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Electrochemical Aptamer Based Sensors for Measurements In Vivo and in Undiluted Blood

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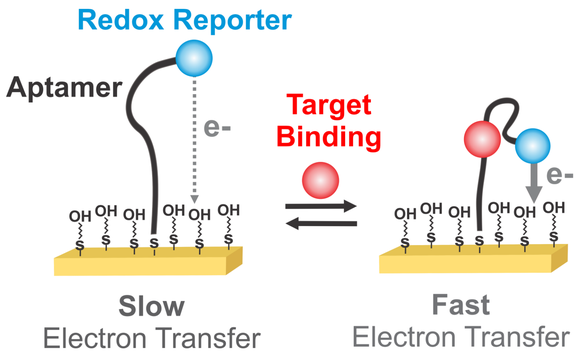
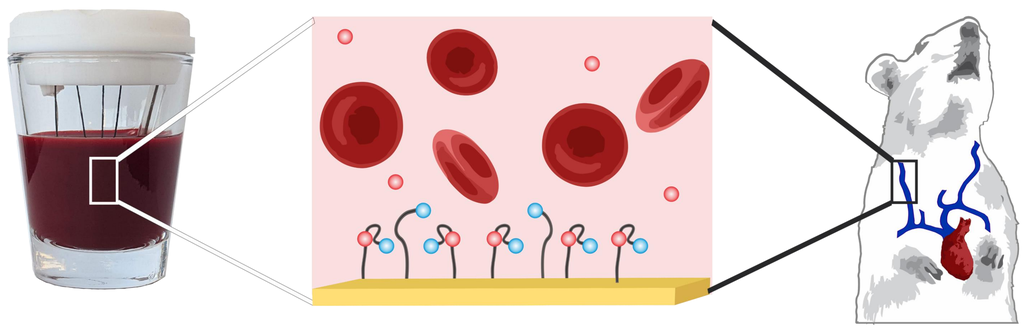
Electrochemical Aptamer Based Sensors

DNA aptamers are artificially selected to bind to a target, such as a small molecule, protein, or metabolite



Typically, electrochemical aptamer based sensors consist of a **redox reporter-modified aptamer sequence** attached to a gold electrode via a surface assembled monolayer

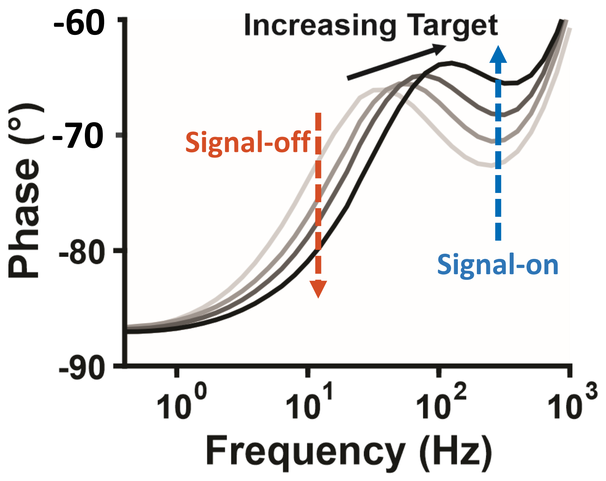
Target binding to the aptamer triggers a **change in electron transfer** from the redox reporter



These sensors:

- **Function both in whole blood and in the living body**
- Enable real-time measurements of rising and falling target concentrations
- Are generalizable to a range of different targets

Sub-second Measurements Using Impedance[1]

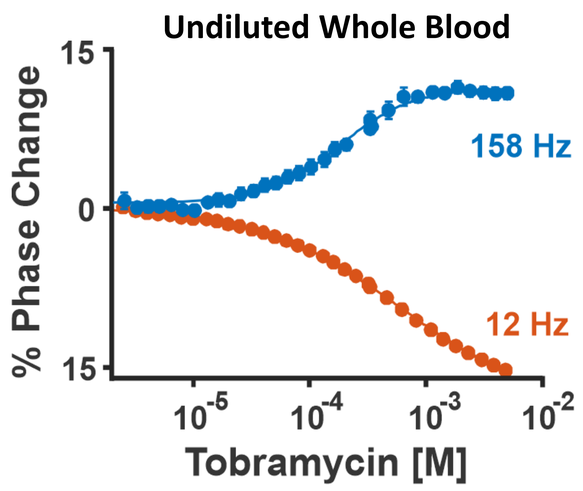


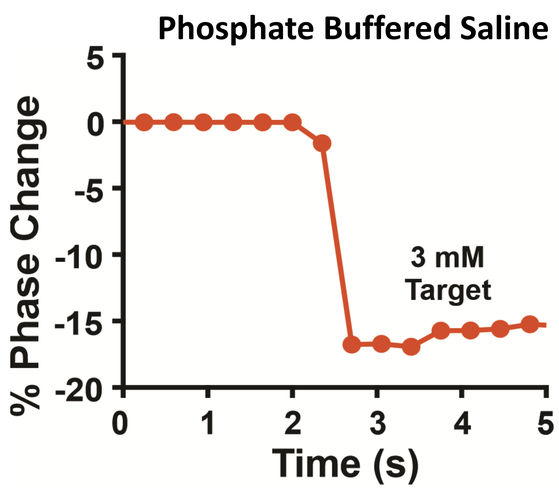
- When interrogating a sensor at its redox potential, a peak occurs in the phase component of impedance
- **With target addition the peak position moves toward higher frequencies.**
- Here, we use phase changes to measure the antibiotic, tobramycin.

Measuring phase at specific frequencies yields calibration curves.

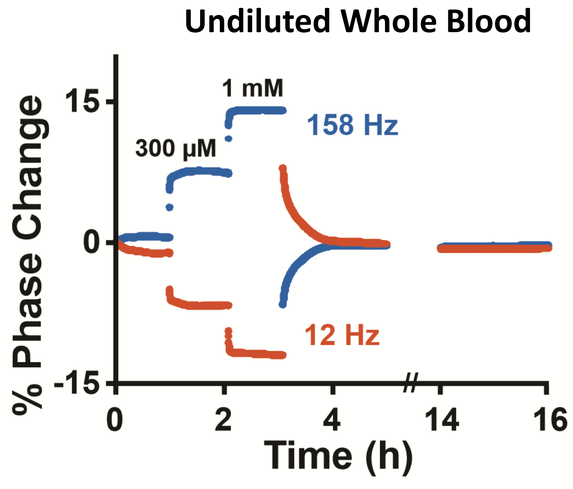
Depending on frequency, the response:

- Increases in phase toward 0 degrees (Signal-on) or
- Decreases in phase angle toward – 90 degrees (Signal-off)





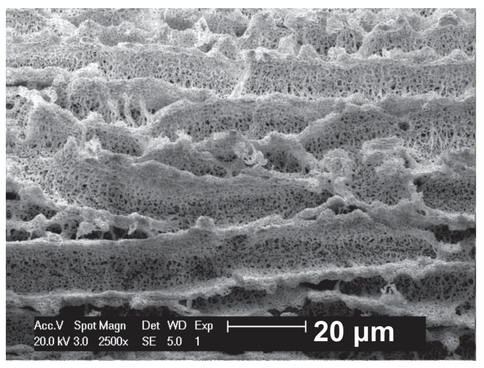
Collecting phase at specific frequencies near the phase peak **achieves sub-second temporal resolution**

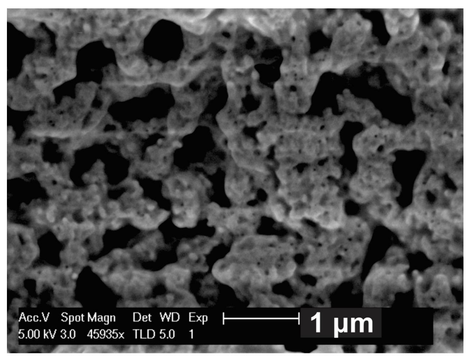


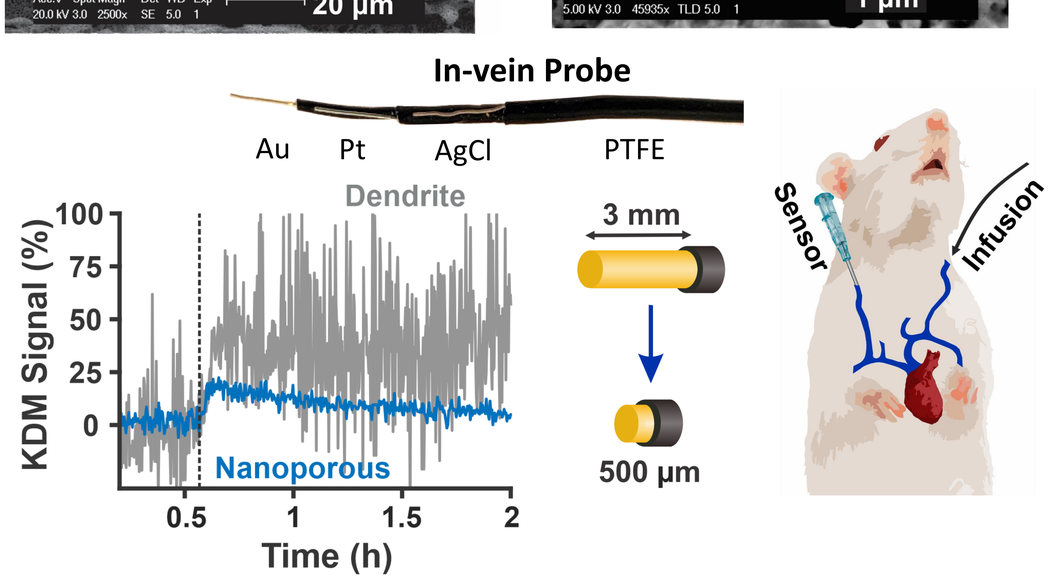
Phase interrogation yields stable measurements in whole blood for long time durations

Sensor Miniaturization Using Nanoporous Gold[2]

Electrochemically-deposited nanoporous gold increases electrode surface area by 75-100X. This increase yields a 20-30X increase in sensor redox signal.

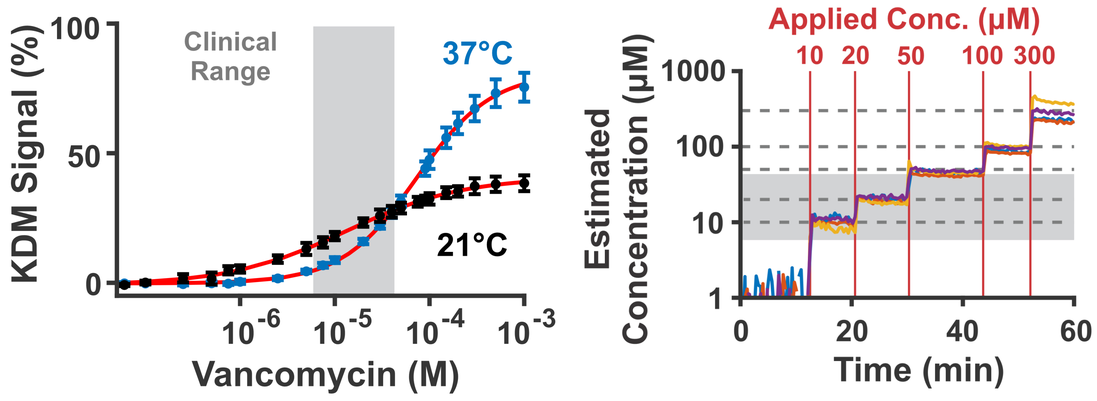






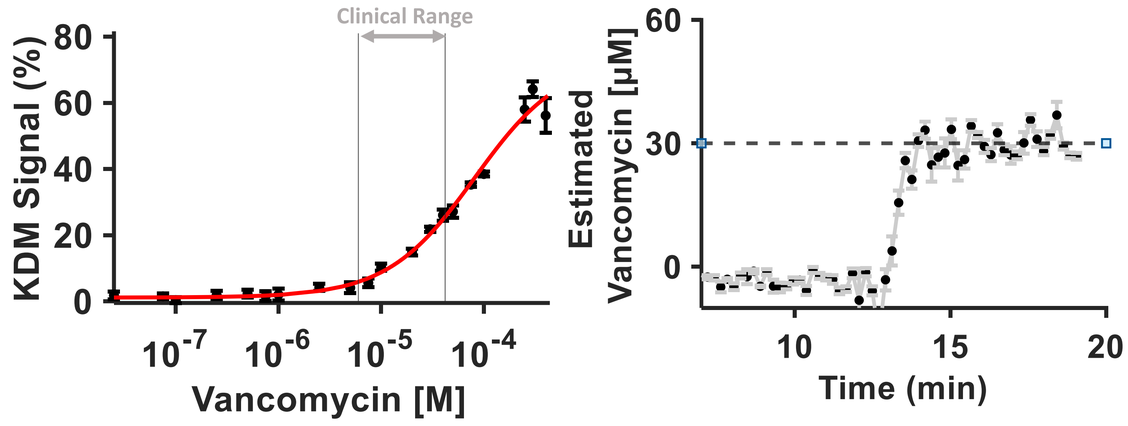
- **The nanoporous morphology enables miniaturization** of in-vein working electrode by 6-fold, while the dendrite morphology typically used in vivo does not.
- Here, we demonstrate in vivo dosing and measurement of the antibiotic, vancomycin, using square wave voltammetry

Measurement Accuracy in Whole Blood[3]



- Temperature influences the response of electrochemical aptamer based sensors by changing the rate of electron transfer.
- Using **freshly collected, body temperature blood improves the sensor calibration** accuracy to greater than 10% in the clinical range.

Microneedle-based Measurements in Whole Blood



- The sensors, when implemented in a **microneedle format**, achieve measurement of vancomycin in body temperature whole blood

Citations and Acknowledgements

[1] A. Downs, J. Gerson, K.L. Ploense, et al. **Analytical Chemistry** 92 (20), 14063-14068. **2020**.
[2] A. Downs, J. Gerson, M.N. Hossain, et al. **ACS Sensors** 6 (6) 2299-2306. **2021**.
[3] A. Downs, J. Gerson, K. Leung, et al. **Scientific Reports** 12, 5535, **2022**.

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