

Supplementary Material:

Ultrafast Detection of Arsenic using Carbon-Fiber Microelectrodes and Fast-Scan Cyclic Voltammetry

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Detection of As^{3+} in 0.1 M KCl: We initiated our optimization studies in a simple KCl solution as this is the first time fast-scan cyclic voltammetry (FSCV) has been used with carbon-fiber microelectrodes (CFMs) to detect As^{3+} at ultra-fast temporal resolution. As illustrated in Figure S1, we observed an identifiable oxidation peak on the forward scan and a reduction peak on the backward scan for 10 μM As^{3+} when scanning from -0.6 V to 1.3 V with a resting potential of -0.6 V in 0.1 M KCl.

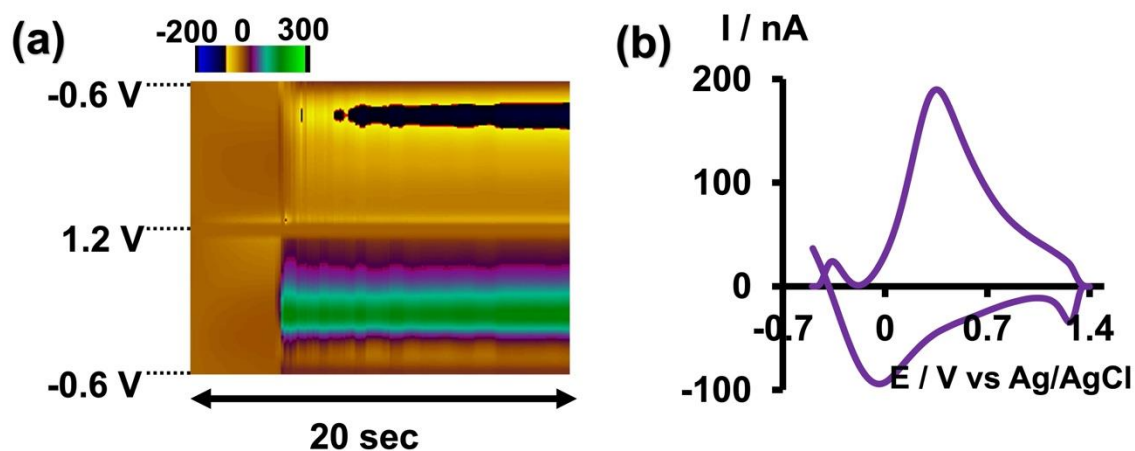


Figure S1. Representative (a) color plot and (b) CV for 10 μM As^{3+} in 0.1 M KCl.

Optimization of scan rate in acidic and basic conditions: After optimizing the positive, negative, and resting potentials, we explored various scan rates from 100 V/s to 500 V/s to identify the optimal scan rate for generating the maximum oxidation/reduction currents and a non-distorted As^{3+} CV for both acidic and basic tris solutions. As depicted in Figure S2, the oxidation current for As^{3+} in both conditions increased up to 400 V/s, plateauing at 500 V/s. Although the current at 500 V/s was similar to that at 400 V/s, the CV shape appeared distorted; therefore, 400 V/s was chosen as the optimal scan rate.

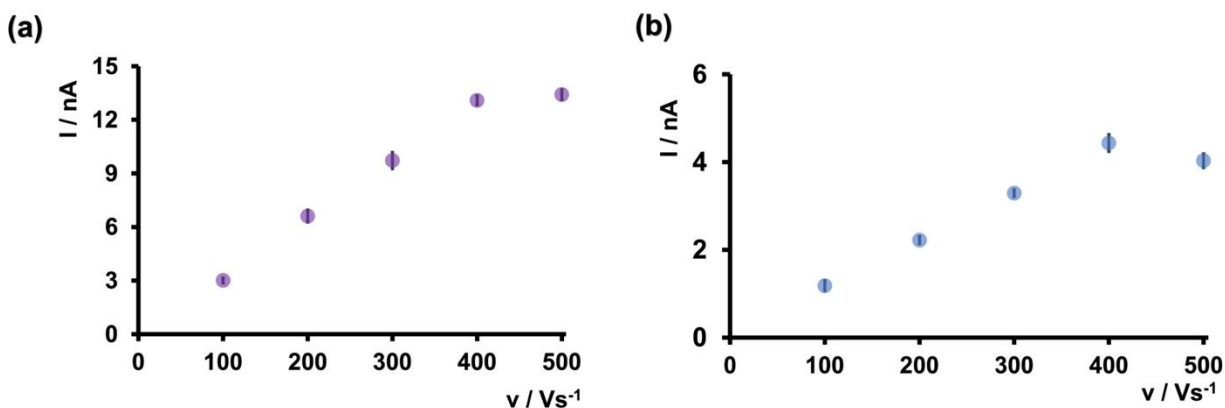


Figure S2. (a) The plot of maximum oxidation current vs. scan rate for 5 μM As^{3+} in tris buffer pH 6.5 upon cycling the potential was from -0.4 V to 1.2 V and back to -0.4 V. (b) The plot of maximum reduction current vs. scan rate for 5 μM As^{3+} in tris buffer pH 8.5 upon cycling the potential was from 0.5 V to -0.7 V and back to 0.5 V. Each data point represents the average reduction current \pm standard error of mean obtained for three CFMs with at least four replicate measurements for each CFM (minimum of 12 total replicates).

Stability test in acidic conditions: We assessed the sensitivity of our sensor by consecutively injecting As^{3+} . As depicted in Figure S3, after 20 consecutive injections of $1\ \mu\text{M}$ As^{3+} , the maximum oxidation current remained stable, indicating the excellent stability of our sensor.

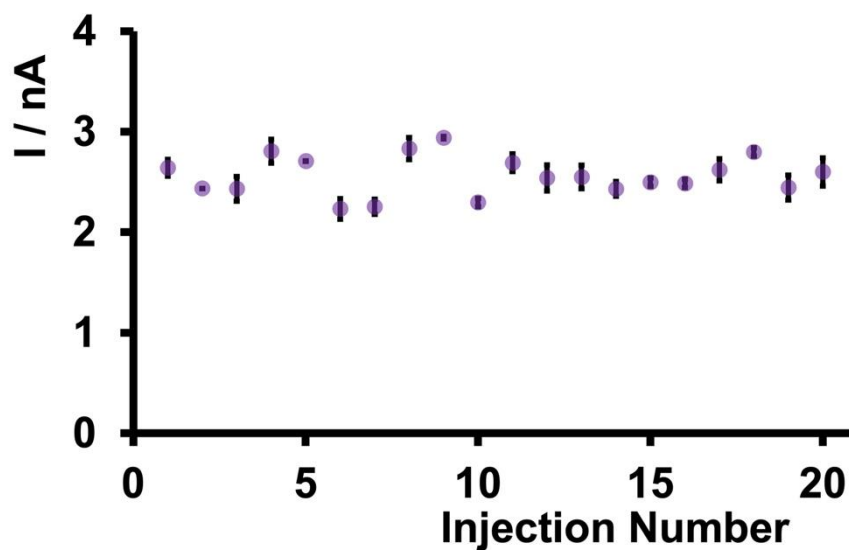


Figure S3. Maximum FSCV oxidation current obtained upon successive injections of $1\ \mu\text{M}$ As^{3+} onto CFMs in tris buffer at pH 6.5. Each data point represents the average oxidation current \pm standard error of the mean obtained for three CFMs.

Comparison of As^{3+} response on bare CFM and gold nanoparticle-modified CFM: To enhance the sensing capability of our sensor, we modified CFMs by electrodepositing gold nanoparticles. However, as shown in Figure S4, there was no increase in the oxidation current of As^{3+} CV; instead, the response decreased. Therefore, we did not perform further experiments with surface-modified CFMs.

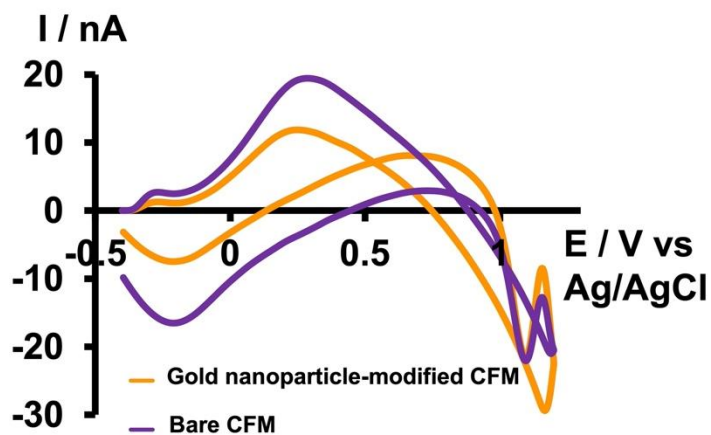


Figure S4. (a) Representative CVs obtained for 10 μM As^{3+} with gold nanoparticle-modified CFM (orange) and 10 μM As^{3+} with bare CFM (purple) using acidic waveform in tris buffer pH 6.5.

Oscilloscope images of the double-bore CFMs in As^{3+} - Cd^{2+} and As^{3+} - Cu^{2+} solutions: Before conducting co-detection of As^{3+} with Cd^{2+} and Cu^{2+} using double-bore CFMs, we confirmed the stability of the CFMs and tested whether they could maintain a stable gap between the two electrodes. Additionally, we modified one of the CFMs with gold nanoparticles to enable Cd^{2+} detection. As shown below, both double-bore CFM assemblies maintained the gap when different potential windows were applied.

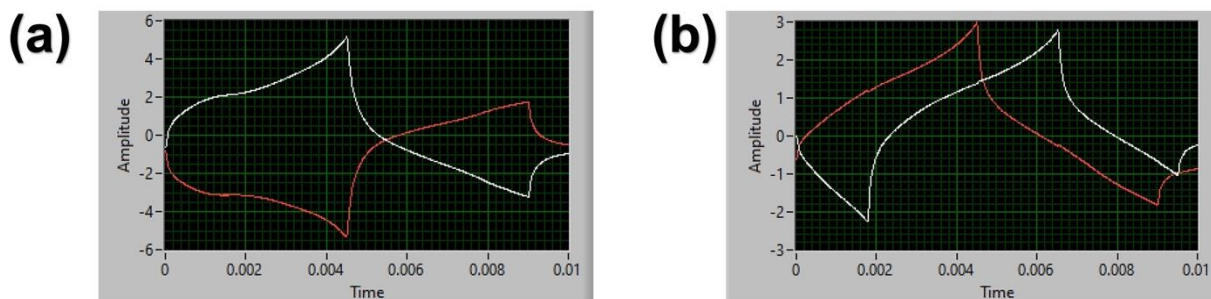


Figure S5. Oscilloscope images when two separate waveforms applied to double-bore CFMs in As^{3+} - Cd^{2+} and As^{3+} - Cu^{2+} solutions prepared in tris buffer at pH 6.5. (a) Red line corresponds to the Cd^{2+} waveform (-0.8 V to -1.4 V at 400 V/s) and the white line to the As^{3+} waveform (-0.4 V to $+1.2\text{ V}$ at 400 V/s). (b) Red line corresponds to As^{3+} waveform (-0.4 V to $+1.2\text{ V}$ at 400 V/s) and the white line corresponds to Cu^{2+} waveform (-0.7 V to $+1.2\text{ V}$ at 400 V/s).