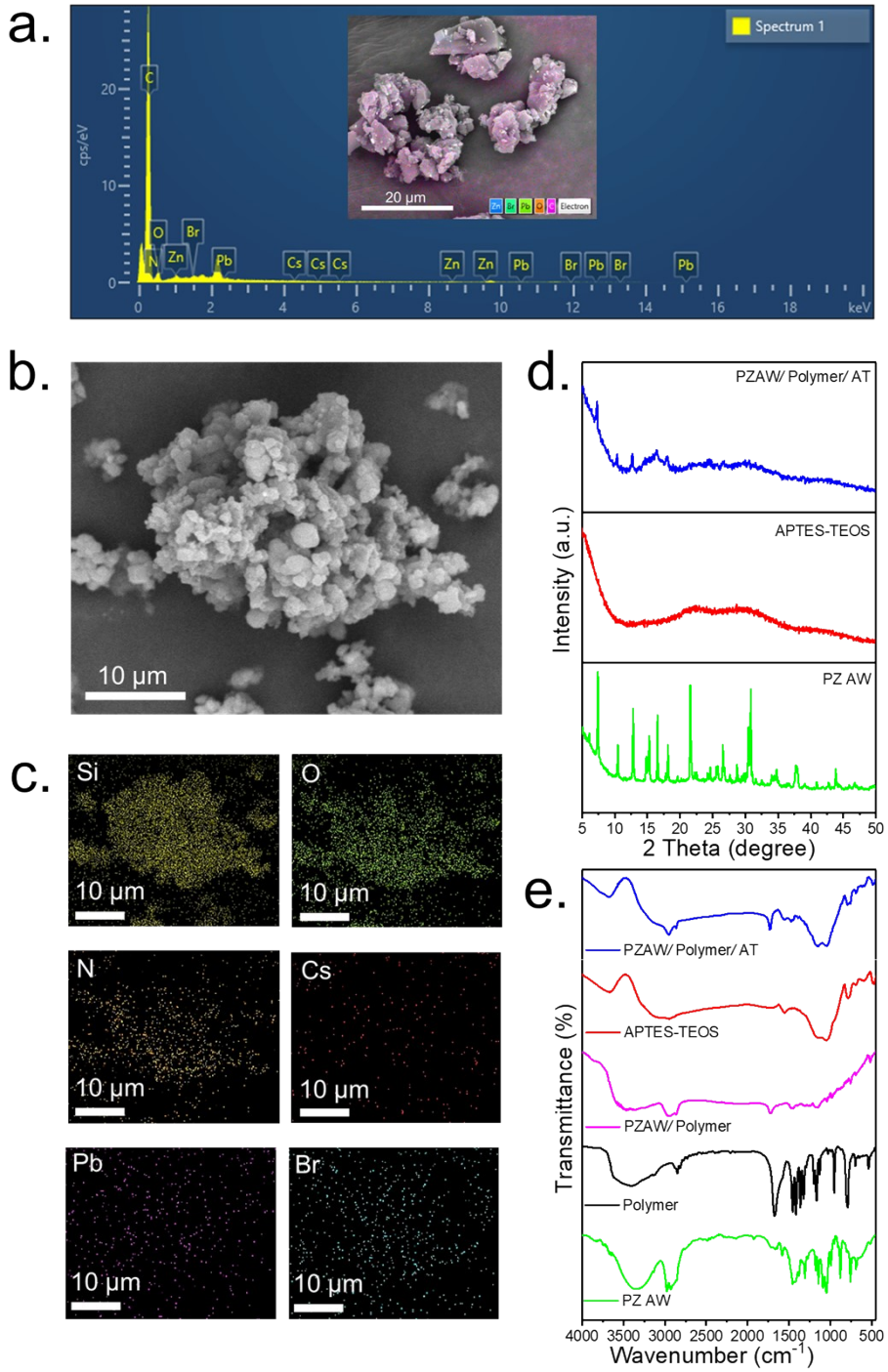


Figure S10. (a) SEM and EDS image of PZ hybrid material after stirring in the water, combined with polymer. (b) SEM image, (c) EDS elemental distribution, (d) XRD pattern, and (e) FTIR analysis of PZ hybrid material after stirring in the water, combined with polymer and coated with APTES-TEOS.

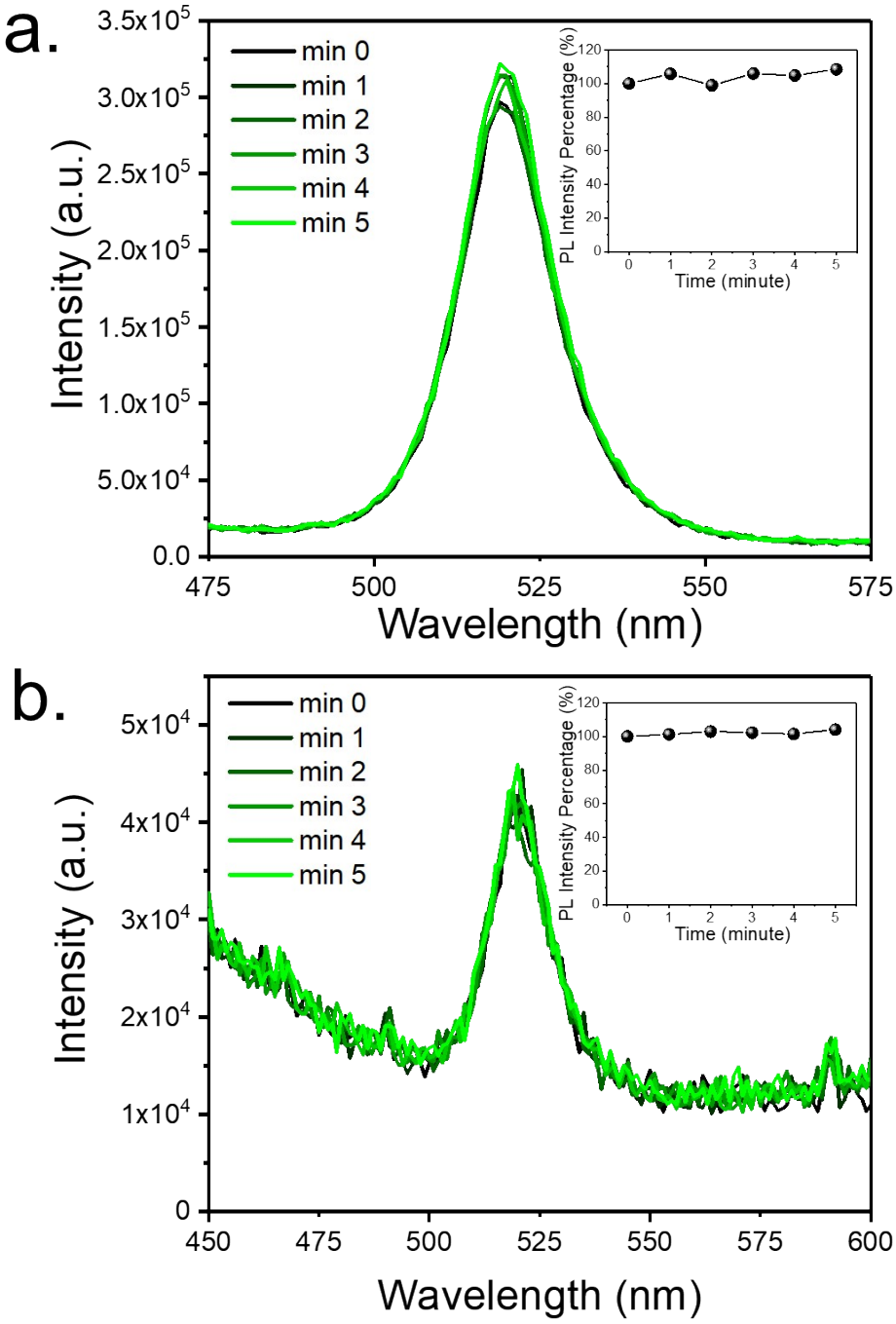


Figure S11. Fluorescence stability of (a) PZAW/Polymer/AT and (b) PZBW/Polymer/AT in the water for five minutes.

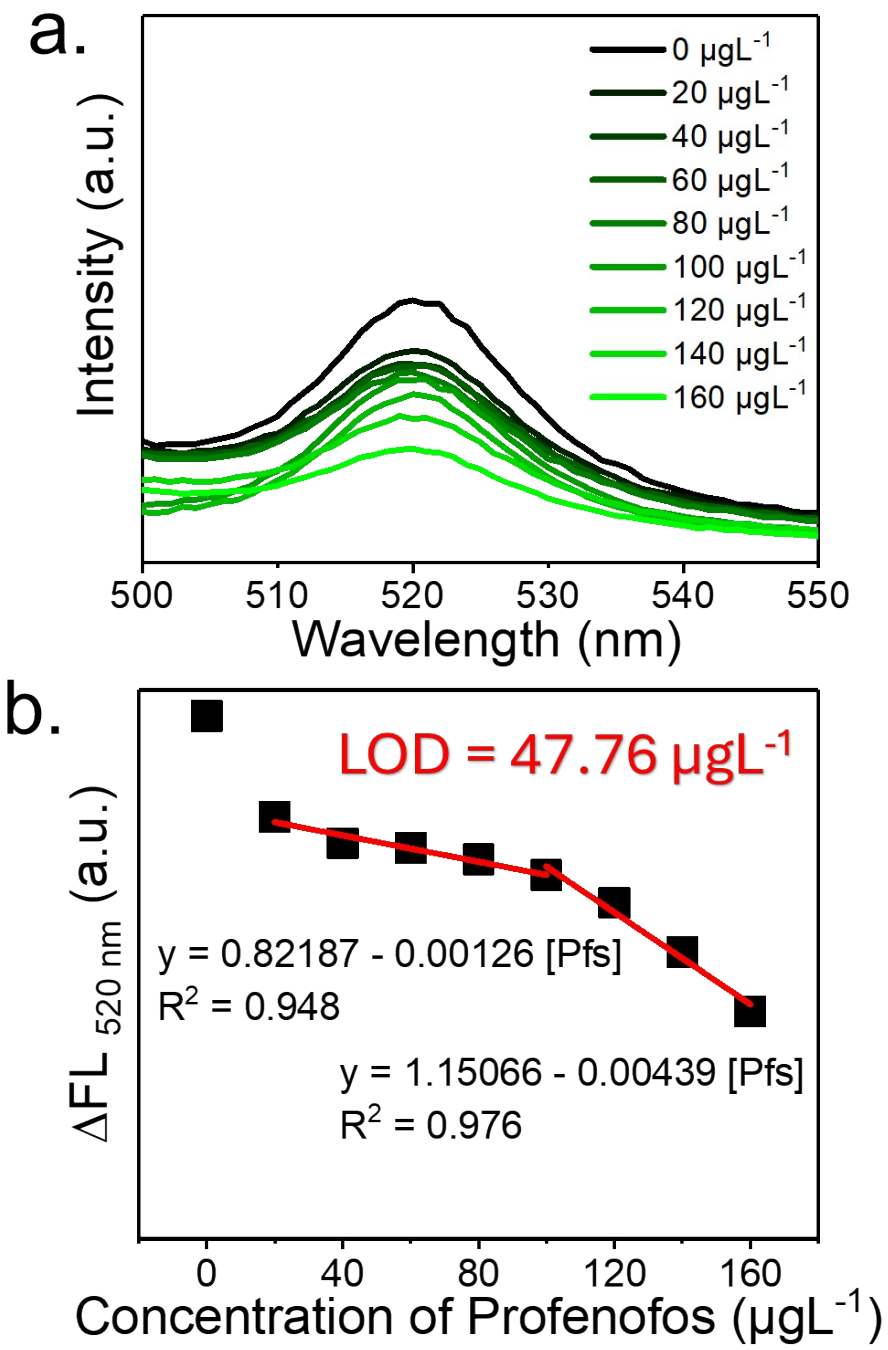


Figure S12. Fluorescence sensor performance of PZBW/Polymer/AT. (a) Fluorescence quenching spectra and its (b) linear fitting graphic for calculating LOD.