Measuring the Double Layer Capacitance of Electrolytes with Varied Concentrations

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INTRODUCTION

When electric potentials are applied from an electrolytic fluid to a metal, a double layer capacitor, C_{dl}, develops at the interface. The layer directly at the interface is called the Stern layer, and has a thickness equal to roughly the size of the ions in the fluid. The next layer, the diffuse layer, arises from the gathering of like charges in the Stern layer. This layer is the distance needed for ionic concentrations to match the bulk fluid. This distance, called the Debye length, λ, depends on the square root of the electrolyte concentration. To study the properties of the diffuse layer, we measure C using different concentrations of electrolyte solutions in a cylindrical capacitor system we machined.

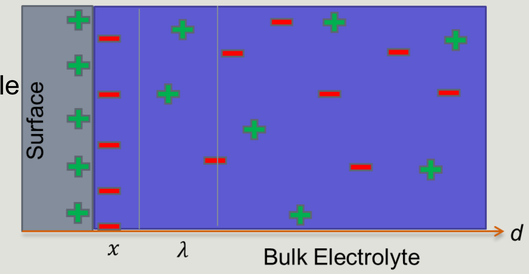
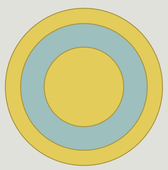


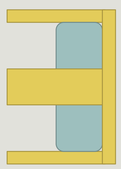
Figure 1: Model of double layer capacitance

EXPERIMENT

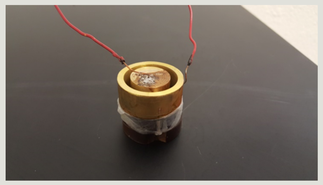
- Intent: Change fluid level on single device while measuring C
- Built cylindrical capacitor
  - Brass cylinders
  - Garolite base
  - Parafilm O-ring
- Mixed solutions: NaCl, Phosphate Buffer, and HEPES

Figure 2: Schematic of cylindrical capacitor and real device





$$C = \frac{2\pi\varepsilon_0\kappa l}{\ln b/a}$$



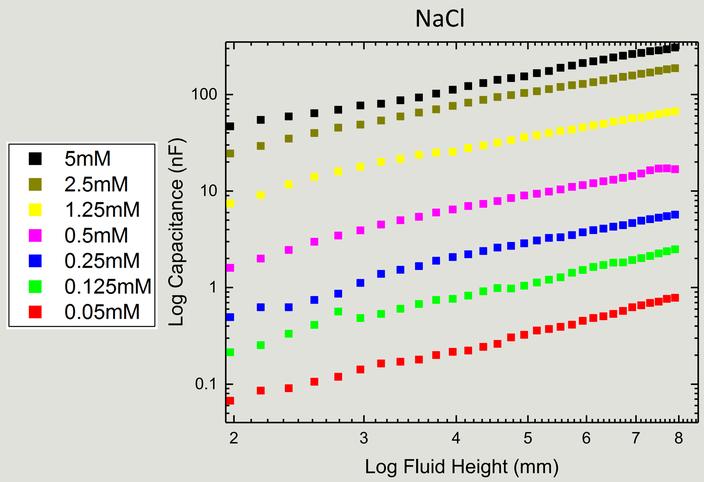


Figure 3: Log of the linear capacitance plots over the log of varied fluid height.

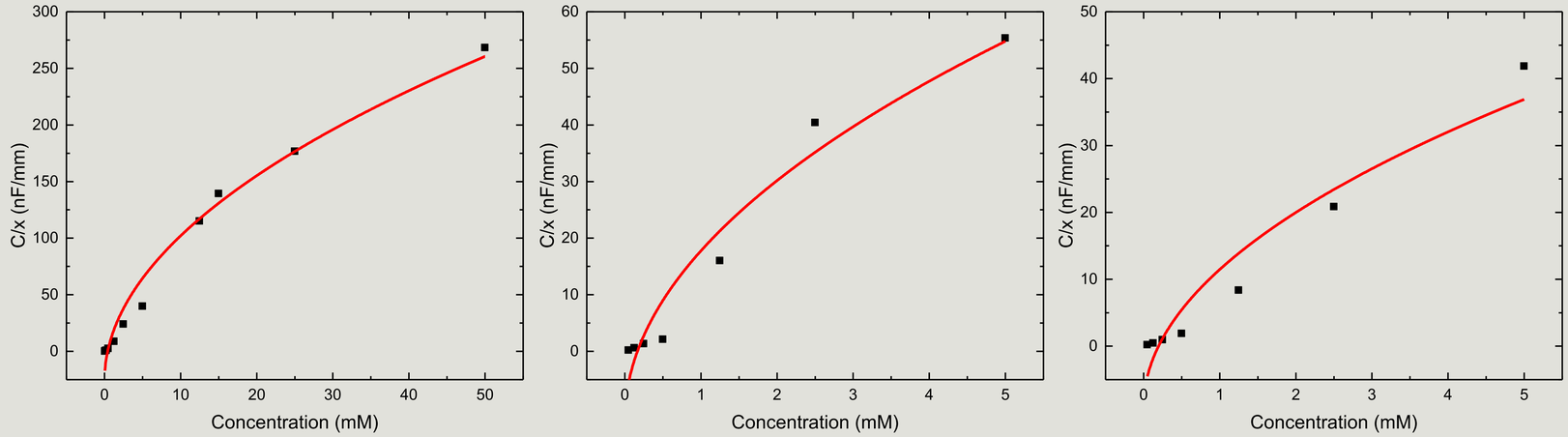


Figure 4: $\sqrt{c}$ fits for the slopes of each concentration.

RESULTS & ANALYSIS

- Linear correlation between capacitance and fluid height
- Strong $\sqrt{c}$ fit for NaCl
  - Weaker fits for Phosphate and HEPES
- Model is not accounting for Stern layer
- In simple solutions $\sqrt{c}$ models effectively
- More complex electrolytes may depend more heavily on Stern layer
- To accurately model ionic behavior in fluid both the Stern layer and Debye length must be accounted for

FUTURE WORK

Future work on this project will be in effectively modeling double layer capacitance with the inclusion of both the Stern layer and Debye length. In this way we can more accurately predict the behavior of different electrolytic solutions.

ACKNOWLEDGEMENTS

Linfield College Department of Physics
Faculty Student Collaborative Research Grant, Linfield College
Dr. Tianbao Xie & Dr. Elizabeth Atkinson (Linfield)
Agatha Ulibarri, Hayden Rock, & Rachel Williams (Linfield)