Thermally Enclosed Phospholipid Enclosure

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ABSTRACT- **Currently there is different research regarding the many different uses of phospholipids, including but not limited to increasing biocompatibility of foreign objects and new drug delivery systems. This paper describes a method for creating a thermally insulated enclosure in order to benefit the study of said phospholipid research. This enclosure will be portable, lightweight, and cheaply manufactured. There will be two main components to this enclosure that will be fitted together. The external thermal insulation layer is made of Nylon 06 and an internal conductive heating cell is comprised of Copper 110. This enclosure can be mounted onto the existing testing rig and will have its temperature maintained and monitored through an external PID controller to within 0.1℃.**

I. INTRODUCTION

Phospholipids are composed of two parts, a hydrophobic and hydrophilic part. Due to the nature of these phospholipids, when they are placed in water, they create a membrane. These membranes can serve as a coating to make materials more biocompatible and can serve as a basis to drug delivery packages.

Dr. Lurio of the NIU Physics department is currently characterizing these membranes using x ray diffraction through an aluminum observation cell. Dr. Lurio's studies would benefit from a thermally controlled enclosure around this aluminum cell. Currently, the aluminum cell has a temperature gradient of just over one degree Celsius from edge to edge.

The goal is to create a thermally controlled enclosure that reduces the temperature gradient to one tenth of a degree Celsius from edge to edge of the observation slide. The enclosure must be easy to use and come to a steady state temperature in a reasonable amount of time.

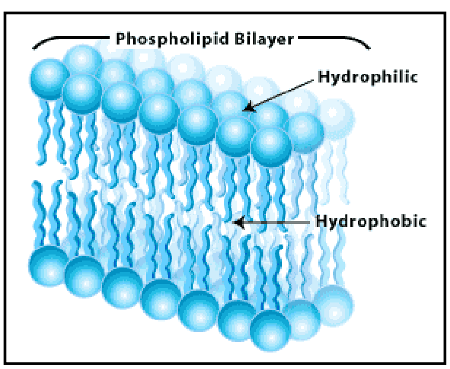

Figure 1: Phospholipid Bilayer

. II. DESIGN

Some of the contextual knowledge used to approach this problem includes understanding different principles of heat transfer. Some of these principles include conduction, convection and radiation. It was these principles that were considered when creating the design for the enclosure.

A. Heating Cell

In the heating simulations without the enclosure, the observation cell could be seen to be losing temperature along the longest edge of the heating cell by conduction. To reduce this effect, all other available sides must be heated evenly to reduce the gradient along the longest edge of the heating cell. Using this conclusion, it became clear that an important property of the enclosure was to create a heating cell that evenly distributes the heat across the observation to maintain a minimum temperature gradient. In order to evenly heat all other available sides of the observation cell at the same time, an enclosure made of copper 110 is placed over the observation cell and mounts directly to the heated surface. The copper enclosure is heated by the mounting surface by conduction, then the heat is distributed to all available surfaces of the observation cell. Copper 110 was selected to be used as the material for the heating cell because of its high thermal conductivity and machinability. The issue we found with this design of the enclosure was that it would lose heat to its exposed surfaces by convection.

B. Insulating Cover

One of the issues found with this design was that there were flat surfaces on the outside of the heating cell that would cause heat loss by convection. The solution to this was placing an insulating cover over the copper heating cell to insulate the heat inside the enclosure. This cover would mount onto the heating cell with a single bolt and would be made from nylon 6. Nylon 6 was selected because of it very low thermal conductivity and minimal cost.

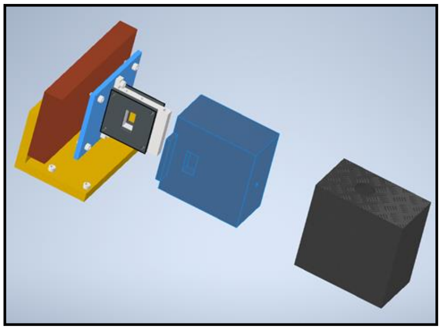

Figure 2: Exploded View of Enclosure

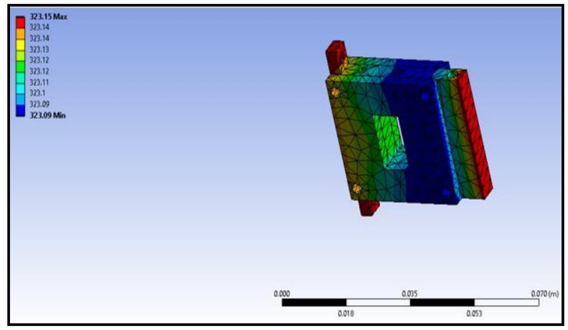

Figure 4: With Thermal Enclosure

III. EXPERIMENTAL

A. Simulation

In order to produce the most accurate results, this projects goal was to create an enclosure that would maintain the fixture's thermal gradient to 0.1℃.

The goal of the first simulation was to replicate the environmental conditions on Dr. Lurio's lab. Doing so would create an understanding of the current temperature distribution inside the observation cell. In order to obtain some of the parameters for testing, convection coefficients must be calculated. The convection coefficient was calculated by using similar heating scenarios found in the fundamentals of heat and mass transfer book. Then the observation cell was then treated as a fin with regards on thermal analysis. After applying the calculated convection coefficients, a 3-D Model was crafted in Autodesk Inventor and imported into ANSYS Steady-State Thermal. Using ANSYS, it was possible to apply calculated parameters as well as experiment with different heating element placements across the fixture. After various simulations, it was identified that the gradient was the lowest when the observation cell was heated at both ends using conduction, while all other available surfaces were heated using convention.

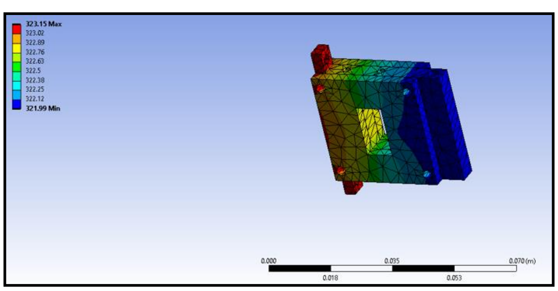

Figure 3: Without Thermal Enclosure

B. Results

As shown in Figure 4, after implementing the environmental parameters that the observation cell would be experiencing while inside the enclosure, it was found that the cell would have a temperature gradient of less then a tenth of a degree Celsius. While there appears to be the same amount of thermal gradient on either figure, the temperature change is quite drastic. In figure 3, the overall temperature loss was 1.16℃ whereas in figure 4, the overall temperature loss was 0.06℃.

C. Testing

After manufacturing the enclosure out of the respective materials, it will be further tested through running a live experiment. There will be an additional hole milled into the top of the enclosure to allow thermistors to enter various points along the test fixture. This will allow for the monitoring of temperature distribution across the system. This is how the temperature gradient will be confirmed across the observation cell.

IV. CONCLUSION

Overall this project focused on creating an enclosure that maintains the temperature around and inside the designated fixture. Through the help of PID control and computer simulations, it was possible to verify that using the thermal enclosure, the temperature gradient was maintained and controlled to within 0.01℃. Upon completion, this project will assist in the research of phospholipid structures for Dr. Laurence Lurio.

ACKNOWLEDGMENT

The completion of this study could not have been possible without the expertise of Dr. Laurence Lurio, our beloved client. We would also like to thank Dr. John Shelton and Matthew Kleszynski for sitting on our panel and taking the time to advise and read our proposal.

REFERENCES

[1] Theodore L. Bergman, and Adrienne S. Lavine, *Fundamentals of Heat and Mass Transfer,* 7th ed. John Wiley & Sons Inc: Don Fowley, 2011