Supporting Information

Engineering *in-situ* growth of Au nanoclusters on hydrophilic paper fibres for fluorescence calligraphy-based chemical logic gates and information encryption

Jun Jiang Luo, Dun Ying Guo, Zi Bo Qu, Hong Qun Luo, Nian Bing Li, Hao Lin Zou and Bang Lin Li**

Key Laboratory of Modern Analytical Chemistry, Chongqing Education Commission, School of Chemistry and Chemical Engineering, Southwest University, Chongqing 400715, P. R. China

Corresponding authors: haolin@swu.edu.cn (H. L. Zou); chemlibl@swu.edu.cn (B. L. Li)

Table of Contents

Materials and Instruments (Page S2)

Figure S1 (Page S3)

Figure S2 (Page S4)

Figure S3 (Page S5)

Figure S4 (Page S6)

Figure S5 (Page S7)

Figure S6 (Page S8)

Figure S7 (Page S9)

Figure S8 (Page S10)

Figure S9 (Page S11)

Figure S10 (Page S12)

Materials and Instruments

Glutathione (GSH), chloroauric acid ($HAuCl_4$), L-methionine (Met), L-cysteine (Cys), L-proline (Pro), L-serine (Ser), L-aspartic acid (Asp), L-lysine (Lys), L-glutamic acid (Glu), L-leucine (Leu), L-threonine (Thr), L-arginine (Arg), L-valine (Val), L-phenylalanine (Phe), ascorbic acid (AA) were obtained from Aladdin Co. Ltd. (Shanghai, China). Those commercial whole-raw rice papers and half-raw rice papers were purchased from China Xuan Paper Co. Ltd. (Anhui, China). Polyvinylidene fluoride (PVDF) film and nitrocellulose (NC) films were obtained from the Merck Millipore (Germany). Fourier transform infrared (FTIR) spectra were acquired from an In-Situ IRTracer-100 instrument (Shimadzu, Japan). The fluorescence spectra were recorded though a F-7100 fluorescence spectrophotometer (Hitachi, Japan). The scanning electron microscope (SEM) images were obtained from a Gemini 300 electron microscope (Zeiss, Germany). In addition, transmitting electron microscope (TEM) images were captured by a Tecnai G2 T20 UTWIN instrument (FEI, USA). The fluorescence imaging pictures were captured by a Gel imager with the model of Gel Doc XR+ (Biorad, USA). Contact angle values of droplets on paper substrates were measured by an angle goniometer (Sindin, China).

Figure S1

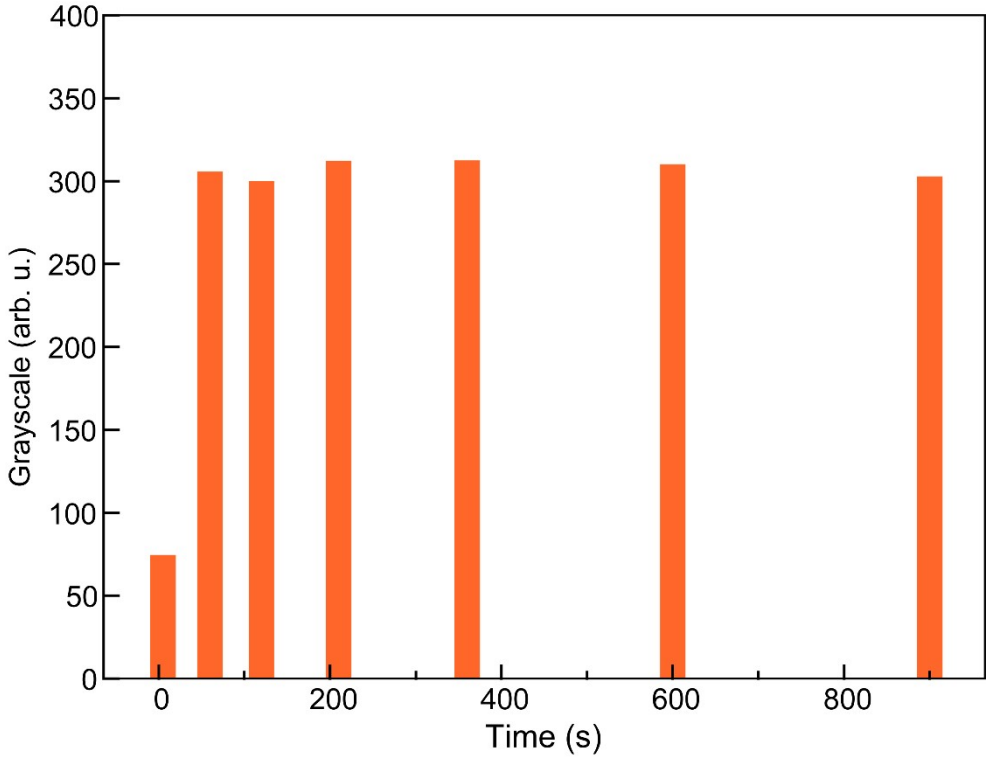

Fig. S1 The maximum grayscale values of the fluorescence images of the stained rice papers which were analyzed from the gel imager.

Figure S2

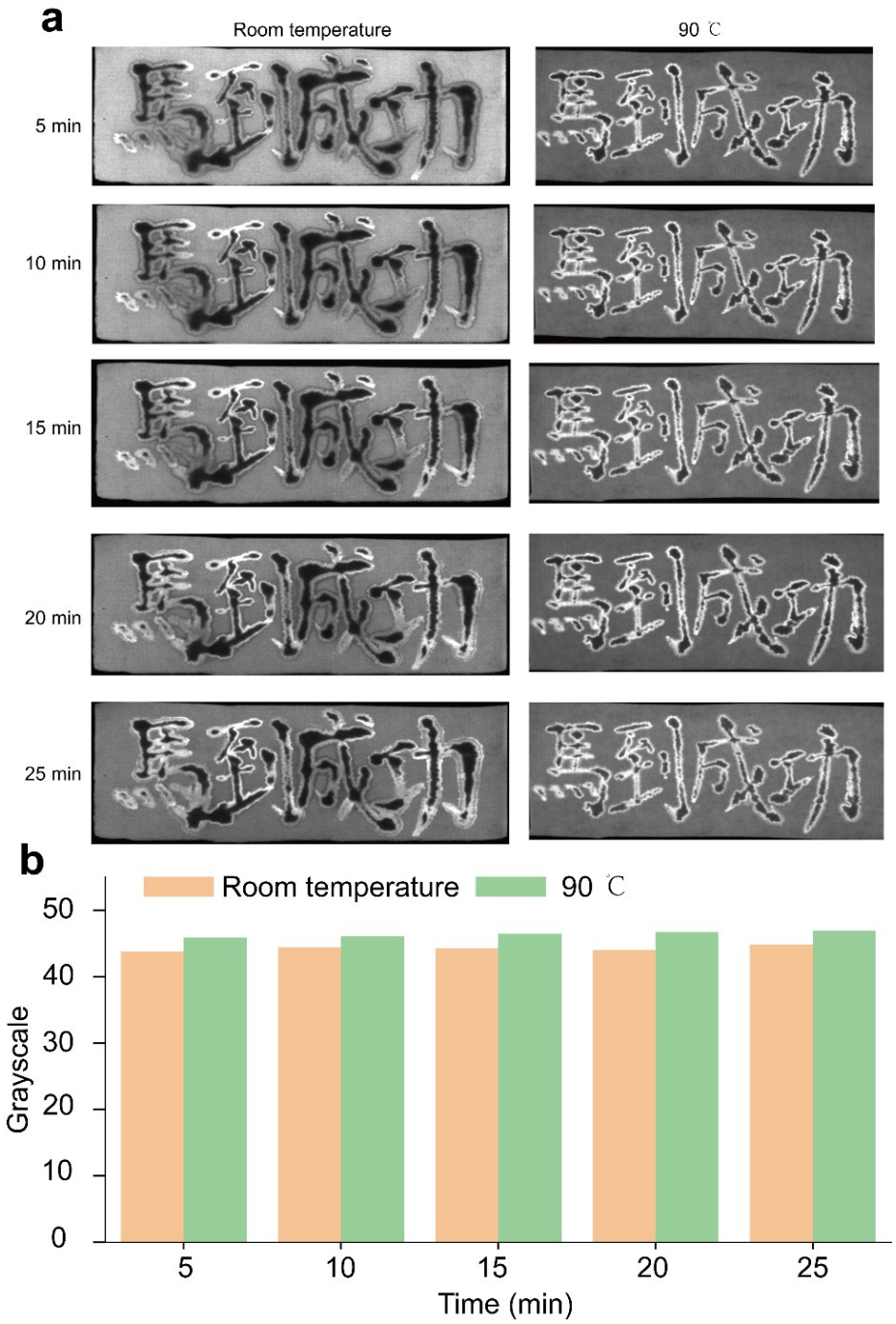

Fig. S2 (a)The time-dependent fluorescence intensity images of the $HAuCl_4$ stained rice paper from a gel fluorescence imager. (b) The maximum grayscale values of the fluorescence images of those stained rice papers which were analyzed from the gel imager.

Figure S3

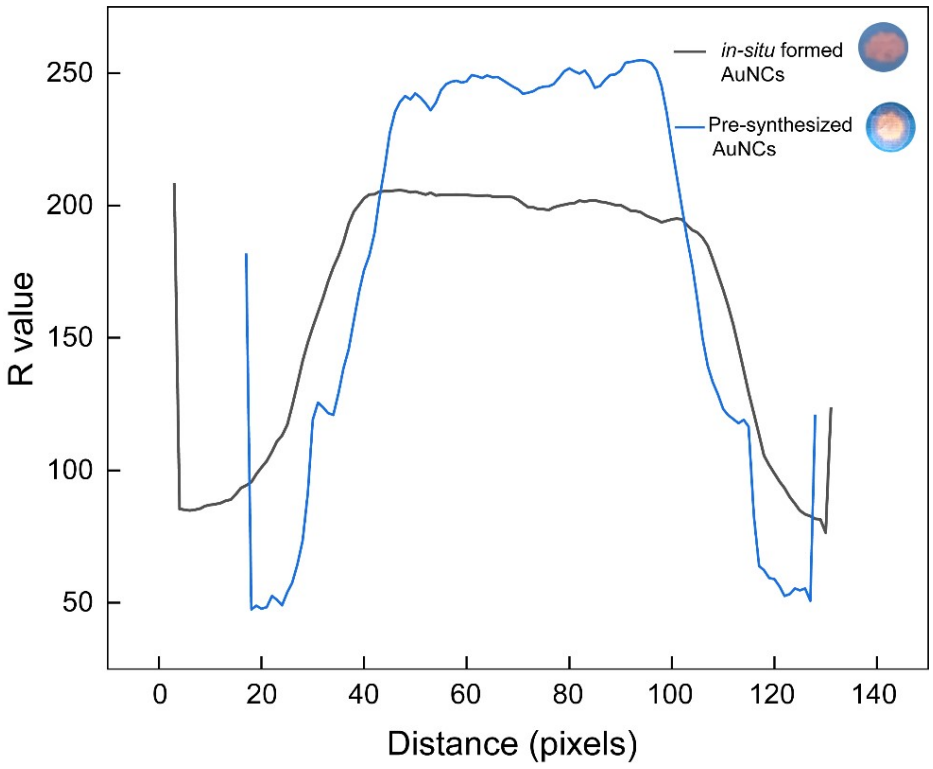

Fig. S3 The R value distribution of the two papers which were prepared from the staining of pre-synthetic AuNCs (Blue line) and *in-situ* formed AuNCs (Black line), respectively.

Figure S4

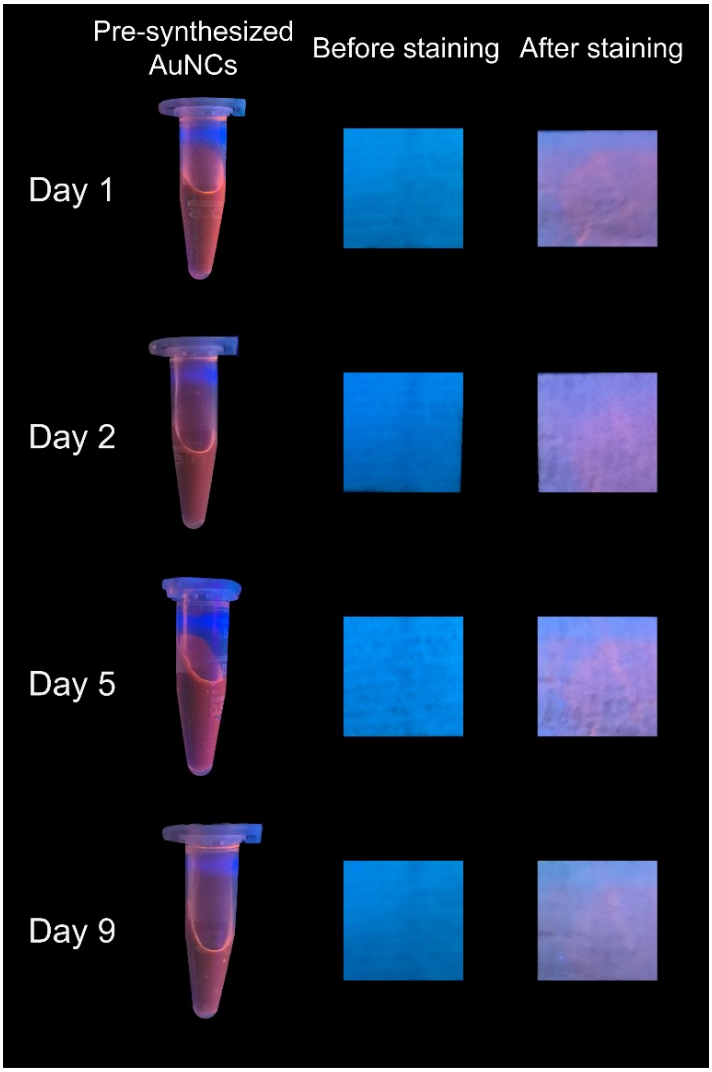

Fig. S4 Fluorescence imaging results of the pre-synthetic AuNCs and rice paper before and after the staining of *in-situ*-prepared AuNCs for different days (1, 2, 5, and 9 days).

Figure S5

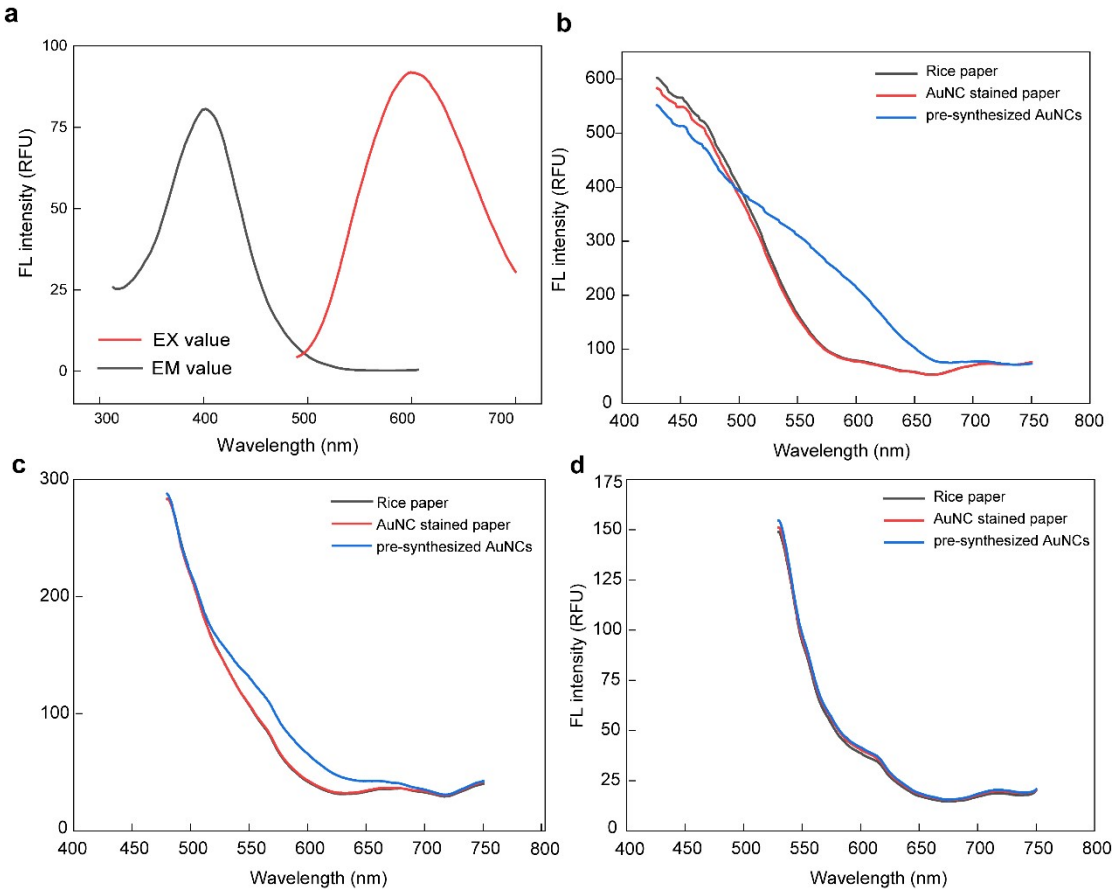

Fig. S5 (a) Fluorescence spectra of the pre-synthesized AuNCs in aqueous solution. (b-d) Fluorescence emission spectra of blank rice paper, *in-situ*-prepared AuNC stained rice paper, and pre-synthesized AuNCs stained rice paper when the excitation wavelengths were 430 nm (b), 480 nm (c) and 530 nm (d), respectively.

Figure S6

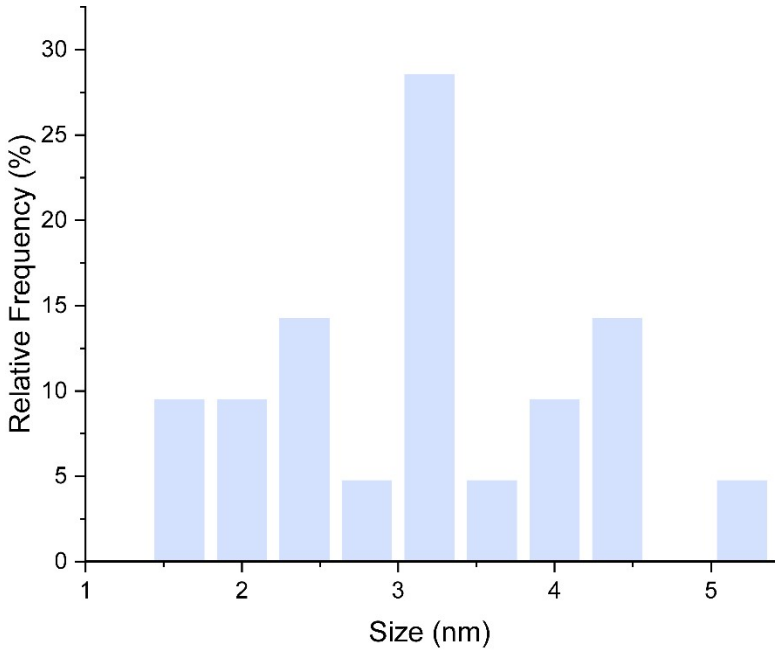

Fig. S6 Size distribution obtained from the HRTEM results of the *in-situ*-prepared AuNCs shows the average size of about 3.16 nm.

Figure S7

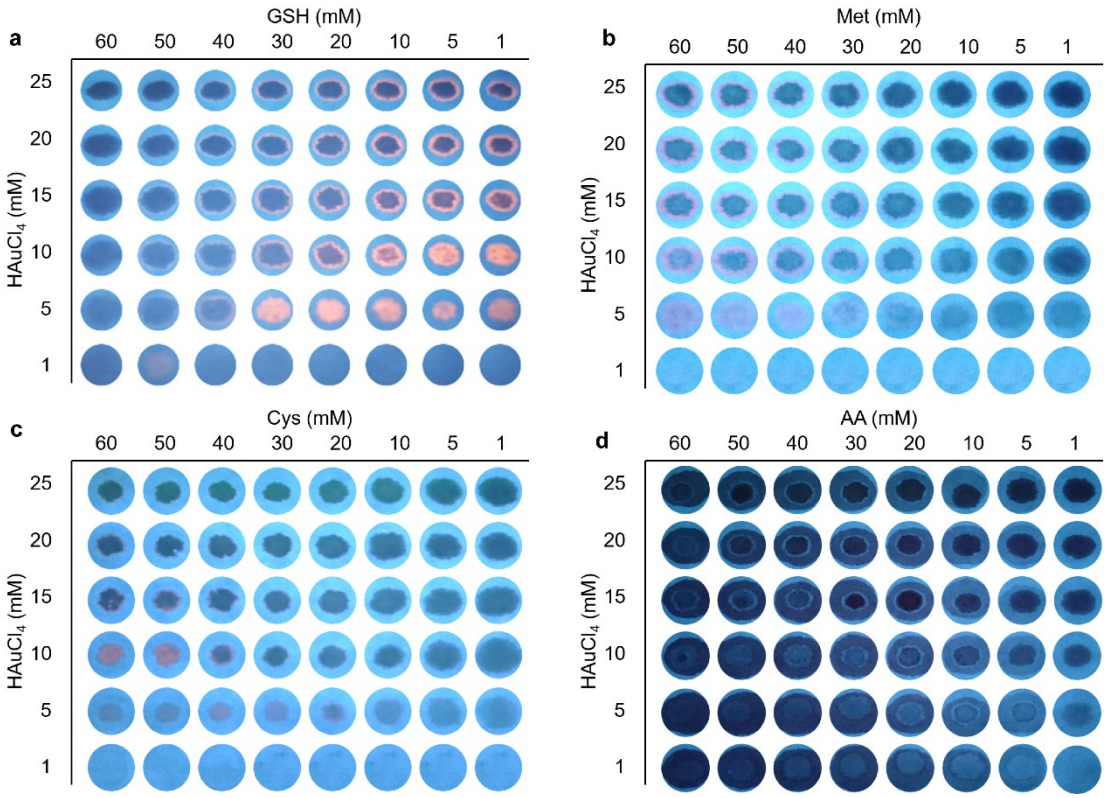

Fig. S7 Photos of $HAuCl_4$ stained rice papers which were pre-modified with GSH (a), Met (b), Cys (c) and AA (d) and those samples were irradiated by an UV lamp (254 nm).

Figure S8

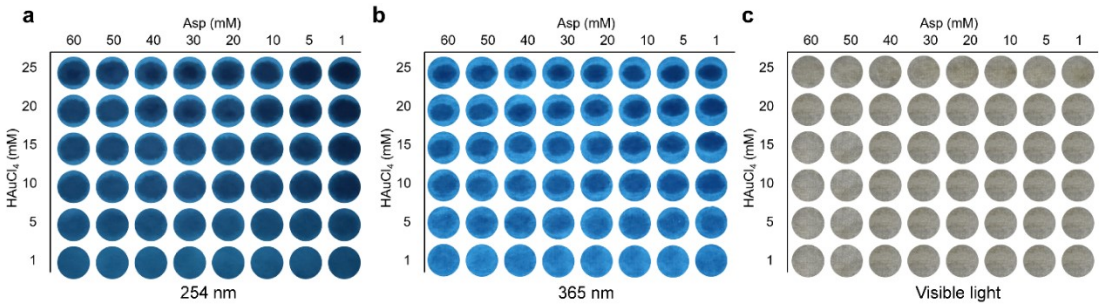

Fig. S8 The fluorescence photos of stained rice papers which were pre-modified with different concentration Asp solutions and the samples were irradiated under the 254 nm UV lamp (a), 365 nm UV lamp (b) and visible light (c), respectively.

Figure S9

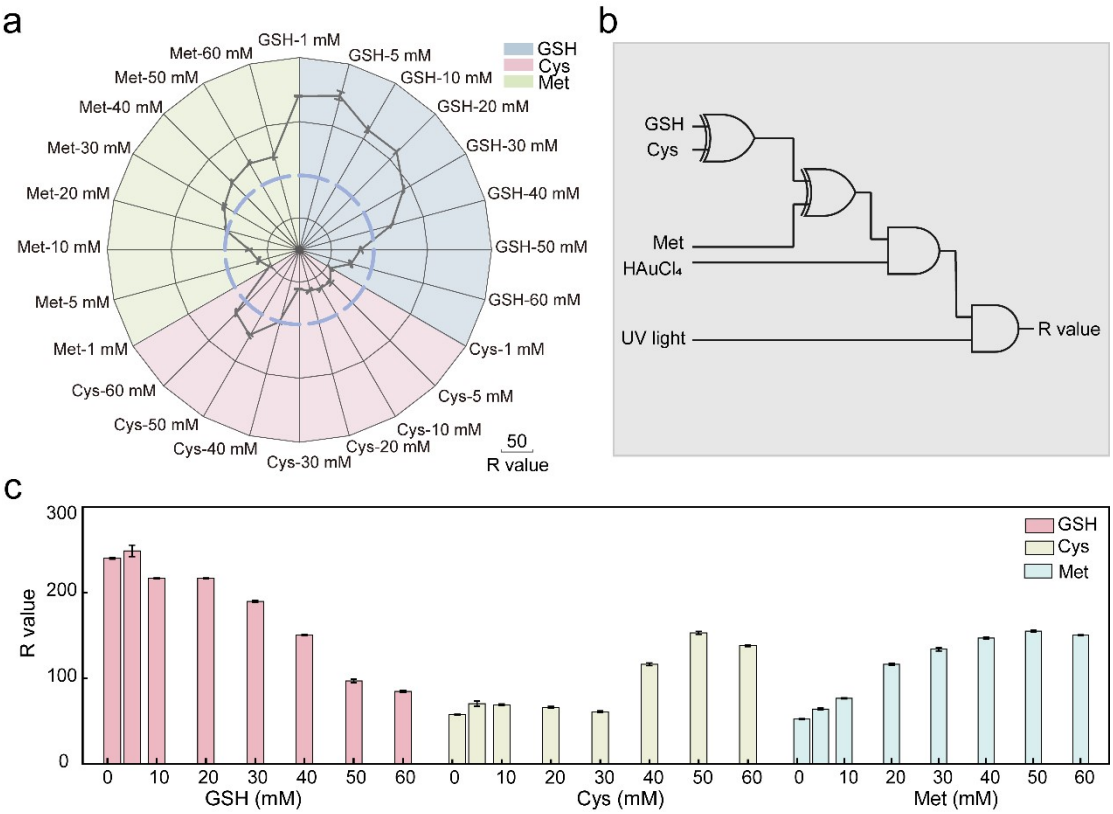

Fig. S9 (a) Radar plot showing the relationship between GSH, Cys and $HAuCl_4$ with the fluorescence R values of the stained rice papers. (b) Scheme showing a constructed logic system with the signals acquired from the R values. (c) Column plot of the R values of the stained papers with different concentrations of $HAuCl_4$ and those studied small molecules.

Figure S10

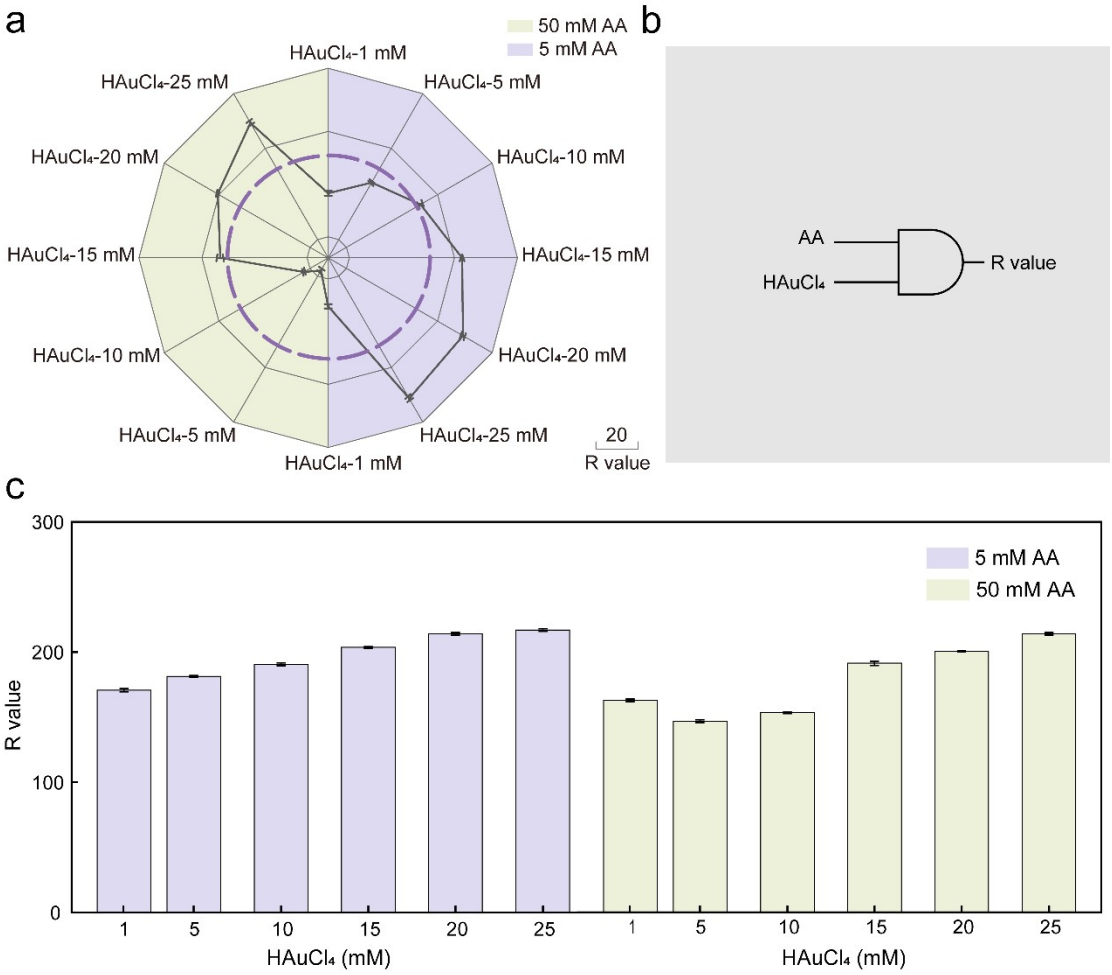

Fig. S10 (a) Radar plot showing the relationship between AA and $HAuCl_4$ with the fluorescence R values of the stained rice papers. (b) Scheme showing a constructed logic system with the signals acquired from the R values. (c) Column plot of the R values of the stained papers with different AA and $HAuCl_4$ concentrations.