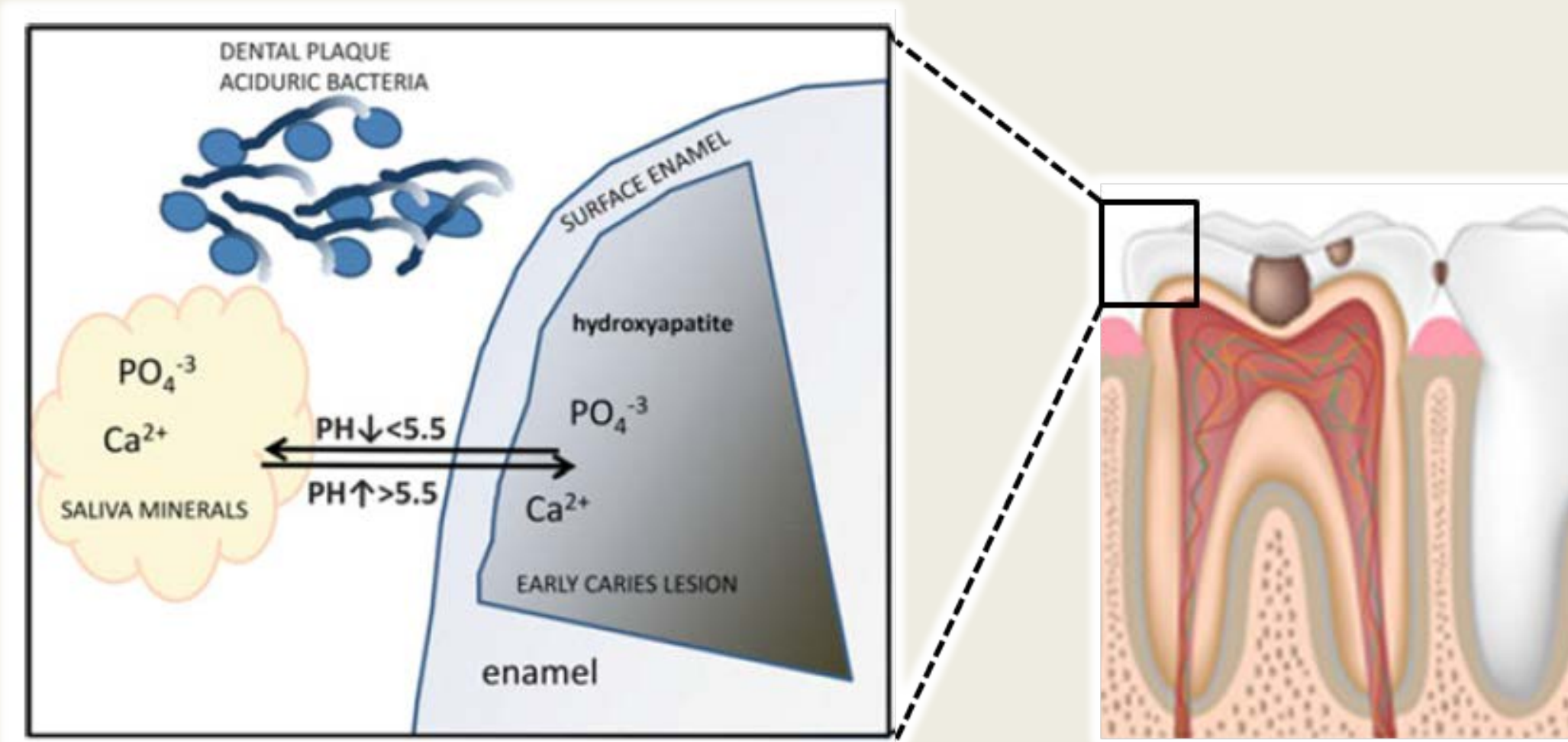


Background

Tooth decay is caused by demineralization in acidic conditions.

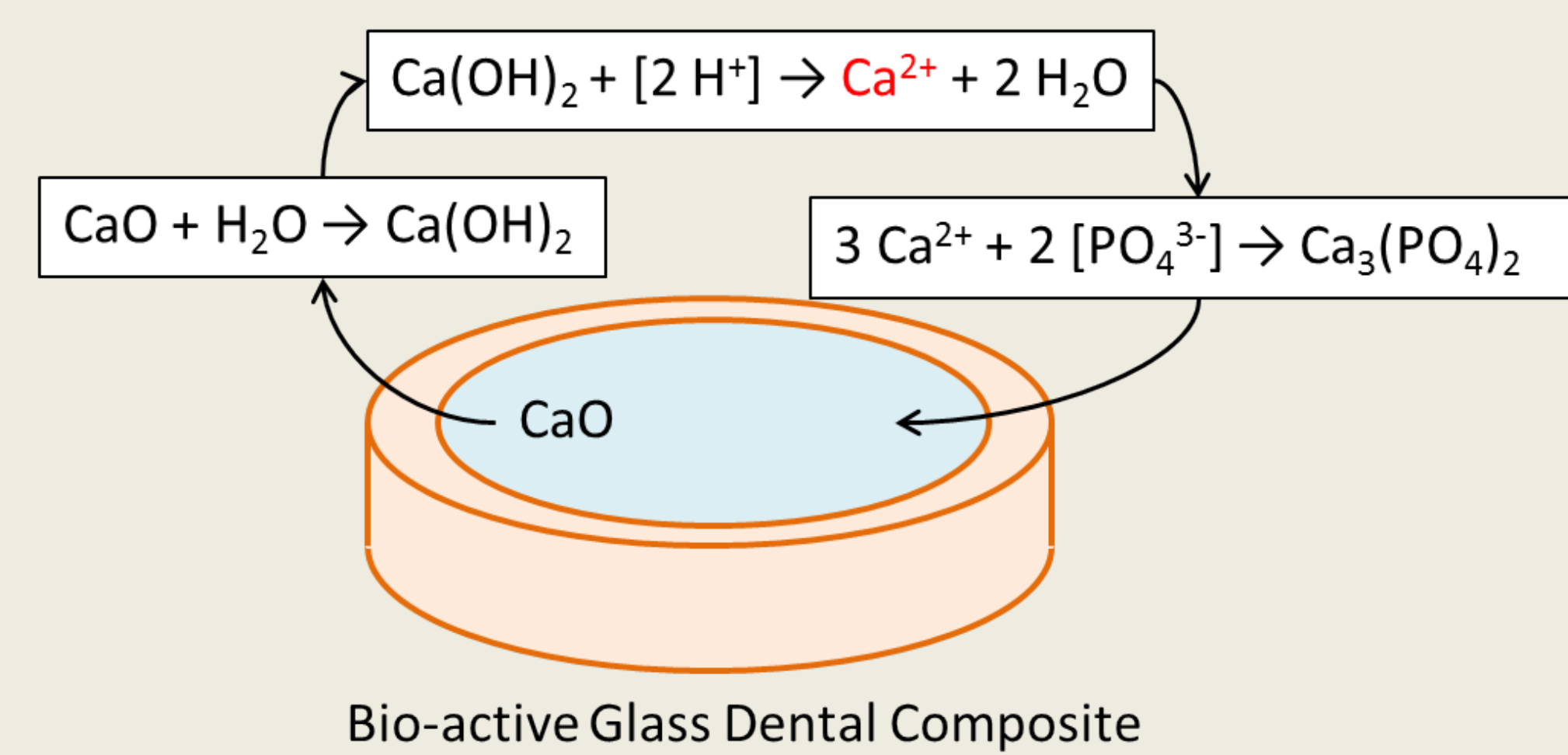


Current dental fillings have a 50% failure rate. A new bio-active glass dental composite uses calcium oxide to neutralize acidic pH and prevent tooth decay.

Opportunity

This research focuses on creating pH sensing ultramicroelectrodes (UME) used in scanning electrochemical microscopy (SECM) for high resolution pH mapping of local environments on biofilms.

Bioactive Glass



Bio-active glass releases calcium oxide to neutralize acidic environments, reducing harmful bacterial growth.

Electrode Design Goals

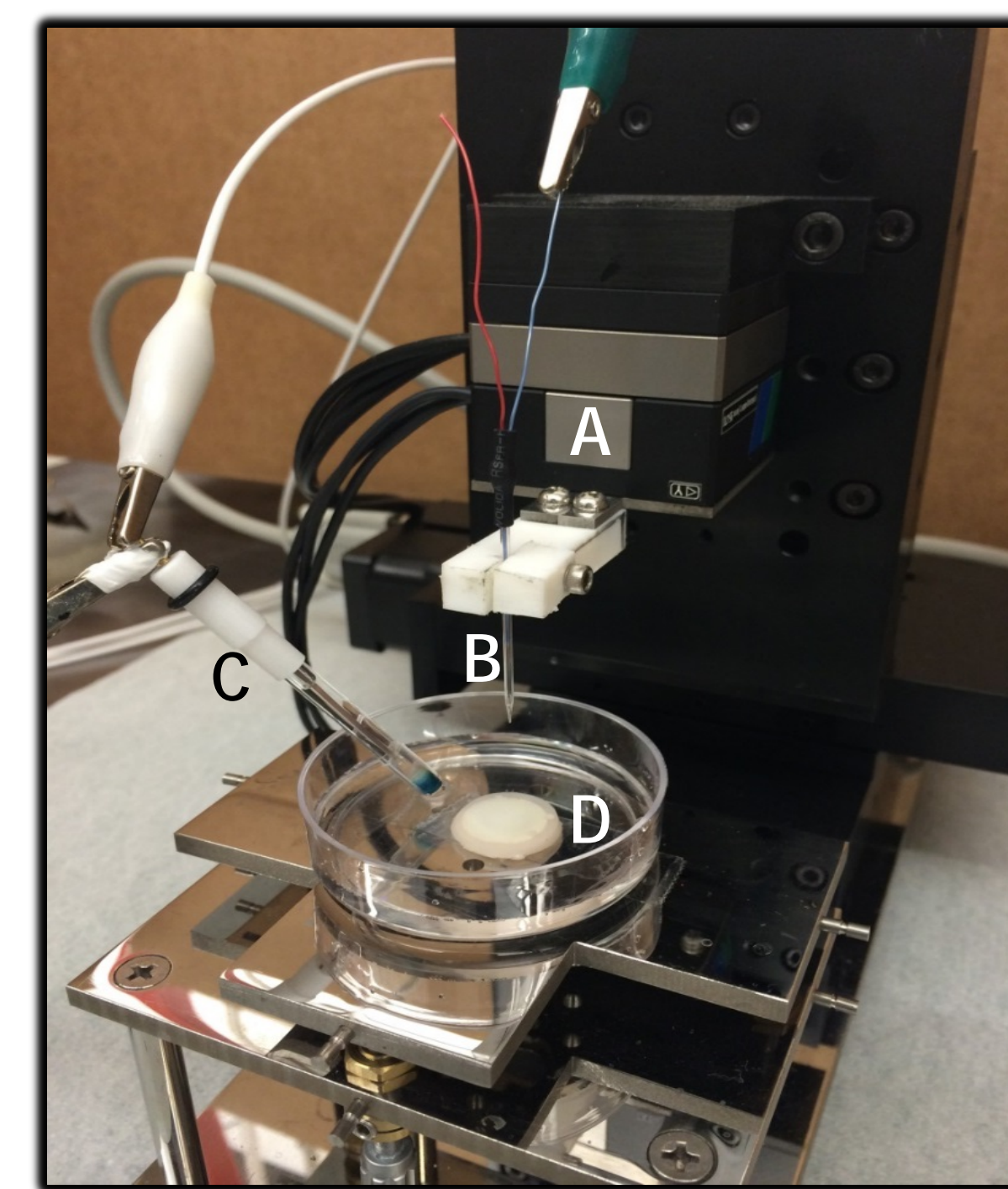
- Response time: <1 second
- Working range: pH 4 – 9
- Stability: 4+ hours

ELECTROCHEMICAL MICROSENSORS FOR HIGH-RESOLUTION CHEMICAL IMAGING OF BIOFILMS

Rachel Chan, Corey Downs and Dustin Harris
Project Sponsor: Dr. Dipankar Koley

SECM (Scanning Electrochemical Microscope)

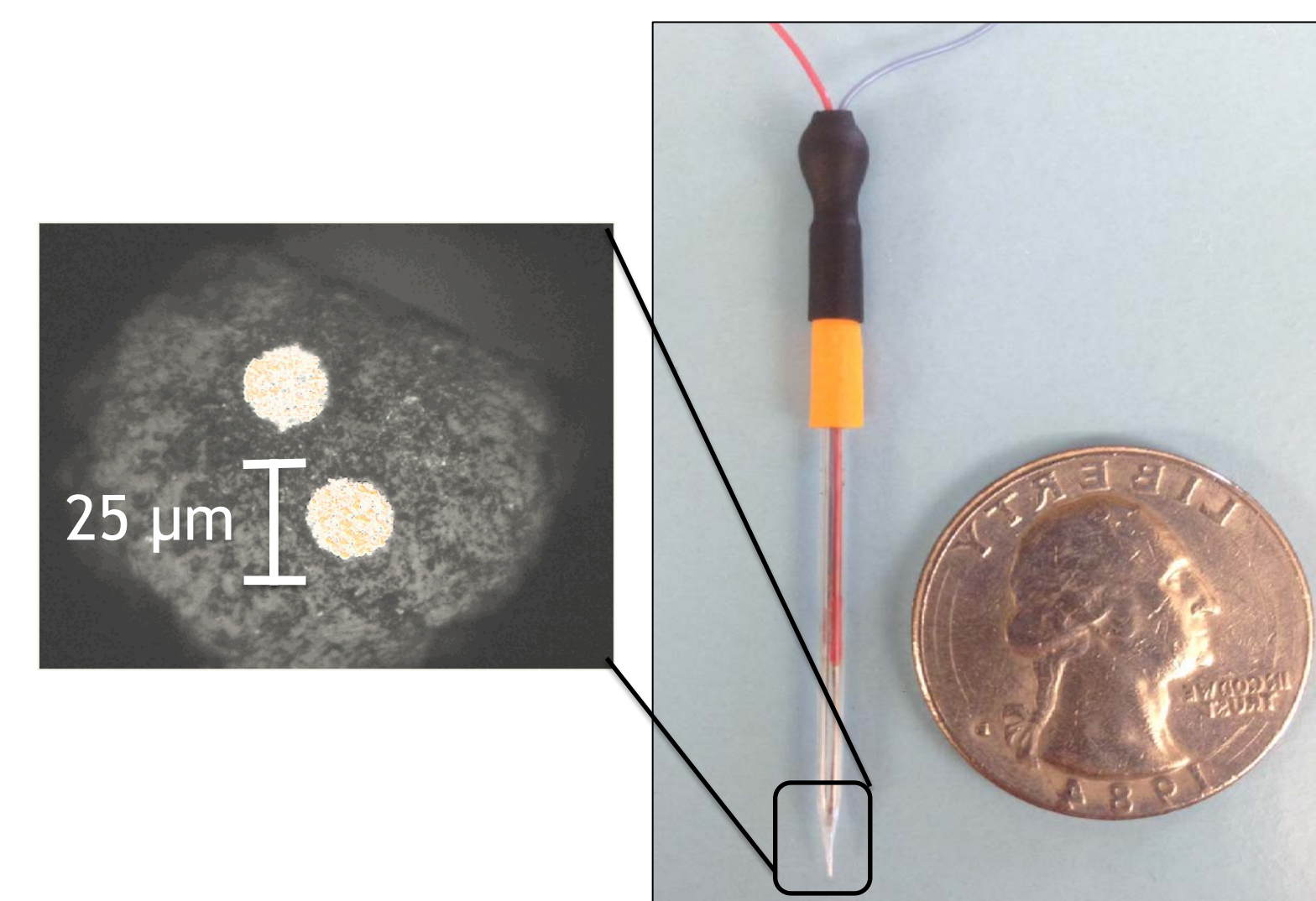
- SECM positions electrode in three-dimensions
- Spatial information is combined with chemical information to create a 3-D concentration profile



A: SECM motor
B: Dual-Tip electrode
C: Reference Electrode
D: Bio-active Glass

CH Instruments SECM device performing pH mapping of bio-active glass sample with a polyaniline modified UME.

Electrode Fabrication

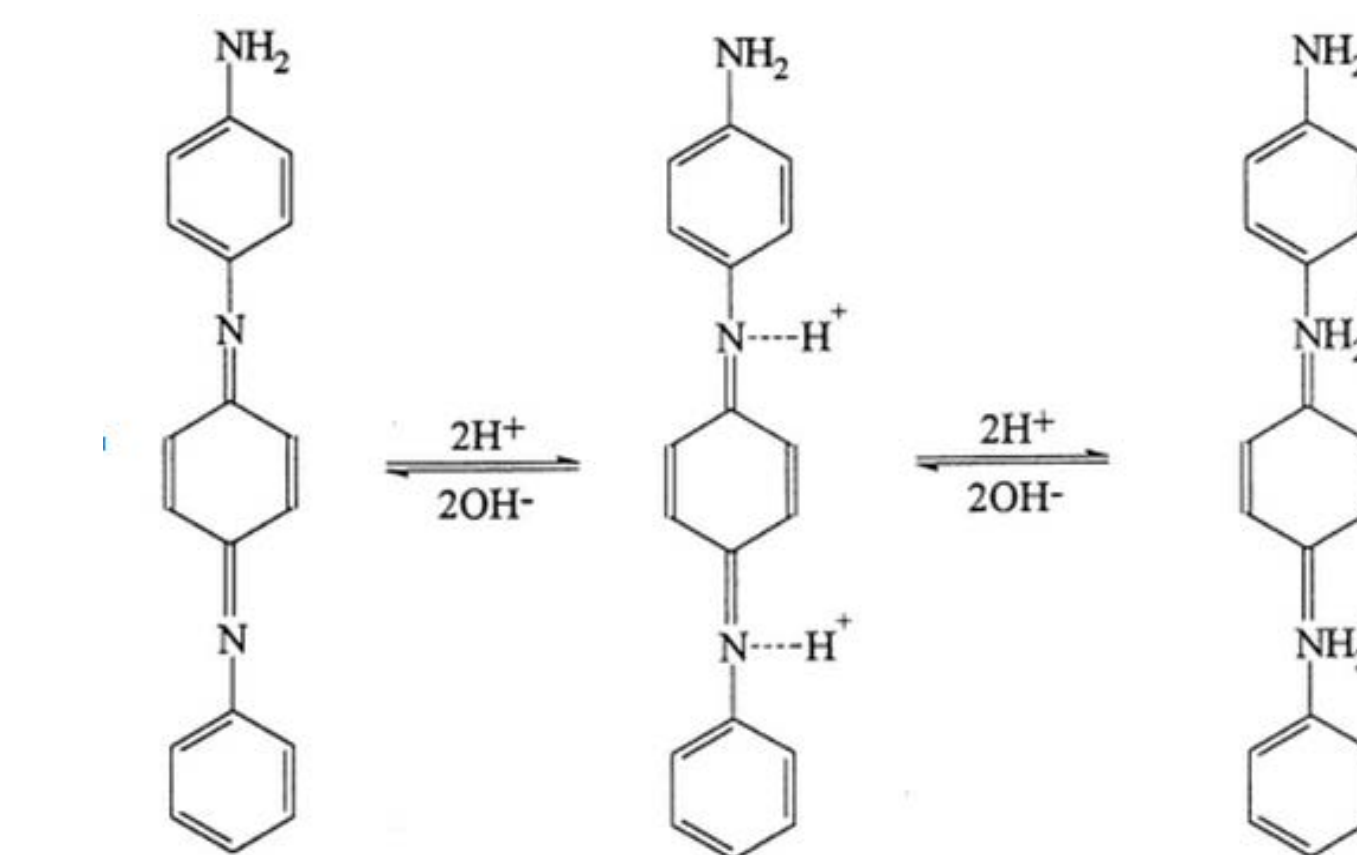
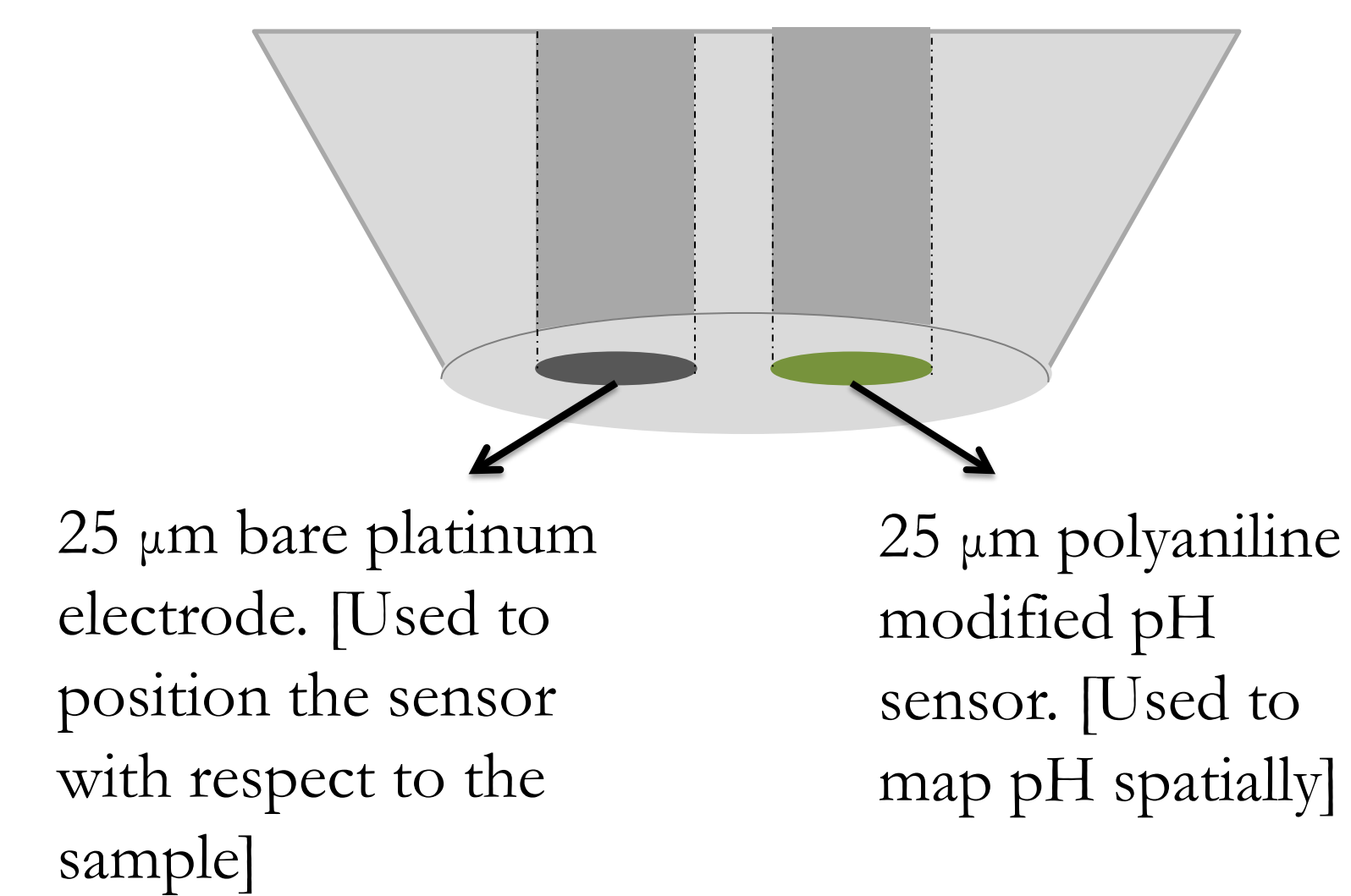


Dual-Tip UME fabricated by sealing two 25 μm diameter platinum wires in borosilicate glass pipette.

References

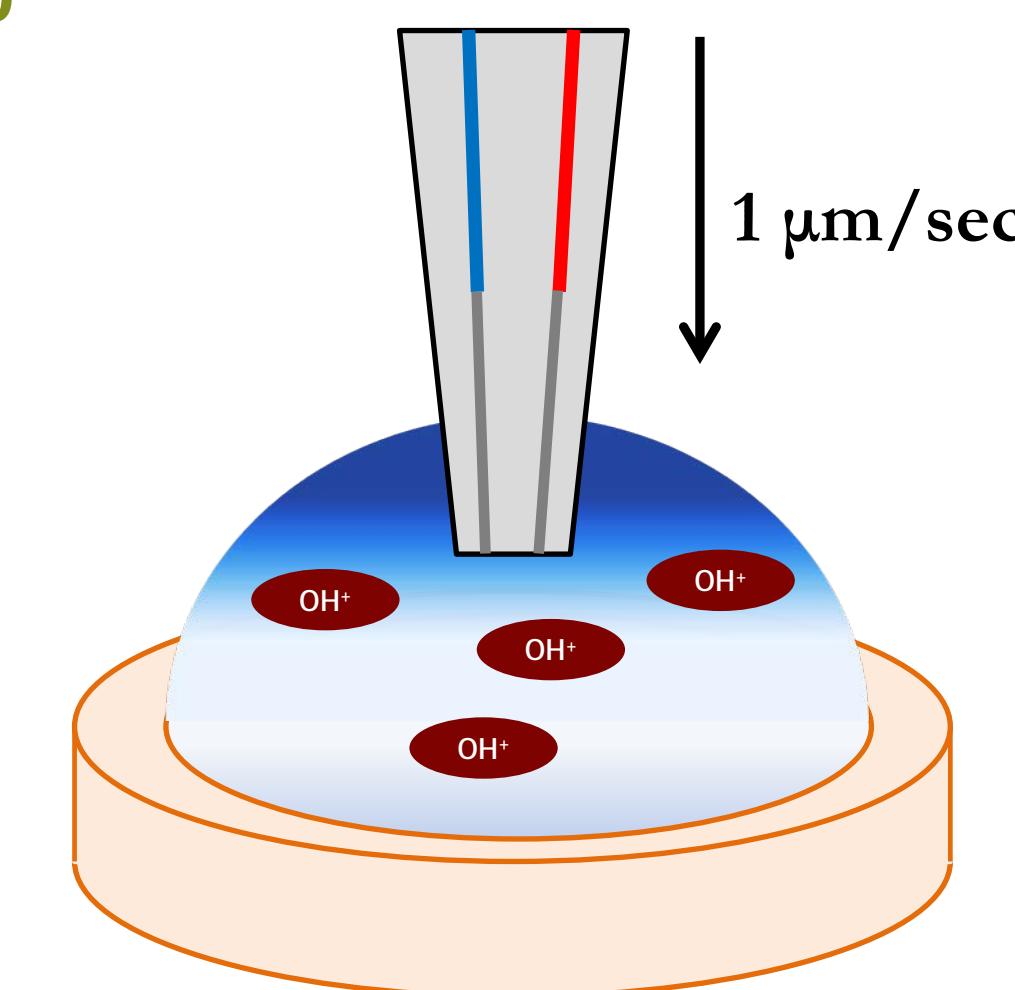
[1] Zhang, Xueji, Božidar Ogorevc, and Joseph Wang. "Solid-state PH Nanoelectrode Based on Polyaniline Thin Film Electrodeposited onto Ion-beam Etched Carbon Fiber." *Analytica Chimica Acta* 452.1 (2002): 1-10. [2] Xuhui Liu, Matthew M Ramsey, Xiaole Chen, Dipankar Koley, Marvin Whiteley and Allen J. Bard, "Real Time Mapping of a Hydrogen Peroxide Concentration Profile Across a Polymicrobial Bacterial Biofilm Using Scanning Electrochemical Microscopy (SECM)", *Proc. Natl. Acad. Sci. U.S.A. (PNAS)*, 108(7), 2668-2673 (2011)

pH Sensing Dual-Tip



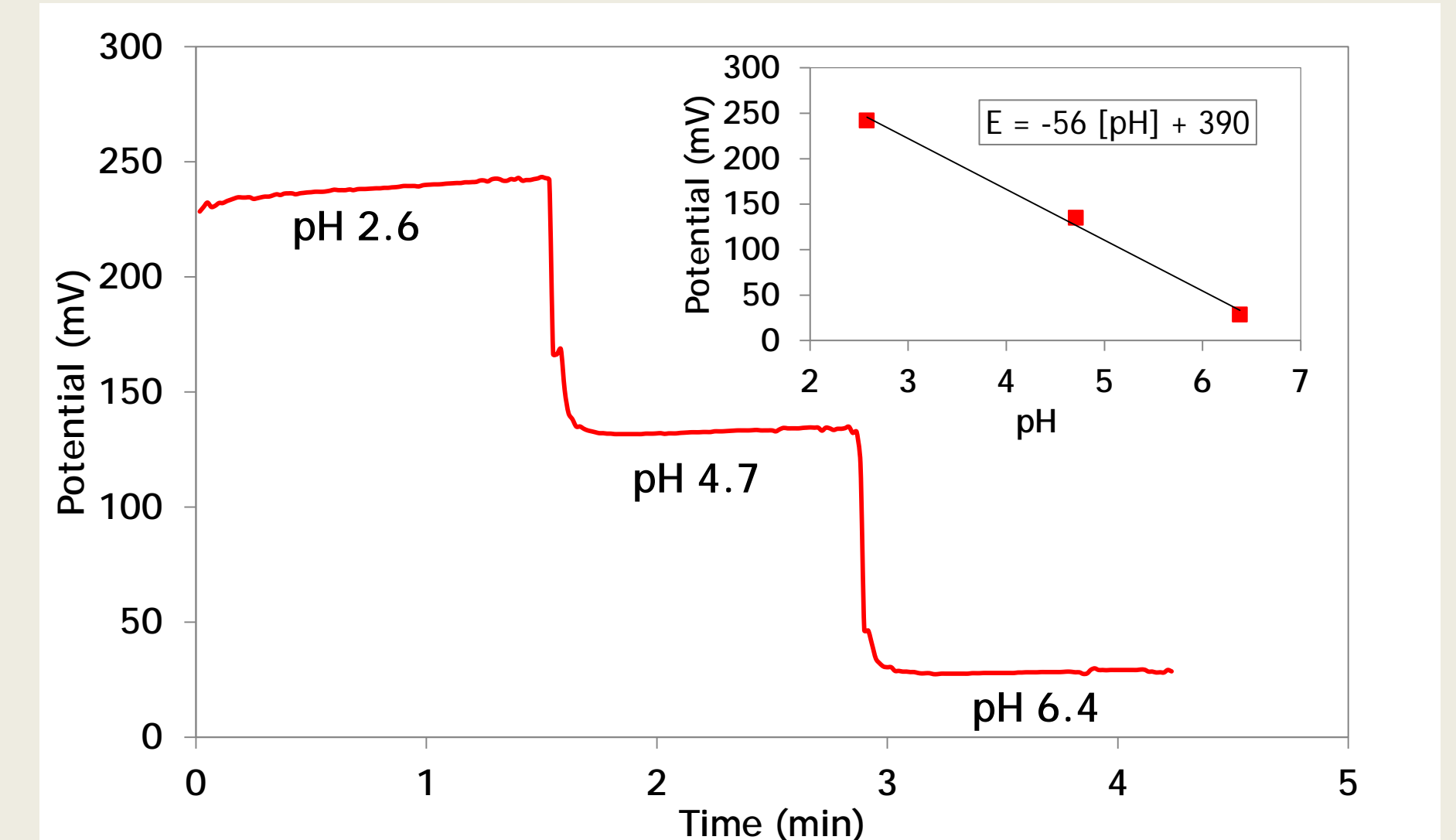
Polyaniline is a conductive polymer that can respond to pH.

pH Mapping



pH concentration data is obtained using dual-tip electrode and SECM. Chemical data is coupled with position data to produce a chemical profile over the bio-active glass dental composite.

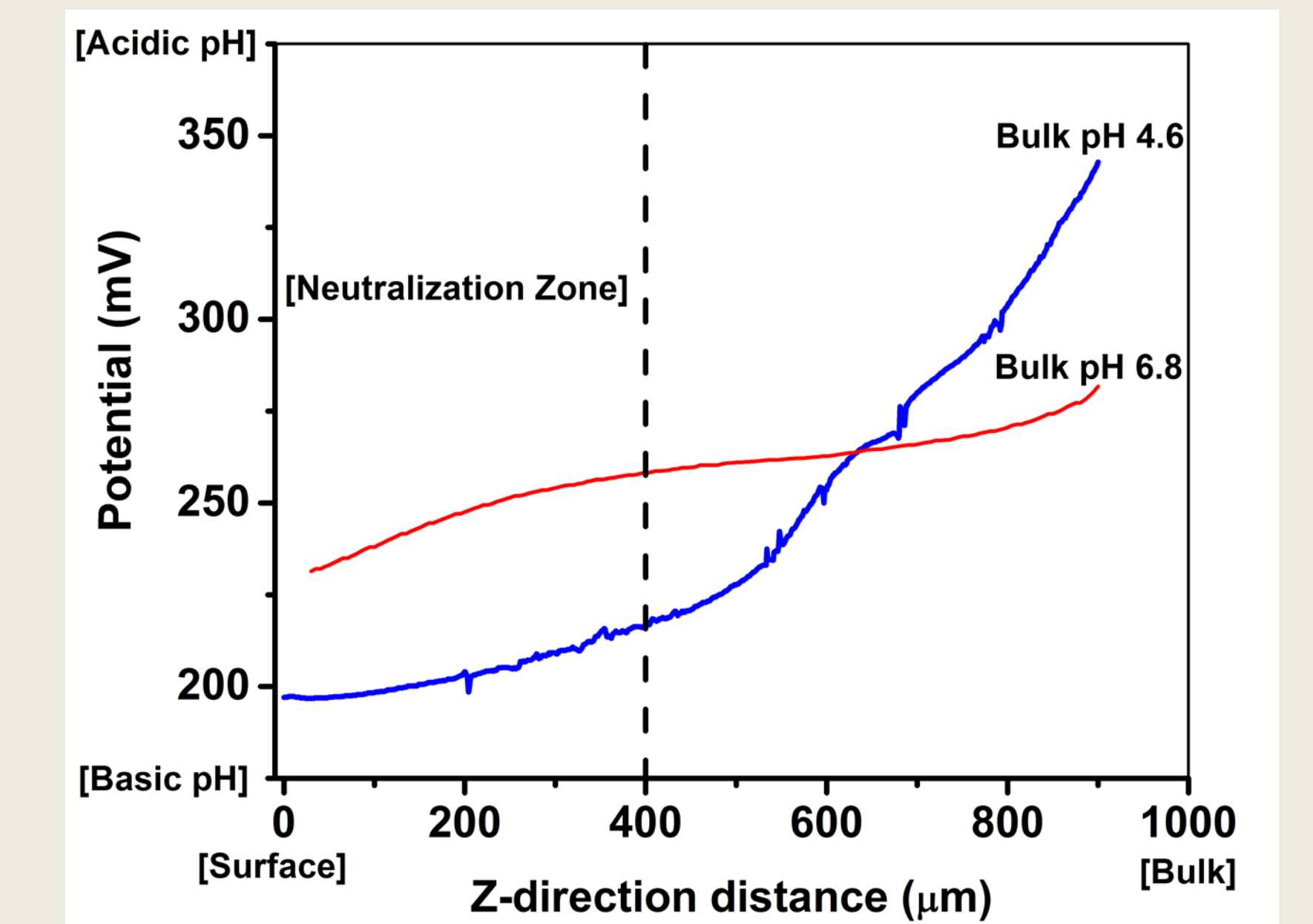
Results



Calibration of pH sensing dual-tip in universal buffer solution. The slope and intercept of each fabrication varies slightly.

$$E = \frac{RT}{nF} \ln [H^+] + E^0 = -59 [pH] + E^0$$

Nernst Equation provides theoretical basis for slope of an ion-selective electrochemical sensor.



Z-direction pH mapping above bio-active glass. Neutralization occurs near the surface of the bio-active glass where potential decreases. Observed signal is expected to plateau in bulk solution.

Future Work

- Continued characterization of bio-active glass
- pH and morphology mapping of dental biofilms grown on bio-active glass

Acknowledgments

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