Development of Calcium and Oxygen Nanosensors for In-Vivo Diagnostics

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Motivation

Current *in-vivo* diagnostic tests can require repetitive testing or extensive training to enable accurate data analysis. To overcome these limitations, we developed two nanosensors which respond optically to changes in surrounding analyte concentration. These sensors have a dynamic range which encompasses most biological systems and are reversible lending to their promise as an *in-vivo* diagnostic test.

Mechanisms

Ca^{2+} Sensor Mechanism:

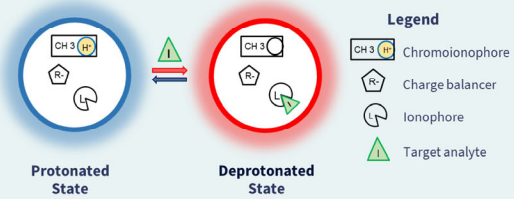


Figure 1: Schematic of Ion exchange between nanosensor and analyte

O_2 Sensor Mechanism:

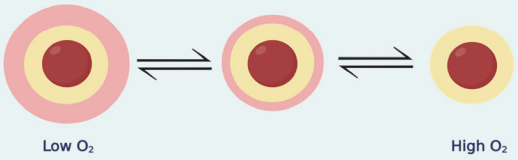


Figure 2: Schematic of quenching in increasing O_2 concentrations

Calcium Nanosensors

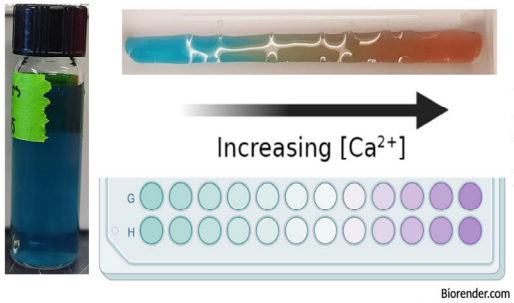


Figure 2a: Colorimetric readout and experimental set-up of calcium nanosensors

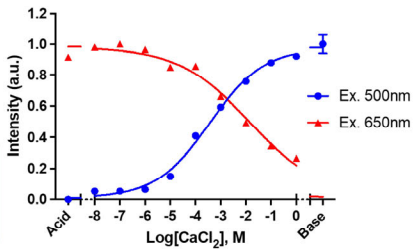


Figure 2b: Ratiometric fluorescence response of calcium nanosensors

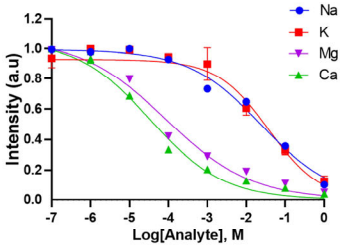


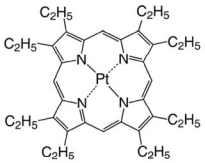
Figure 2c: Selectivity of calcium nanosensors over relevant cations

Ca^{2+} plays many biological roles including nerve signaling, making its measurement *in-vivo* beneficial.

These sensors can detect calcium concentrations ranging from 1 M to 100 µM. Additionally, these sensors are selective to Ca^{2+} over other biologically relevant cations such as Na^+, K^+, or Mg^{2+}.

Oxygen Nanosensors

PtOEP (O_2 Sensitive Dye)



DiA (Reference Dye)

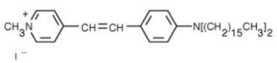


Figure 3a: Molecular structures of PtOEP, used as the O_2 sensitive dye, and DiA, used as an O_2 independent reference dye.

These sensors showed a sensitivity to O_2 from atmospheric (21%) to anoxic (0%) conditions. Additionally, these sensors are reversible, allowing for dynamic *in-vivo* sensing.

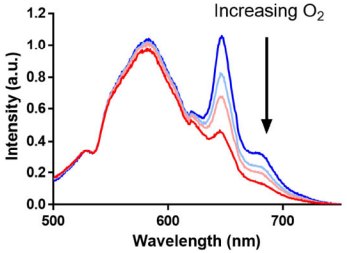


Figure 3b: Normalized luminescent response of O_2 sensors

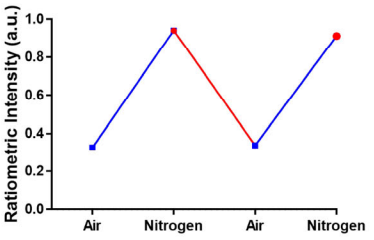


Figure 3c: Reversibility of O_2 Sensors

O_2 participates in cellular respiration and energy generation, making *in-vivo* studies beneficial.

Acknowledgments

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Conclusions

Ca sensors can detect concentrations as low as 100µM. The O_2 sensors are sensitive from atmospheric (21%) to anoxic (0%) conditions and are reversible.

References

S. C. Saccomano and K. J. Cash, "A near-infrared optical nanosensor for measuring aerobic respiration in microbial systems," *The Analyst*, vol. 147, no. 1, pp. 120–129, Nov. 2021.