

Supporting Information
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Platinum Nanoparticle-Based Collision Electrochemistry for Rapid Detection of Breast Cancer MCF-7 Cells

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S1. Zeta potential of the prepared Pt NPs.

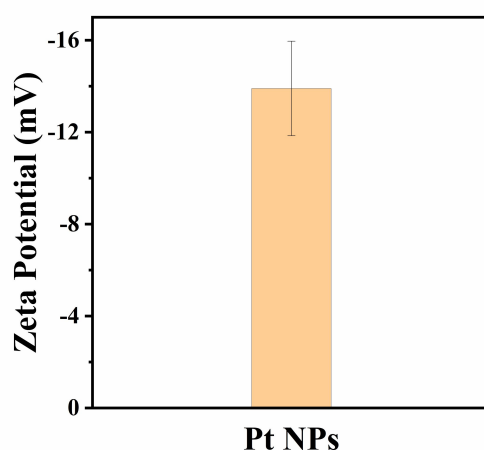


Fig. S1 Zeta potential of the prepared Pt NPs.

S2. Calculation the concentration of Pt NPs.

The concentration of the synthesized Pt NPs suspension was determined to be 292 μM by ultraviolet-visible spectroscopy [1]. The 100 μM H_2PtCl_6 stock solution was further diluted with 0.1 M HCl to prepare eight Pt salt standard solutions with concentrations of 5, 10, 15, 20, 25, 30, 35, and 40 μM . The UV-Vis spectrum of the standard solution was measured based on a 0.1 M HCl blank solution. After the baseline was corrected, the peak absorbance value at the wavelength of 262 nm was plotted against the concentration to construct a calibration curve (Fig. S2).

1 mL of synthesized Pt NPs was digested with 2 mL of aqua regia, heated until completely evaporated, dissolved in 4 mL of 0.1 M HCl, and the absorption spectrum was measured based on 0.1 M HCl blank. The Pt ion concentration was calculated from the calibration curve. (In this experiment: the measured absorbance at 262 nm was 0.469, the corresponding concentration was 35.031 μM , the concentration of Pt salt in the sample was $35.031 \mu\text{M} \times 4 \text{ mL} / 1 \text{ mL} = 0.1401 \text{ mM}$)

The stoichiometric ratio of Pt atoms per NP was estimated from TEM. The average radius of the nanoparticles determined from the TEM was used to calculate the average volume (in cubic centimeters) of each particle:

$$V = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3 \quad \#(1)$$

V is the volume of one Pt NP; d is the diameter of Pt NP which is measured by TEM. The density of Pt atoms per cubic centimeter was calculated from the density of Pt (21.45 g/cm^3), the atomic mass of Pt (195 g/mol), and the Avogadro number ($6.02 \times 10^{23} \text{ atoms/mol}$). Estimate the number of Pt atoms per NP by multiplying the density of Pt atoms ($6.62 \times 10^{22} \text{ atoms/cm}^3$) by the average volume (cm^3/NP):

$$n_{Pt} = \frac{\rho V N_A}{M} \quad \#(2)$$

n_{Pt} is the number of Pt atom in one Pt NP; ρ is the density of Pt (21.45 g/cm^3); N_A is the Avogadro's number ($6.02 \times 10^{23} \text{ atoms/mol}$); M is the atomic mass of Pt (195 g/mol). Divide the Pt ion concentration of the spectrum analysis by the number of Pt atoms in each NP to find the NP concentration of the sample:

$$C_{NP} = \frac{C_{Pt(IV)}}{n_{Pt}} \quad \#(3)$$

C_{NP} is the particle concentration of Pt NPs; $C_{Pt(IV)}$ is the concentration of Pt salt.

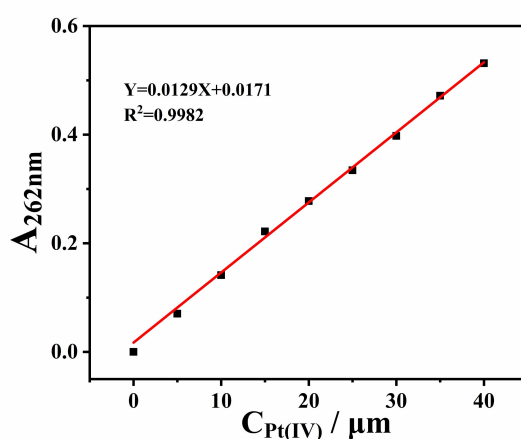


Fig. S2 Linear curve between H_2PtCl_6 concentrations and UV-vis absorption intensities at 262 nm.

S3. Preparation process and characterization of Au UME.

Disk-shaped Au UME was prepared by fire sealing method, and its preparation process was shown in Fig. S3. According to the diffusion-limited steady-state current equation (4), the radius of the Au UME can be calculated to be 13.6 μm following the limiting current plateau of 20 nA:

$$a = \frac{i_{lim}}{4nFDC} = \frac{20 \times 10^{-9} \text{ A}}{4 \times 1 \times 96500 \text{ C/mol} \times 7.6 \times 10^{-6} \text{ cm}^2/\text{s} \times 5 \text{ mM}} = 13.6 \mu\text{m} \quad (4)$$

i_{lim} is the steady-state current of Au UME (20 nA), F is Faraday's constant, D and C are the diffusion coefficient ($D = 7.6 \times 10^{-6} \text{ cm}^2/\text{s}$) and the molar concentration of ferrous cyanide ($C = 5 \text{ mM}$), n is the number of electrons transferred per molecule ($n = 4$), and a is the radius of Au UME.

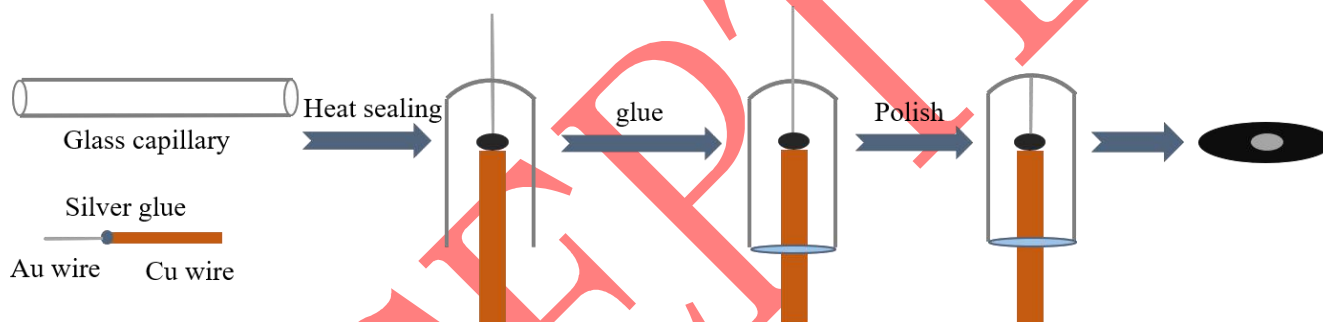


Fig. S3 Schematic diagram of the preparation process of the home-made Au UME.

S4. Capture efficiency of MBs.

Fig. S4 shows the adsorption efficiency of the magnet on the magnetic ball. Firstly, we diluted the magnetic ball to 10 mg/mL and tested its UV-visible absorption spectrum to get its absorption value A_0 . And the absorption value A_n of the supernatant of the magnet to the magnetic ball adsorption for different time was recorded. Then the adsorption efficiency of the magnet to the magnetic ball at the corresponding time point was equal to $(A_0 - A_n)/A_0$. Each group of samples was tested three times to take the average value. Plotting the adsorption efficiency with adsorption time as x-axis and adsorption efficiency as y-axis yields Fig. S4.

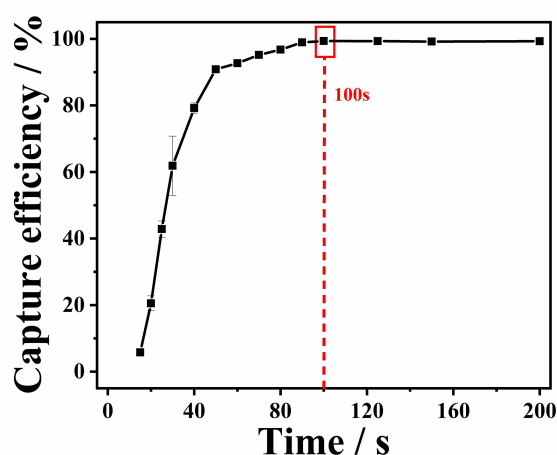


Fig. S4 Capture efficiency of MBs.

S5. Optimization of KCl concentration.

The concentration of Pt NPs was kept constant and the concentration of KCl was varied, the hydrated particle size of Pt NPs in different concentrations of KCl solution was measured by dynamic light scattering (DLS, Malvern), and the concentration of KCl solution was taken as the x-axis, and the hydrated particle size of Pt NPs was plotted as the y-axis to obtain Fig. S5.

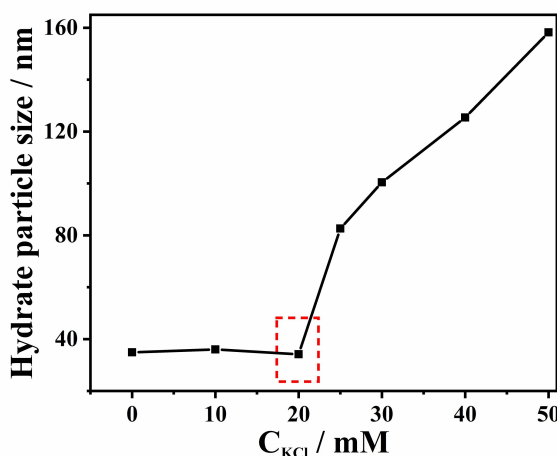


Fig. S5 Hydrodynamic diameter of Pt NPs in different concentrations of KCl.

S6. Cyclic voltammograms of Au UME and Au UME after collision recorded in 10 mM N_2H_4 .

In order to investigate whether the particles leave the electrode surface after colliding with the electrode, the CV curve between Au UME and Au UME after collision were recorded in 10 mM N_2H_4 (Fig. S6). After Pt NPs collided with the UME, the initial charge of the oxidation of N_2H_4 was obviously negatively shifted, indicating that Pt NPs were adhered to the surface of Au UME after collision.

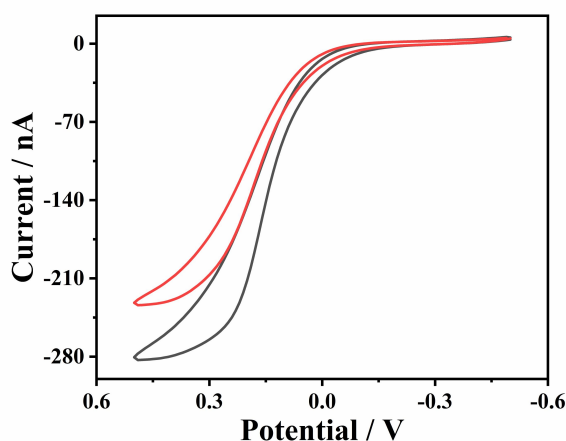


Fig. S6 Cyclic voltammograms of Au UME and Au UME after collision recorded in 10 mM N_2H_4 .

References

- [1] Bai Y Y, Yang Y J, Wu Z, Yang X Y, Lin M, Pang D W, Zhang Z L. Size-resolved single entity collision biosensing for dual quantification of microRNAs in a single run[J]. ACS Applied Materials & Interfaces, 2021, 13(19): 22254-22261.