Surface Instability Of Inverted Polymer Tubes

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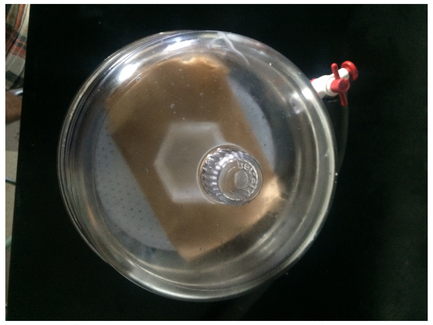
ABSTRACT

Geometric properties and surface instabilities of polymer tubes have been studied through simulations. These simulations have predicted deformations and creasing in inverted tubes. This experiment served the purpose of verifying the accuracy of those predictions, by creating and inverting tubes of varying thickness.

The experimental results reveal that the trends shown by the graph, in regards to deformation of the inverted tube, are accurate. Meanwhile the inverted tube of thickness larger than critical value generates creasing instability on the inner surface of the tube.

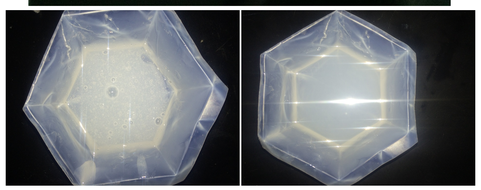
Constructing the Polymer Tubes

1. Stir together equal components A and B of Dragon Skin.



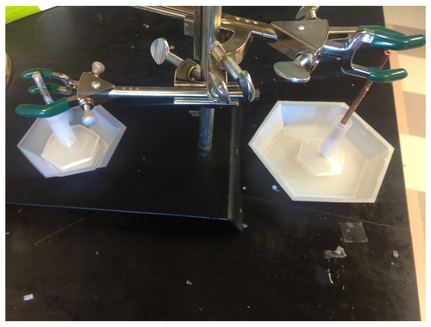
2. Place material in a vacuum chamber to remove bubbles.

3. Poor material in to graduated cylinders.



Before After

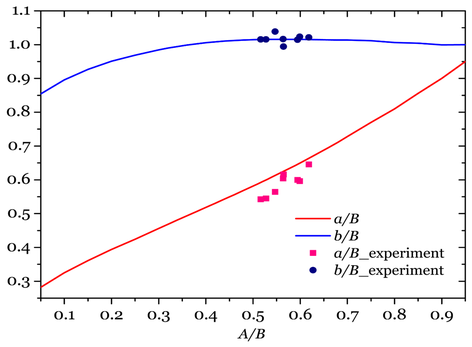
4. Push the rod through to make the tube.

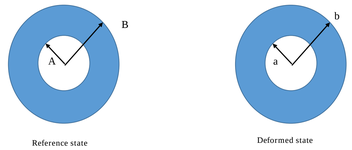


5. Use ring stands to insure tubes do not become slanted.

6. Wait for material to completely dry.

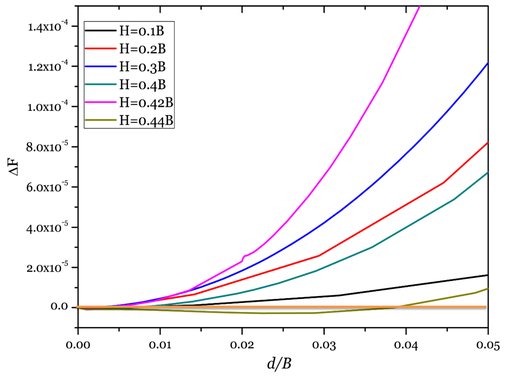
Geometric Properties Before and After Eversion





The graph shows two lines which represent predictions from simulations. The pink squares and blue circles are values based on measurements from tubes made in this experiment. Clearly, the results obtained through experimentation follow the predictions closely.

Surface Instability of Inverted Tube

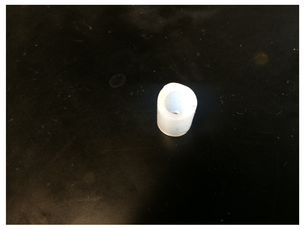


The graph above shows the change in free energy versus the geometric change in the tube. The different colored lines represent different thicknesses of the tube. The line at the bottom is seen to go below the zero line (Orange line). This is because when this tube is inverted the free energy decreases and makes forming a crease on the inner surface more favorable. When the free energy increase forming a crease is no longer favorable. The pictures below show what the creasing can look like.

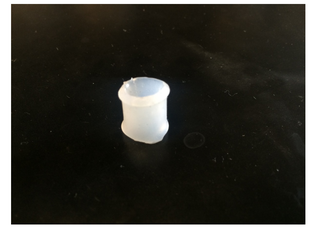
CONCLUSIONS

The completion of this experiment verifies two important predictions. The first one being that the data gathered by simulations can be accurately reproduced in real life, in regards to geometric deformation of the tubes. The points shown on the graph to the left represent the values obtain from the tube produced for this experiment.

The second one being that there is a threshold or critical value for when the free energy in the system will decrease and thereby make the formation of creases on the inner surface favorable. Below are pictures a tube before and after eversion. It can be seen that no crease is formed due to an increase of free energy in the system.



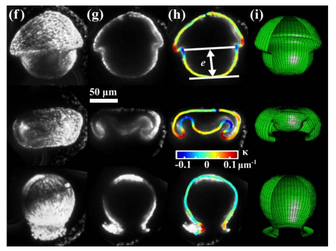
Before Eversion



After Eversion

FUTURE RESEARCH AND IMPACT

This research is important because it will allow for a more complete understanding of certain biological processes which involve an organism inverting itself. For example, the picture below shows the Volvox embryo inverting itself.



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While conducting this experiment, there were a few errors that occurred. Most were in regards to the alignment of tube. In order to address this problem different solutions for molding the material into the tubes must be developed. For example, the prototype shown below was made using a 3D printer.