Supplementary Information

Colorimetric and dynamic light scattering dual-readout assay for formaldehyde detection based on hybridization chain reaction and gold nanoparticles

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Materials and reagents

All DNA sequences were purchased from Sangon Co., Ltd. (Shanghai, China), and the sequences are shown in Table S1. Chloroauric acid was purchased from Sinopharm Chemical Reagent Co., Ltd (Shanghai, China). Trisodium citrate and silver nitrate were purchased from Aladdin Reagent Co., Ltd. (Shanghai, China). Formaldehyde solution purchased from Guangdong Guanghua Technology Co., Ltd. Ultrapure water (18.25 MΩ·cm) was obtained from a Milli-Q water purification system. The NaAc-HAc buffer (10.0 mmol L^{-1}, pH 5.0) used to dissolve the DNA sequence dry powder was prepared by the laboratory, and both sodium acetate and acetic acid were purchased from Guangzhou Chemical Reagent Factory. Trichloroethyl phosphate (TCEP) used for DNA sequence reduction was purchased from Sangon Co., Ltd. The PBS buffer (10.0 mmol L^{-1}, pH 7.4, containing 0.1 mol L^{-1} NaCl) was prepared by the laboratory, and disodium hydrogen phosphate, sodium dihydrogen phosphate and sodium chloride were purchased from Guangzhou Chemical Reagent Factory. DNA molecular weight standard marker A (DNA marker), 30% acrylamide/methylenediacrylamide solution, ammonium persulfate (APS), N,N,N, N-tetramethylenediamine solution (TEMED solution), 6 × polysucrose gel loading buffer (6 × loading buffer), 5 × triborate EDTA buffer (5 × TBE buffer), 4S Red nucleic acid stain were purchased from Sangon Co., Ltd. Air samples were collected from the laboratory at Sun Yat-sen University.

Apparatus

The indoor air was sampled using a peristaltic pump (Chuangrui YZ1515X). UV−vis absorption spectra were recorded on the Shanghai Elite ultraviolet-visible spectrophotometer. The diameter of AuNPs was measured using a Malvern 2000E nanometer/Zeta potentiometer (Malvern Instruments, UK). Transmission electron microscopy (TEM, JEM-3010) was used to characterize AuNPs. Gel electrophoresis images were photographed using a JY02S Gel Image Analysis System. A smartphone

with a 64 megapixel camera (Vivo S7) was used to photograph the color of AuNPs solution, the exposure time is set to 0.01s. A round LED lamp with a diameter of 26 cm was used to maintain constant illumination during the shooting process. The LED lamp and the smartphone were fixed 11 cm and 10 cm above the measuring tube, respectively. The measuring tube was placed on a white A4 paper, and the smartphone application *color* collect was adopted to read the RGB values from the center of the measuring tube.

Fig. S1 Setup image for the colorimetric analysis

Polyacrylamide gel electrophoresis analysis

The HCR process was investigated by polyacrylamide gel electrophoresis. As shown in Figure S1, column 1 is the band of DNA marker. Columns 2, 3, and 4 are H1, H2, and HP strips, respectively. The 5th column is H1 + H2 band, weak band can be seen, HCR substrate chain has some extension, but no more HCR products are formed. The sixth column is H1 + H2 + HP bands, and stronger bands can be observed, accompanied by the attenuation of substrate chain bands, indicating that more substrate chains are consumed after HCR reaction, resulting in the prolonged HCR products.

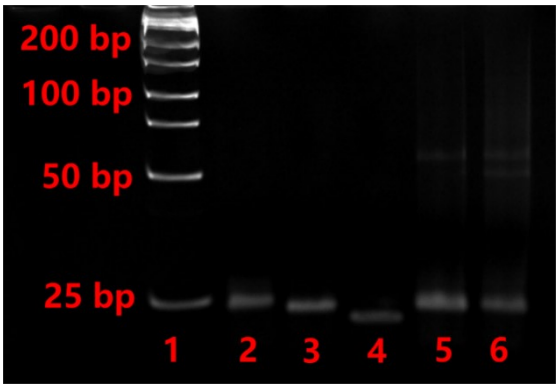

Fig. S2 Polyacrylamide gel electrophoresis images of HCR substrates and products. Lane 1: DNA marker; Lane 2: H1; Lane 3: H2; Lane 4: HP; Lane 5: H1 + H2; Lane 6: H1 + H2 + HP.

Characterization of AuNPs

The TEM image characterization of AuNPs was used to verify that in the absence of FA, AuNPs in the system presented a dispersed state (Fig. S2A), and after the addition of FA, AuNPs in the system became an aggregated state (Fig. S2B). These results indicate that the addition of FA can induce HCR reaction in the substrate chain to form long nicked dsDNA, and then AuNPs-Oligo 1 probes were combined with HCR products through DNA hybridization, thereby AuNPs form an aggregation state.

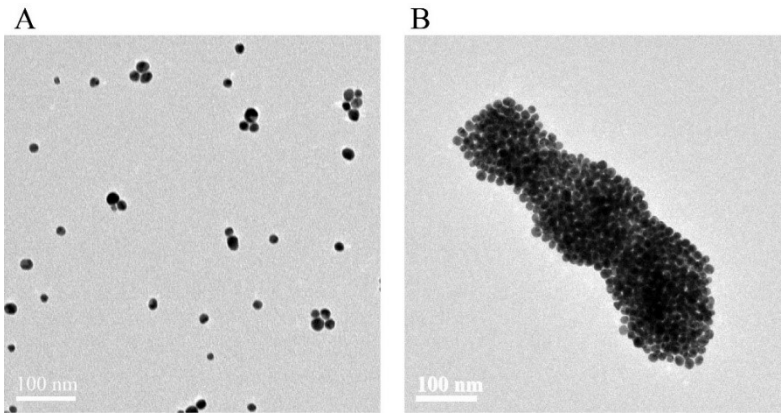

Fig. S3 TEM images of AuNP probes in the absence (A) and presence (B) of FA. Scale bar: 100 nm.

Table S1 DNA sequences used in the experiment

Name	Sequence (from 5' to 3')
HP	TACGCCATCAGCTCCAACCTACCGCAGCAGACTAGC
H1	GGAGCTGATGGCGTACATAGTTACGCCATCAAAAAAAAAAAA
H2	TACGCCATCAGCTCCGATGGCGTAACTATGAAAAAAAAAAAA
oligo 1	HS-C_6-TTTTTTTTTTTTTTTTTTT

Table S2 Comparison of the proposed sensing strategy with previously reported methods for FA detection.

Detection method	LOD (μmol L^{-1})	Linear range (μmol L^{-1})	Reference
Fluorescence	6.0	0-2.7 × 10^4	1
Colorimetry	27.99	30-50	2
Electrochemistry	3.3	3.3-990	3
Electrochemistry	50	250-2.0 × 10^4	4
Smartphone	3.3	9.9-330	5
Smartphone	0.66	1.65-132	This work
DLS	0.033	0.066-132	This work

References

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