Measuring Surface Tension of Propylene Glycol and water mixtures for use as a propellant for Cube Satellites. **Jordan Patterson[1], John Lee[2] and Po-Hao Adam Huang,Ph.D.[3]** [1]Pittsburg State University Department of Biology, 1701 South Broadway Pittsburg , KS, 66762, U.S.A. (jordankeith3@yahoo.com), [2] University of Arkansas Department of Mechanical Engineering, Fayetteville, AR, 72701, U.S.A (jbl003@uark.edu), [3] University of Arkansas Department of Mechanical Engineering, Fayetteville, AR, 72701, U.S.A (phuang@uark.edu)

Background: Cube Satellites[1] are miniature satellites that measure 10 cm^3. There has been a huge push in developing these in universities in the past twelve years because of their relatively low cost to make and send into space. This Push has been mainly by Cal Poly Technic University and Stanford University. Most CubeSats in orbit or being developed today are not controlled by thrusters but moved by gravity. This can be a problem when the CubeSat has been sent up for a specific purpose. That is why the focus has now been on developing some kind of propellant system for these satellites. The propellant is going to be a mix of propylene glycol and water which will be pushed thru a membrane. To do this the mixture must have a high surface tension along with a very low freezing point.

Methods: The summer task was to design a set up to measure the surface tension of mixtures made of propylene glycol and water. The equation used to do this was $H = \frac{2\lambda \cos\theta}{pgr}$, using this equation all the variables but H (height) and λ (surface tension) were known. Knowing this an experiment was able to be created (Figure 1). Used in the setup was a capillary tube with a r= .0006 mm, a computer screen to give contrast to the bubble, a fiber lite optic illuminator to brighten the bubble even more, and a HD camera to get the best picture quality. Vision Assistant was then used to zoom in and measure the height on a very small scale (Figure 2). Mixtures for every ten percent from zero to one hundred were chosen to be used. This would allow for the best mixture of solution with the highest surface tension and the lowest freezing point to be chosen. The freezing points are readily available and well documented on the web. For the experiment multiple pictures of each

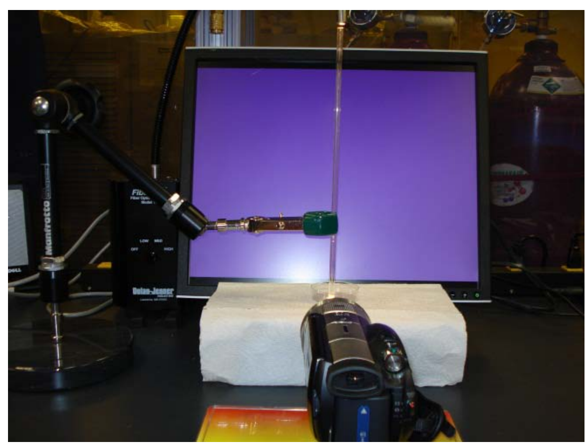

Figure 1. Experiment setup

solution in the capillary tubes (radius = .0006 mm) were taken and measured by processing them thru vision assistant and converting pixels to millimeters. After doing this, average heights for each percentage of the solutions were found. Using vision assistant also got θ which is the contact angle of the solution and the capillary tube.

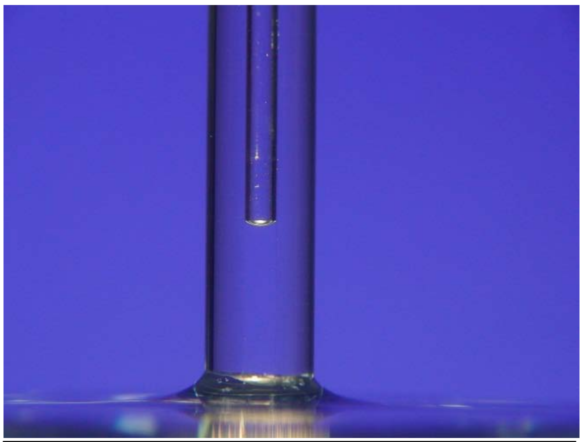

Figure 2. Picture to be analyzed

Results: In the experiment a trend was found in percentages and heights of the solutions. In figure 3 it shows the averages of each solution with a 3rd order polynomial curve.

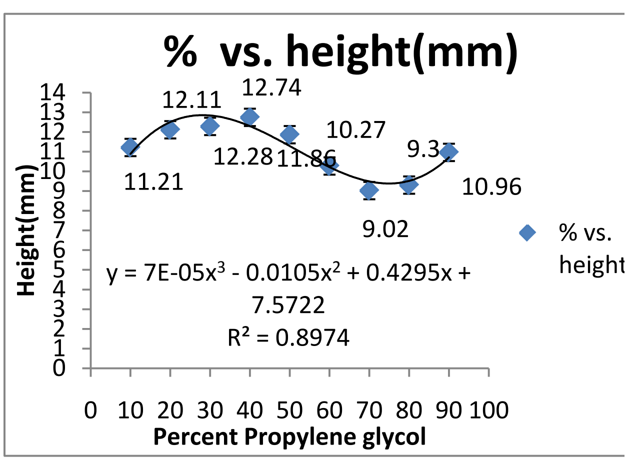

Figure 3. Averages of every ten percent

With this info all the surface tension values of each percentage was found. With these values matched to the known freezing points[2] as shown in figure 4. With this we could then pick the best solution

percent	freezing point©	surface tension
10	-3	0.0547
20	-7	0.0624
30	-12	0.0599
40	-20	0.0248
50	-32	0.0261
60	-51	0.0214
70	-62	0.0339
80	-71	0.0433
90	-80	0.0412

Figure 4. Surface tension chart

Conclusion: These results are not conclusive because only ten trials of each solution were completed. Also human error played some effect in the results. Moving on the goal would be to develop a program that would scan the pictures taken and measure them automatically and give you a height and a contact angle so there would be no human error at all

References:

1. “CubeSats in the news”.Web. www.cubesats.org

2. “Freezing point of percent propylene glycol”. Web. http://en.wikipedia.org/wiki/Propylene glycol