

Article

Fabrication of Low-Cost and Customizable Planar Electrochemical Devices Using Multi-material 3D Printing and Platinum Leaves

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SUPPLEMENTARY MATERIALS

The electrochemically active surface area of the 3D-PtLE was determined using the Randles–Sevcik equation for quasi-reversible electrochemical systems. The calculation was based on the slope obtained from the linear regression of the peak current as a function of the square root of the scan rate for the two redox probes $K_4[Fe(CN)_6]$ and $[Ru(NH_3)_6]Cl_3$, measured in 0.1 M KCl supporting electrolyte.

For quasi-reversible processes, the Randles–Sevcik equation is expressed as:

$$i_p^{quasi} = \pm 0.436 nFAC \left(\frac{nFvD}{RT} \right)^{\frac{1}{2}} \quad (S1)$$

where i_p is the peak current (A), n is the number of electrons transferred ($n=1$), F is the Faraday constant ($F=96485 \text{ C}\cdot\text{mol}^{-1}$), A is the electrode area (cm^2), C is the concentration of the redox probe ($\text{mol}\cdot\text{cm}^{-3}$), v is the scan rate ($\text{V}\cdot\text{s}^{-1}$), D is the diffusion coefficient (D values of $6.8 \times 10^{-6} \text{ cm}^2\cdot\text{s}^{-1}$ and $9.1 \times 10^{-6} \text{ cm}^2\cdot\text{s}^{-1}$ are reported for $K_4[Fe(CN)_6]$ and $[Ru(NH_3)_6]Cl_3$, in 0.1 M KCl supporting electrolyte, respectively), R is the gas constant ($R=8.314 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$) and T is the temperature ($T=298 \text{ K}$) [52–55].

The electrochemically active surface area of the 3D-PtLEs, calculated using the two redox probes, corresponded to $102 \pm 4\%$ and $109 \pm 5\%$ of the apparent geometric surface area for $K_4[Fe(CN)_6]$ and $[Ru(NH_3)_6]Cl_3$, respectively, indicating that the 3D-PtLEs exhibit a highly accessible and electrochemically active surface. In contrast, the corresponding values obtained for the disc electrode were approximately $98 \pm 2\%$ and $99 \pm 2\%$ for $K_4[Fe(CN)_6]$ and $[Ru(NH_3)_6]Cl_3$, respectively. These results suggest a slightly higher electrochemically active surface area, and consequently a higher surface roughness, for the 3D-PtLEs compared with the disc electrode.

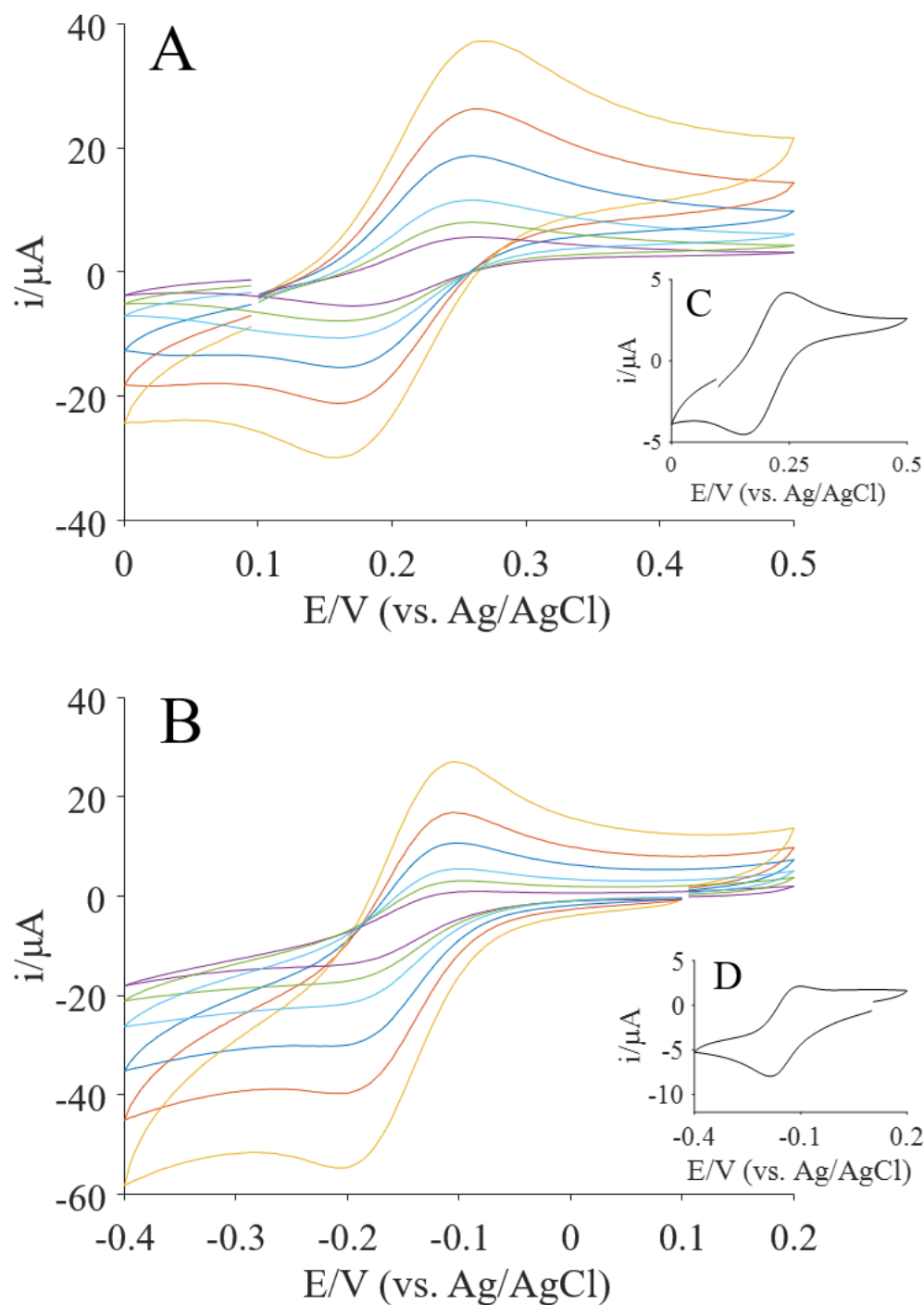


Figure S1. Cyclic voltammograms recorded at scan rates ranging from 5 to 200 $\text{mV}\cdot\text{s}^{-1}$ at 3D-PtLEs in 0.1 M KCl containing (A) 1 mM $\text{K}_4[\text{Fe}(\text{CN})_6]$ or (B) 1 mM $[\text{Ru}(\text{NH}_3)_6]\text{Cl}_3$. Insets, cyclic voltammograms recorded at a mechanically polished platinum disc electrode for (C) 1 mM $\text{K}_4[\text{Fe}(\text{CN})_6]$ or (D) 1 mM $[\text{Ru}(\text{NH}_3)_6]\text{Cl}_3$ in 0.1 M KCl at scan rate of 50 $\text{mV}\cdot\text{s}^{-1}$.