

## Supporting Information

# Electrochemical Detection of Creatinine: Exploiting Copper(II) Complexes at Pt Microelectrode Arrays

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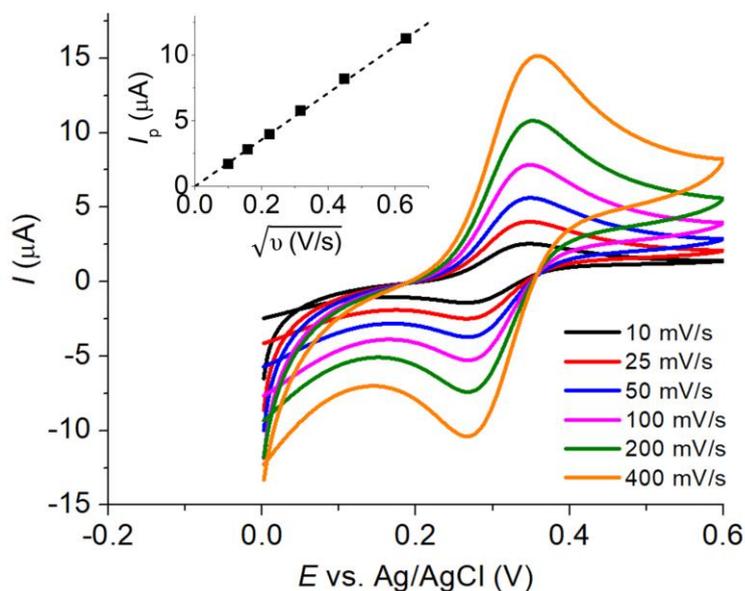
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## S1 Characterization of working electrodes using $[\text{Fe}(\text{CN})_6]^{4-/3-}$

First, cyclic voltammetry measurements were performed at the Pt macrodisc electrode in a solution containing 1.0 mM  $[\text{Fe}(\text{CN})_6]^{4-}$  and 0.10 M KCl as a supporting electrolyte (refer to Figure S1). The scan rates were varied within the range of 10 to 400  $\text{mV s}^{-1}$ , while the temperature was maintained at 298 K. Utilizing the Randles-Sevcik equation (eqn. S1)<sup>1</sup> for an electrochemically reversible one-electron transfer process, the diffusion coefficient of  $[\text{Fe}(\text{CN})_6]^{4-}$  was determined to be  $6.86 \times 10^{-10} \pm 0.01 \times 10^{-10} \text{ m}^2 \text{ s}^{-1}$ , close to the value reported in the literature of  $6.67 \times 10^{-10} \pm 0.14 \times 10^{-10} \text{ m}^2 \text{ s}^{-1}$ .<sup>2</sup>

$$I_p = 0.446FAc^* \sqrt{\frac{FDv}{RT}} \quad (\text{S1}),$$

where  $I_p$  is the peak current,  $F$  is the Faraday's constant ( $96,485 \text{ C mol}^{-1}$ ),  $A$  is the electrode surface area ( $\text{m}^2$ ),  $c^*$  is the bulk concentration of  $[\text{Fe}(\text{CN})_6]^{4-}$ ,  $D$  is the diffusion coefficient of  $[\text{Fe}(\text{CN})_6]^{4-}$  ( $\text{m}^2 \text{ s}^{-1}$ ),  $v$  is the potential scan rate ( $\text{V s}^{-1}$ ),  $R$  is the molar gas constant ( $8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ), and  $T$  is the absolute temperature (K).

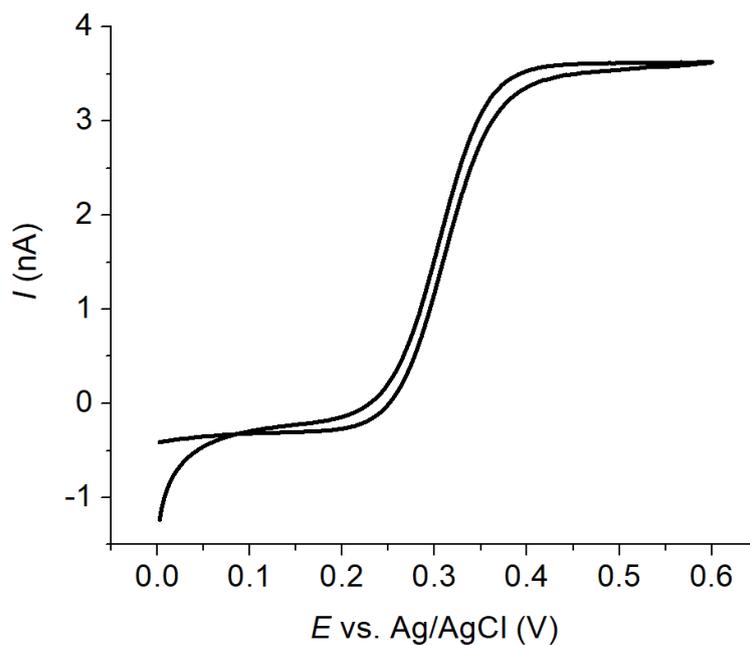


**Figure S1:** CV of 1.0 mM  $[\text{Fe}(\text{CN})_6]^{4-}$  in 0.10 M KCl at a Pt macrodisc electrode at varied scan rates (10 – 400  $\text{mV s}^{-1}$ ). The inlay shows a plot of anodic peak currents against square root of scan rates.

Figure S2 illustrates the steady-state voltammogram of 1.0 mM  $[\text{Fe}(\text{CN})_6]^{4-}$  in the presence of 0.10 M KCl supporting electrolyte at a Pt microdisc electrode, which can be described by eqn. 2.<sup>1</sup> At the Pt microdisc electrode, the diffusion coefficient of  $[\text{Fe}(\text{CN})_6]^{4-}$  was determined to be  $7.54 \times 10^{-10} \pm 0.01 \times 10^{-10} \text{ m}^2 \text{ s}^{-1}$ , close to the value reported in the literature of  $6.67 \times 10^{-10} \pm 0.14 \times 10^{-10} \text{ m}^2 \text{ s}^{-1}$ .<sup>2</sup>

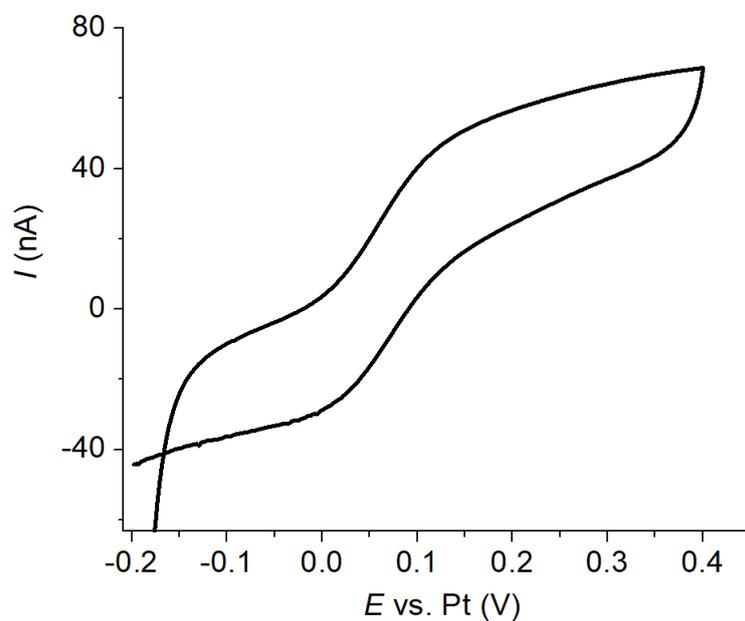
$$I_{ss} = 4nFc^*Dr \quad (\text{S2})$$

where  $I_{ss}$  is the steady-state current.  $r$  is the radius of the microdisc electrode.  $n$ ,  $F$ ,  $c^*$  and  $D$  have the same meaning as the above.



**Figure S2:** CV of 1.0 mM  $[\text{Fe}(\text{CN})_6]^{4-}$  in 0.10 M KCl at a Pt microdisc electrode at a scan rate of  $10 \text{ mV s}^{-1}$ .

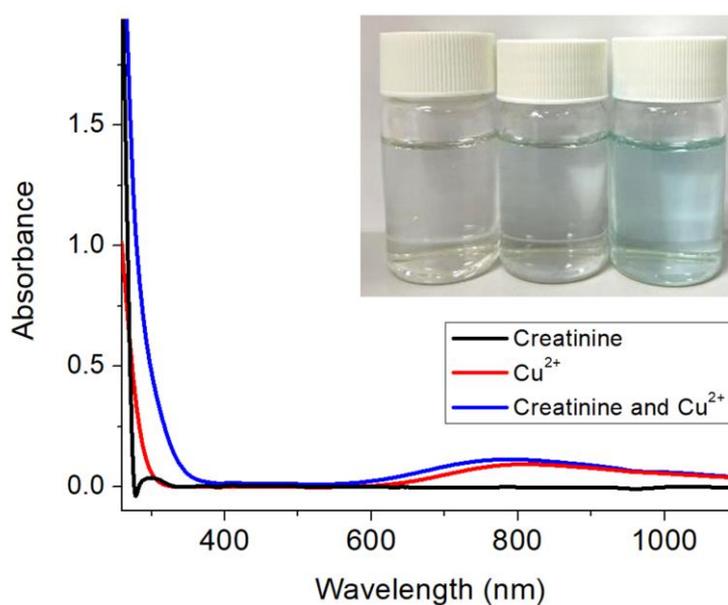
Figure S3 illustrates the steady-state voltammogram of 1.0 mM  $[\text{Fe}(\text{CN})_6]^{4-}$  in the presence of 0.10 M KCl supporting electrolyte at a Pt microdisc electrode array (Pt-MEA).



**Figure S3:** CV of 1.0 mM  $[\text{Fe}(\text{CN})_6]^{4-}$  in 0.10 M KCl at a Pt microdisc electrode array (Pt-MEA) at a scan rate of  $10 \text{ mV s}^{-1}$ .

## S2 Colors and UV-visible spectra of $\text{Cu}^{2+}$ , creatinine, and $\text{Cu(II)}$ - creatinine complex solutions

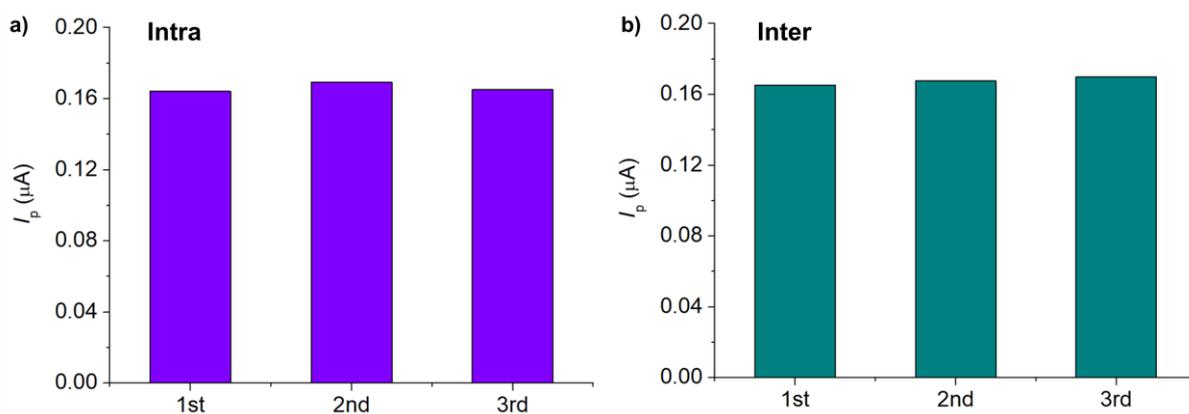
Figure S4 below illustrates the images and UV-visible spectra of 5.00 mM creatinine, 10 mM  $\text{CuSO}_4$ , and a mixture of 5.00 mM creatinine and 10 mM  $\text{CuSO}_4$ . The changes in the color and the UV-visible spectra of the  $\text{CuSO}_4$  solution upon the addition of creatinine provide evidence for the formation of copper-creatinine complexes.<sup>3</sup>



**Figure S4:** UV-visible spectra of 5.00 mM creatinine, 10 mM  $\text{CuSO}_4$ , and a mixture of 5.00 mM creatinine and 10 mM  $\text{CuSO}_4$ . **(Inlay)** Left to right: images of 5.00 mM creatinine, 10 mM  $\text{CuSO}_4$ , and a mixture of 5.00 mM creatinine and 10 mM  $\text{CuSO}_4$ .

### S3 Reproducibility tests

The reproducibility of voltammetric measurements was assessed for both intra (within) and inter (between) Pt-MEAs in a mixture containing 4.0 mM creatinine and 10.0 mM CuSO<sub>4</sub>. The results are presented in Figures S5a and S5b for intra- and inter-reproducibility, respectively. The relative standard deviations (RSD) of voltammetric peak currents were determined to be 1.65% ( $n = 3$ ) and 1.41% ( $n = 3$ ) for intra- and inter-reproducibility tests, as mentioned in the main text.



**Figure S5:** Bar graphs depicting the voltammetric peak currents of Pt-MEAs in a mixture containing 4.0 mM creatinine and 10.0 mM CuSO<sub>4</sub> using **a)** the same Pt-MEA electrode (intra) and **b)** three different Pt-MEAs (inter).

## References

1. Compton, R. G.; Banks, C. E., *Understanding voltammetry*. World Scientific: 2018.
2. Konopka, S.; McDuffie, B., Diffusion coefficients of ferri-and ferrocyanide ions in aqueous media, using twin-electrode thin-layer electrochemistry. *Analytical Chemistry* **1970**, *42* (14), 1741-1746.
3. Ngamchuea, K.; Wannapaiboon, S.; Nongkhunsan, P.; Hirunsit, P.; Fongkaew, I., Structural and electrochemical analysis of copper-creatinine complexes: application in creatinine detection. *Journal of The Electrochemical Society* **2022**, *169* (2), 020567.