Point of Care Calcium Monitoring and Hypercalcemia Diagnosis

Jessica Bazel, Farbod Amirghasemi, Ali Soleimani, Victor Ong, Maral Mousavi
Campbell Hall, Class of 2024 | jessicabazel13@gmail.com
Alfred E. Mann Department of Biomedical Engineering, USC SHINE 2023

USC Viterbi School of Engineering

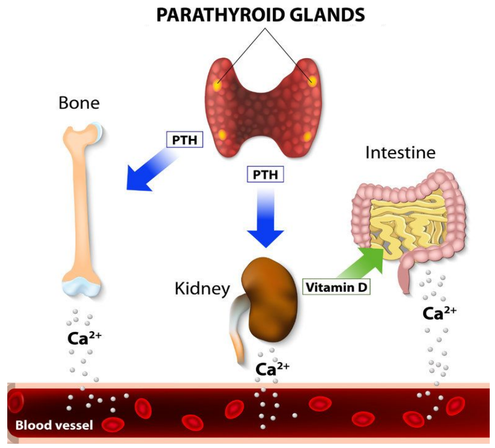
SHINE Summer High School Intensive in Next-Generation Engineering

Introduction & Background

Calcium Purposes:

muscle contraction | heartbeat regulation | bone growth and strength

Calcium Levels:



[1]

Hypercalcemia (high calcium levels) can lead to:
- ➢ Parathyroidism
- ➢ Chronic Kidney Disease

About **140 million** people are affected by hypercalcemia [2]

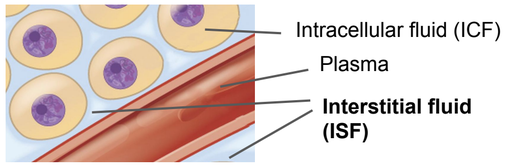
Objective & Impact

Monitoring Calcium Levels

Other approach: Doctor Testing Serum (blood)	Proposed method: At-Home Testing Interstitial fluid (ISF)
✗ Painful	✓ Painless
✗ Risk of infection	✓ Minimally invasive
✗ Time consuming	✓ Self-monitored
✗ Expensive	✓ Low-cost

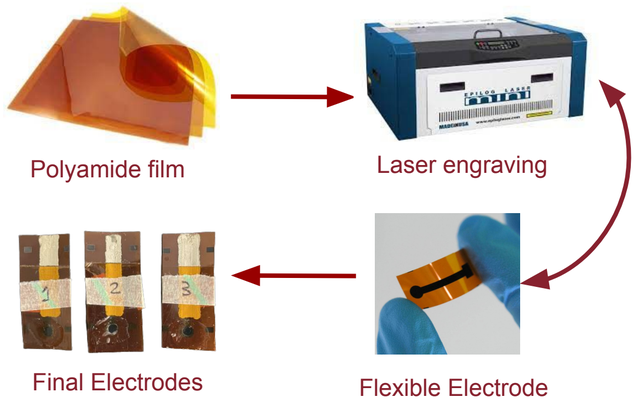
Potentiometric Calcium Detection with Electrodes: Methods & Results

Method of Measurement: Interstitial fluid (ISF)

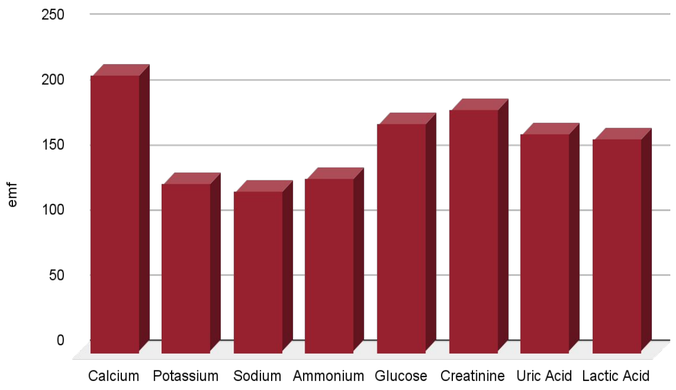


Potentiometry:
- Sensitive and reliable electrochemical method for ion detection
- An ion-selective membrane is attached to the electrode and exposed to a sample

Electrode Fabrication:



Selectivity Assessment



Calcium shows superior selectivity compared to other ions tested.

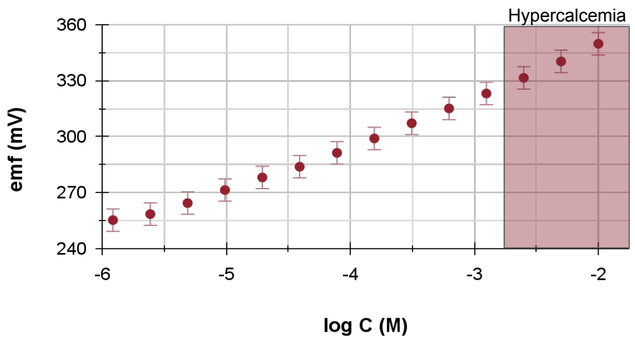
Nernst Equation:
Defines the relationship between the concentration of an ion on either side of an ion-selective membrane and the potential difference in voltage that will be measured

$$E = E_0 + \left(\frac{RT}{nF}\right) \log C$$

- E: potential difference
- E_0: instantaneous potential
- R: Gas Constant: 8.314 J/Kmol
- T: Temperature: 300 Kelvin (K)
- n: number of electrons transferred in the reaction
- F: Faraday Constant: 96485 C/mol
- C: concentration

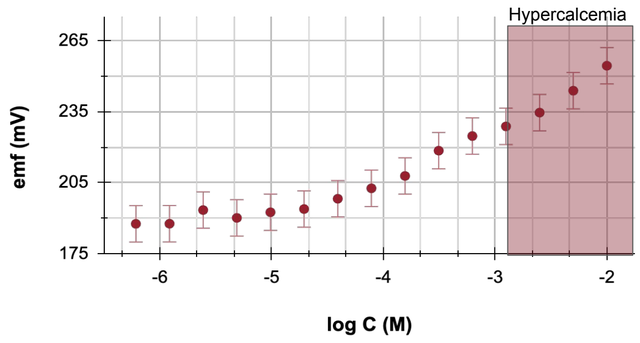
Using the Nernst equation, it was estimated that the slope, or $\frac{RT}{nF}$, should be ~29.1 mV/decade in order for the electrodes to successfully detect calcium ions.

Calibration in DI water



Limit of Detection:	Solution:	Sensitivity:
~15 µL	200 µM Ca^{2+} in DI Water	~26 mV/decade

Calibration in ISF

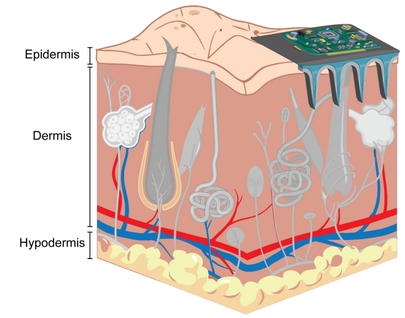


Limit of Detection:	Solution:	Sensitivity:
~96 µL	200 µM Ca^{2+} in Artificial ISF	~21 mV/decade

Future Applications

Once reliable results are acquired with the electrodes, they can then be incorporated into microneedles, enabling ISF collection.

Combining the calcium-ion selective electrodes with microneedles can facilitate painless and minimally invasive calcium monitoring.



References

[1] *What do our parathyroid glands do?* (n.d.)., from https://www.parathyroid.com/blog/what-do-our-parathyroid-glands-do

[2] Sadiq, N. M., Naganathan, S., & Badireddy, M. (2023). Hypercalcemia. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK430714/

Acknowledgements

Special thanks to Dr. Mousavi and my mentors Farbod Amirghasemi, Ali Soleimani, and Victor Ong for the guidance to do this research, and thank you to USC for the resources.