Electrochemical Probe Fabrication and Characterization for Single-Cell Sensing & Detection

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Introduction

This study focuses on developing and characterizing electrochemical probes for intracellular analysis at micro- and nanoscale levels:

Aims

- Fabrication of microscale platinum electrodes for whole cell analysis.
- Fabrication of nanoscale carbon electrodes for sub cell analysis.

Microscale Probes:

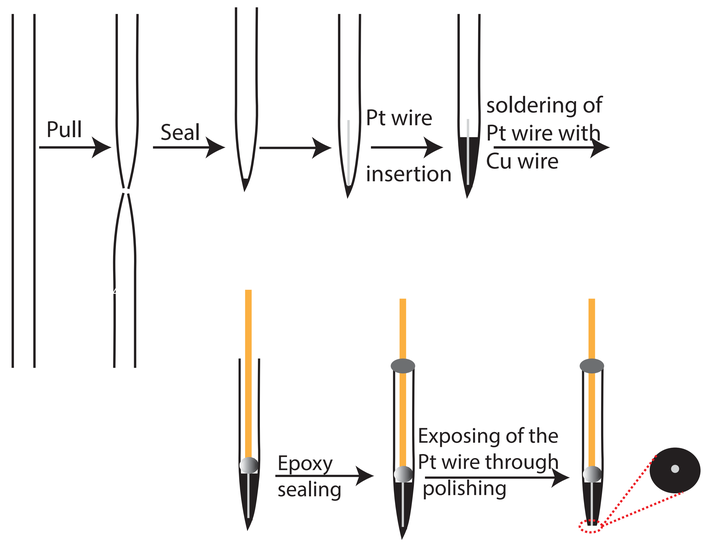
- Pt microelectrodes are fabricated for electrochemical aptamer-based sensors using heat-sealed platinum wire in borosilicate capillaries.
- Cyclic voltammetry (CV) in potassium ferricyanide verifies electrode quality and connectivity.
- Optical microscopy determines the RG value (optimal range: 5-10) to enable precise single-cell positioning.

Nanoscale Probes:

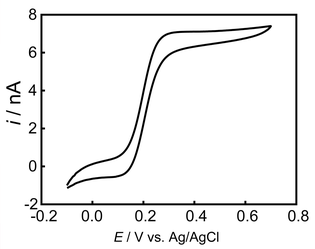
- Carbon-deposited nanopipettes are created by pulling quartz capillaries and using pyrolysis to form carbon electrodes.
- CV assesses probe performance and reproducibility.

By applying the limiting current equation i_{lim}= 4nFaDC, probe dimensions and diffusion-limited behavior can be validated, ensuring reliable electrochemical analysis.

Fabrication of Platinum Microelectrodes



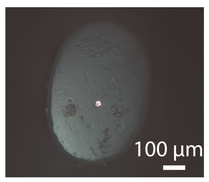
Results for Platinum Microelectrodes



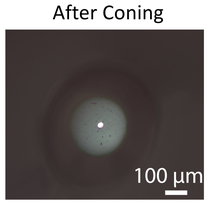
i_{lim}= 4nFaDC = 7.04 nA

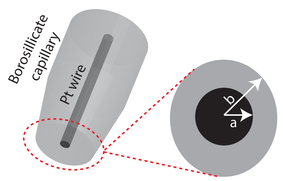
- n = # electrons (1)
- F = Faraday's Constant (96500 C/mol)
- a = radius (12.5 x 10^{-6} m)
- D = Diffusion Coefficient (7.3 x 10^{-6} cm^2/s)
- C = concentration (2 mmol/L)

Before Coning



After Coning

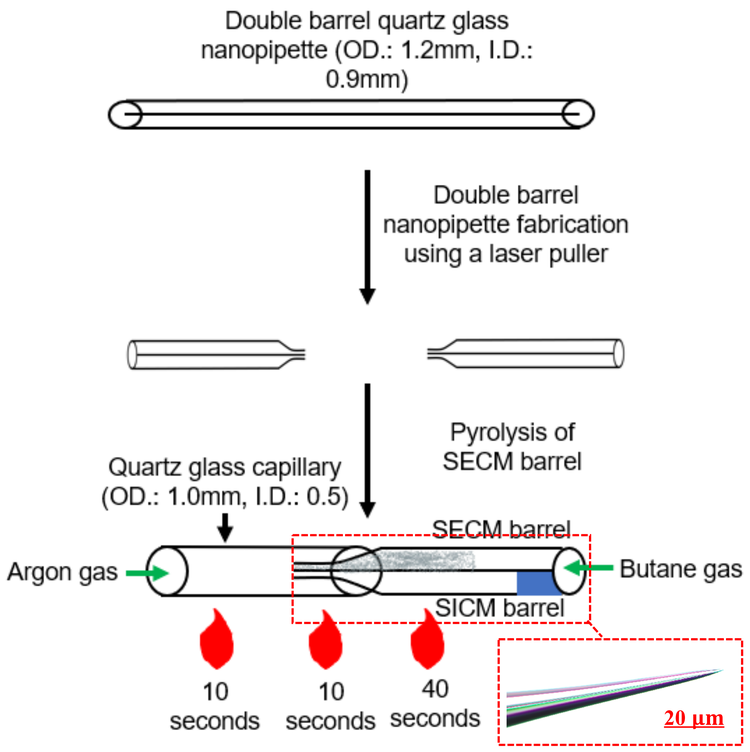




RG value = b/a
b : Radius from middle of the wire to the outside wall of insulator
a : Radius of the platinum wire (12.5µm)

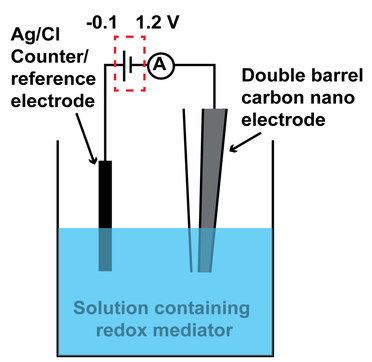
Goal : RG value between 5 and 10

Fabrication of Carbon Nanoelectrodes

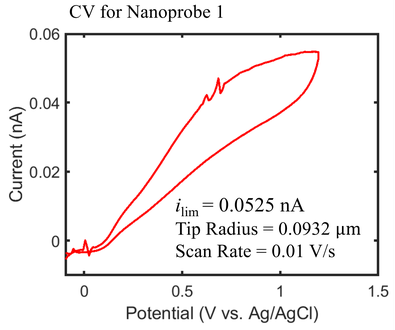


Results for Carbon Nanoelectrodes

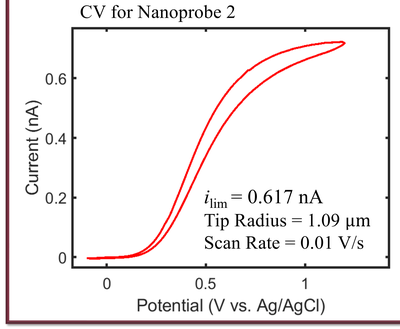
Electrochemical Set-Up, Redox Mediator: 0.02 M $[Fe(CN)_6]^{4-}$, Supporting Electrolyte: KNO_3



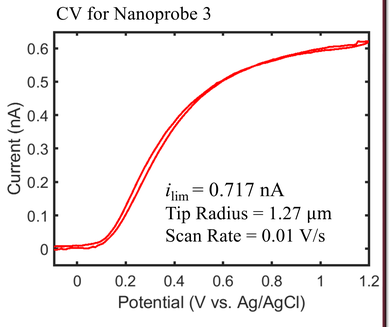
CV for Nanoprobe 1



CV for Nanoprobe 2



CV for Nanoprobe 3



Conclusion & Future Work

Carbon-Deposited Nanoelectrodes)

- Successfully fabricated but had inconsistent reproducibility.
- CV confirmed functionality.
- Challenges: resistivity variations, inconsistent carbon pyrolysis deposition.

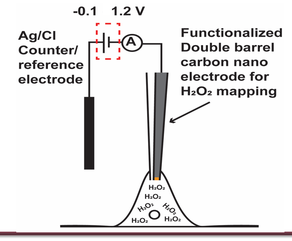
Platinum Microelectrodes

- CV confirmed platinum exposure and stability.
- Optical microscopy determined RG for whole cell sensing.

Future Work

- Improve nanopipette reproducibility and deposition techniques.
- Enhance electrode performance for single-cell electrochemical measurements.

Future Work for Nanoelectrodes:



Group Information

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