Electronic Supplementary Material (ESI) for Analytical Methods.

Supplementary data

Clarity improvement of discoloration boundary and detection of Hg^{2+} ions by polystyrene nanoparticle-modified paper-based microdevice

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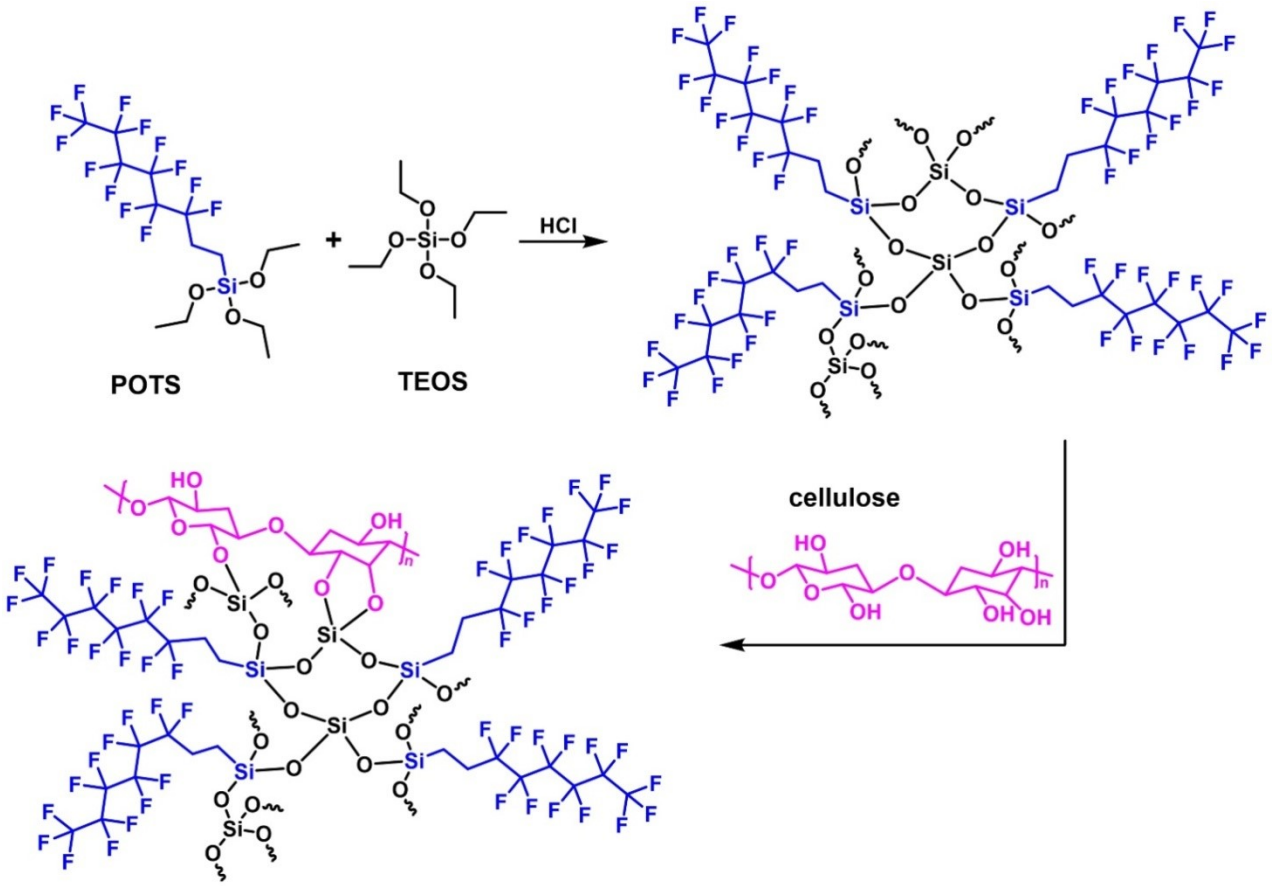


Figure S1. Preparation of the hydrophobic ink and its reaction with cellulose.

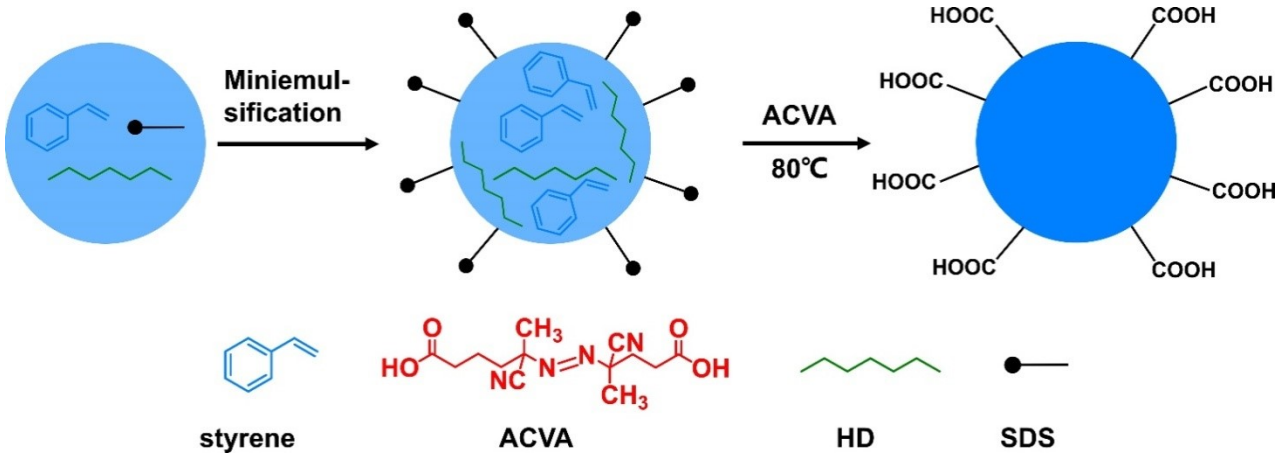


Figure S2. Schematic illustration of the PS NPs preparation route.

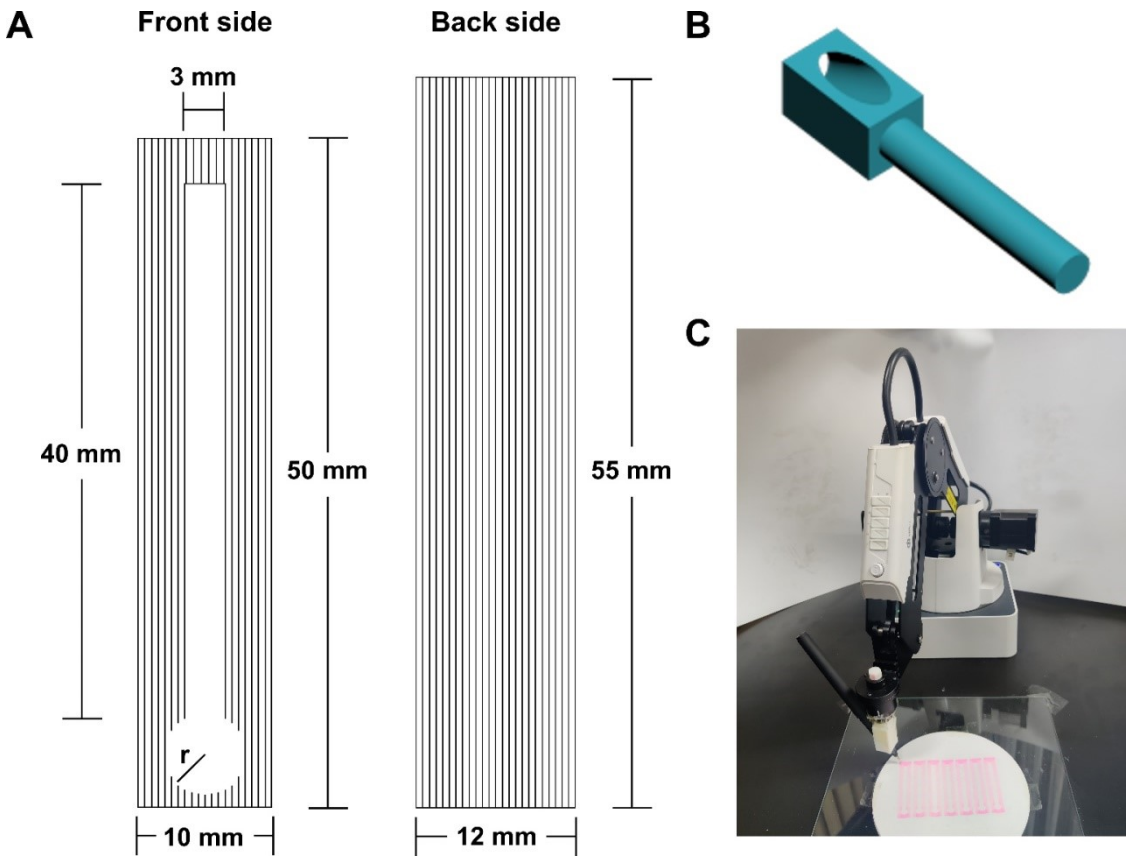


Figure S3. Design illustration of (A) single-channel μPAD (r = 2.5 mm) and (B) pen-holding assembly. (C) Working image of the robotic arm with pen-holding assembly.

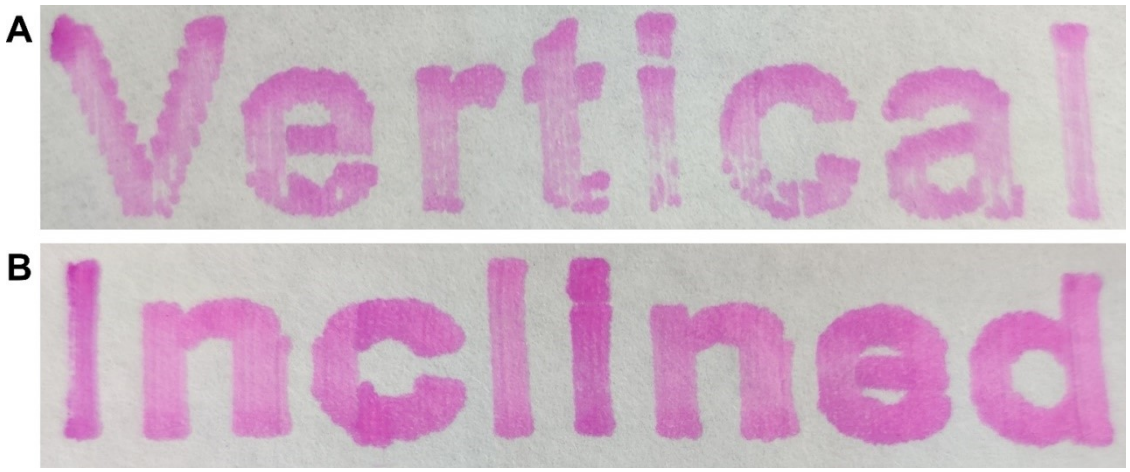


Figure S4. Clamping method optimization. (A) Vertical clamping to write the word 'Vertical'. (B) Inclined clamping to write the word 'Inclined'.

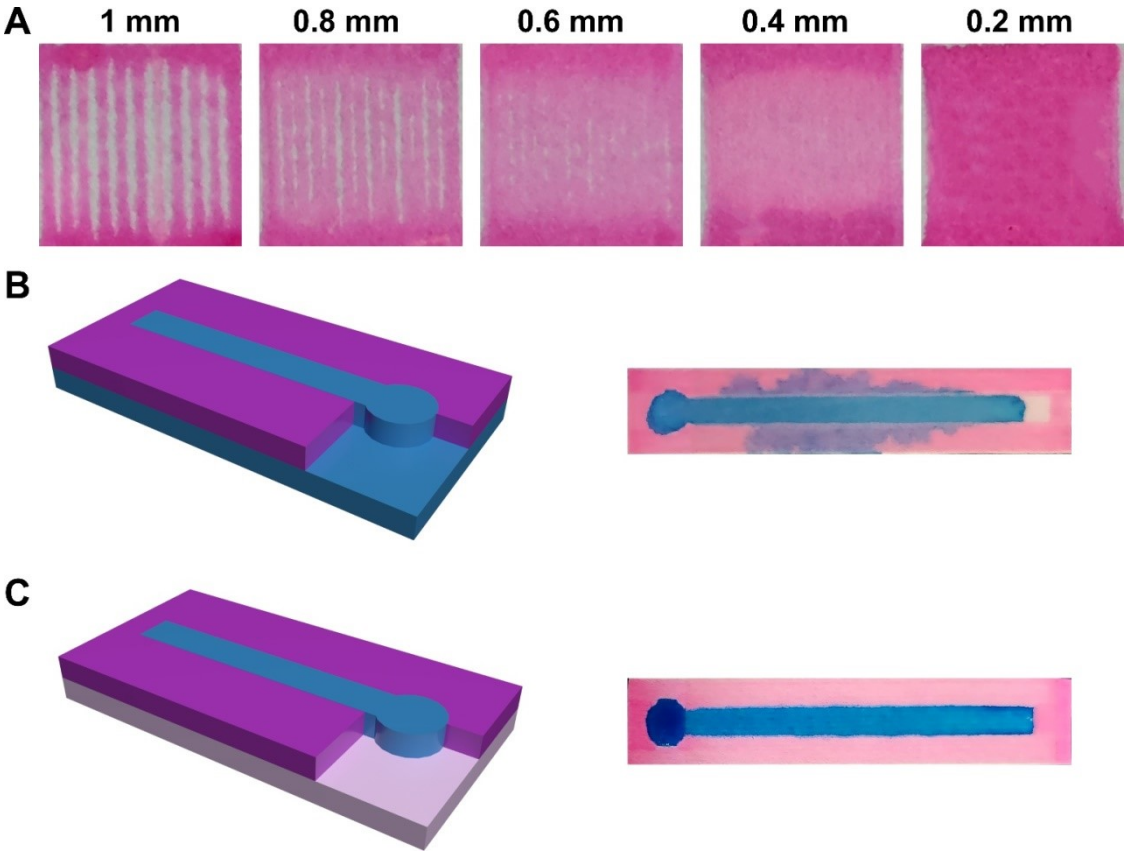


Figure S5. (A) Optimization of the drawing intervals. Solution flow of the μPADs drawn on the top side (B) and both sides (C).

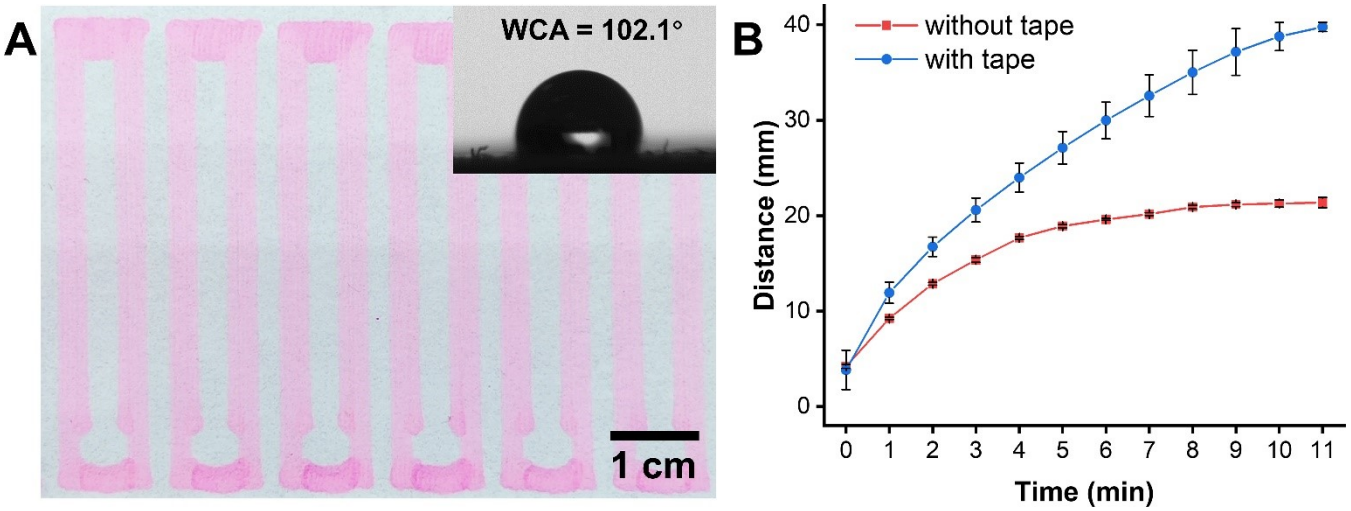


Figure S6. (A) Optical image of μPAD (inset: water contact angle image of the hydrophobic region). (B) Variation of the flow distance with and without tape encapsulation.

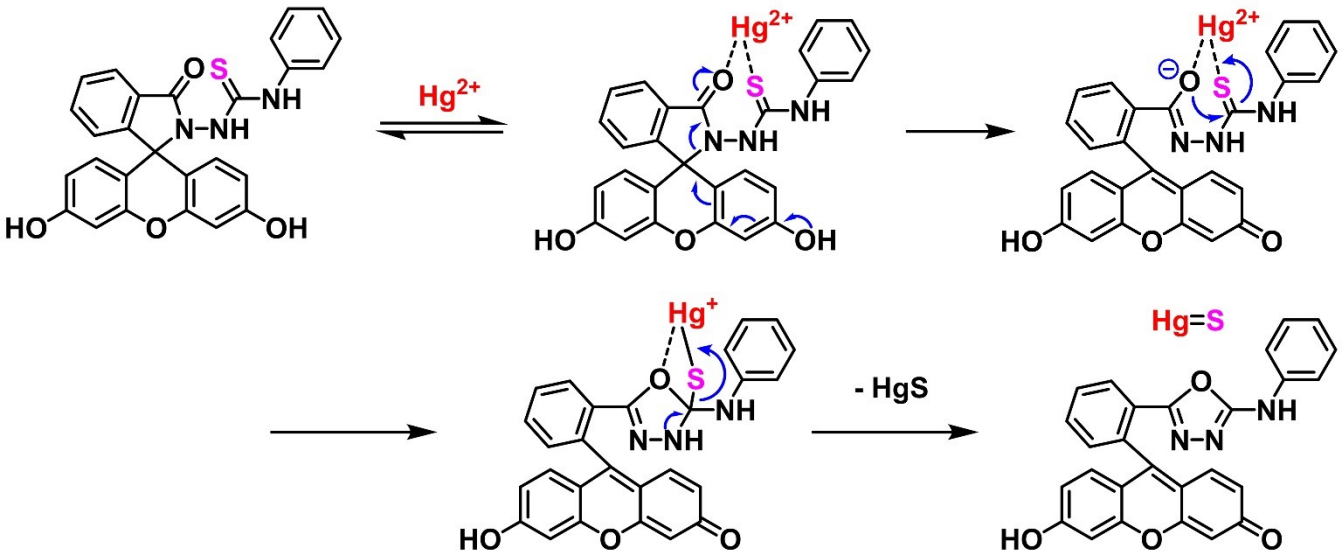


Figure S7. The reaction mechanism of Hg^{2+} ions detecting with FLPI.

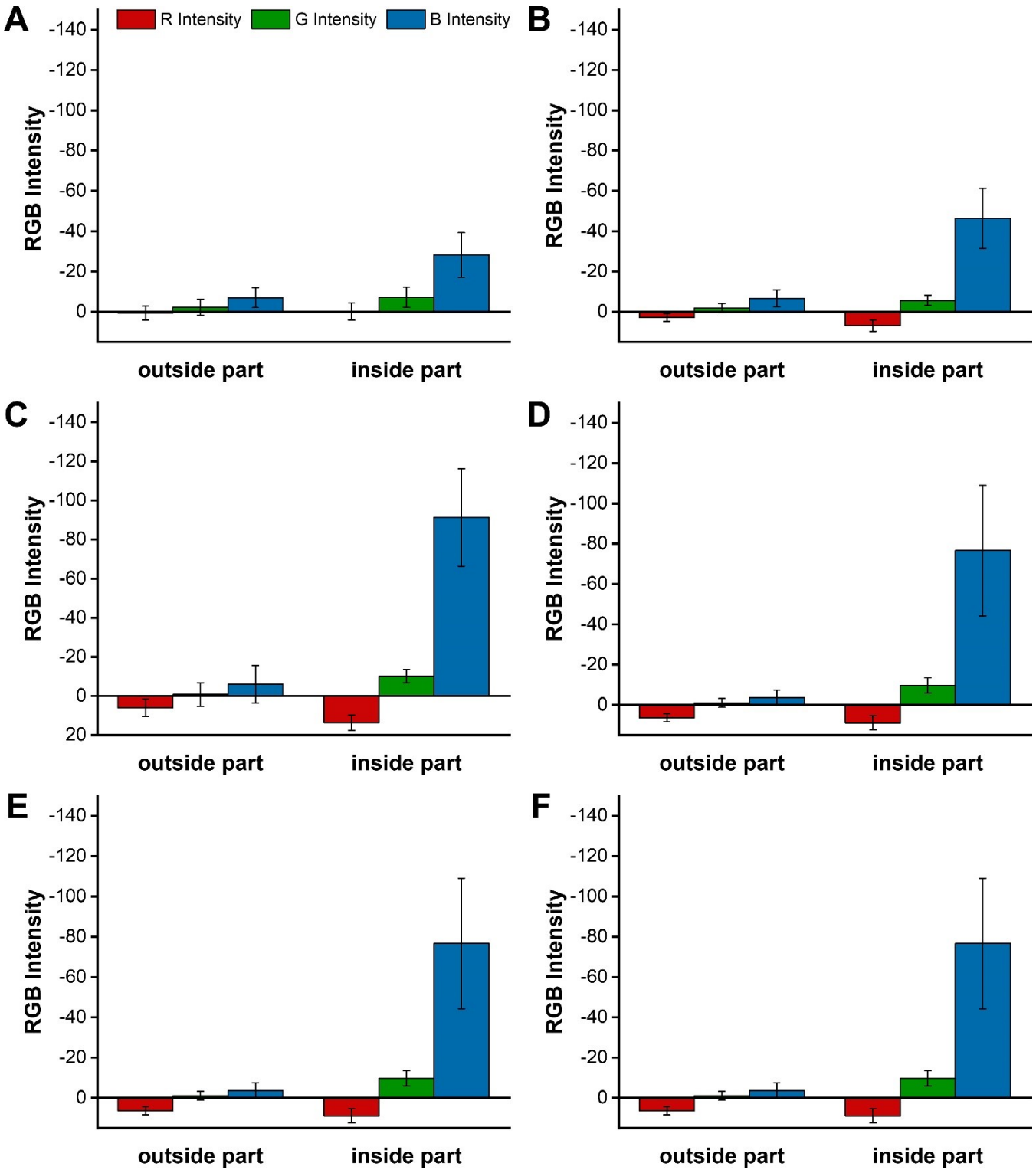
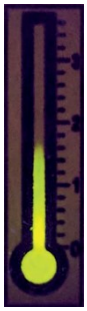
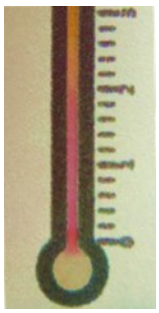


Figure S8. RGB values of the inside and outside part after modified μPAD with (A) 0 μL, (B) 10 μL, (C) 20 μL, (D) 30 μL, (E) 40 μL, and (F) 50 μL of PS NPs suspension.

Table S1. Detection of Hg^{2+} ions in real samples.

Sample	Added (μM)	PS-μPAD		LC-AFS	
		Found (μM)	Recovery ± RSD (%)	Found (μM)	Recovery ± RSD (%)
Tap water	250	243.5	97.4 ± 8.9	246.7	98.7 ± 5.3
	500	515.4	103.1 ± 5.0	501.1	100.2 ± 4.9
	750	742.0	98.9 ± 6.3	757.5	101.0 ± 6.7

Table S2. Comparison of the proposed method with other distance-based methods of Hg^{2+} detection.

Material	SD of the measurements (%)	LOD (nM)	Detection time (min)	Real sample type	Reference
DNA	 0.0688	10	25	lake water	1
carbon dots	 0.3209	29.9	40	drinking water pond water tap water	2
DNAzyme	 0.0599	0.23	35	lake water tap water river water	3
dithizone	 0.3237	4.64×10^3	N/A	whitening cream	4
small molecular probe	 0.1420	6.45×10^4	15	tap water	This work

References

1 T. Dong, G. A. Wang, M. W. Li and F. Li, *Anal. Methods*, 2019, **11**, 5376-5380.

2 B. Ninwong, P. Sangkaew, P. Hapa, N. Ratnarathorn, R. F. Menger, C. S. Henry and W. Dungchai, *RSC Adv.*, 2020, **10**, 9884-9893.

3 C. Wu, G. Gao, K. Zhai, L. Xu and D. Zhang, *Food Chem.*, 2020, **331**, 127208.

4 L. Cai, Y. Fang, Y. Mo, Y. Huang, C. Xu,Z. Zhang and M. Wang, *AIP Adv.*, 2017, **7**, 085214.