Propylene Glycol and Water as Propellant for Cube Satellites

Jordan Patterson, Pittsburg State University Department of Biology, 1701 South Broadway Pittsburg , KS, 66762, John Lee and Po-Hao Adam Huang Ph.D., University of Arkansas Department of Mechanical Engineering, Fayetteville, AR, 72701, U.S.A.

Introduction:

- Cube satellites have been being researched for the past twelve years by Cal Poly Technic University and Stanford University[1]

-Cube Satellites are satellites on the Nano scale that measure in about 10 cm^3 as seen in figure 1.

-Can be inexpensively made and sent into space.

-Do not have own propulsion system yet and are moved by gravity

-They are available to the public.

Figure 1. A standard cube satellite

Objective:

The Objective of the project was to find a way to accurately and repeatedly measure the surface tension ,using a capillary tube, of any mixture of water and propylene glycol because this would be needed to accurately choose which solution would be used as the propellant for the cube satellite. The solution must have a high surface tension with a low freezing point because it will be pushed through a membrane.

Equation:

1) $$H = \frac{2\lambda \cos\theta}{pgr}$$

H= height of solution
λ= surface tension
p= density of solution
g= gravity
r= radius of capillary tube
Θ= contact angle

Methods:

A good contrast of light was needed to see the meniscus and get the measurements so the computer screen was used to get the right colors. After tests it showed that different color gave the same solutions different heights due to frequency as seen in figure 3. The setup used to measure the height is shown in figure 2. The process is listed below

-Mix 9 solutions(1 every 10%)
-place in front of computer screen with purple background
-pour solution into Petri dish
-place capillary tube in arm to hold in place
-place optic light illuminator directly over tube to give great contrast to the meniscus
-focus with HD Sony camera
-process image thru Vision Assistant to get height and angle
-convert height from pixels to mm using the know width of tube

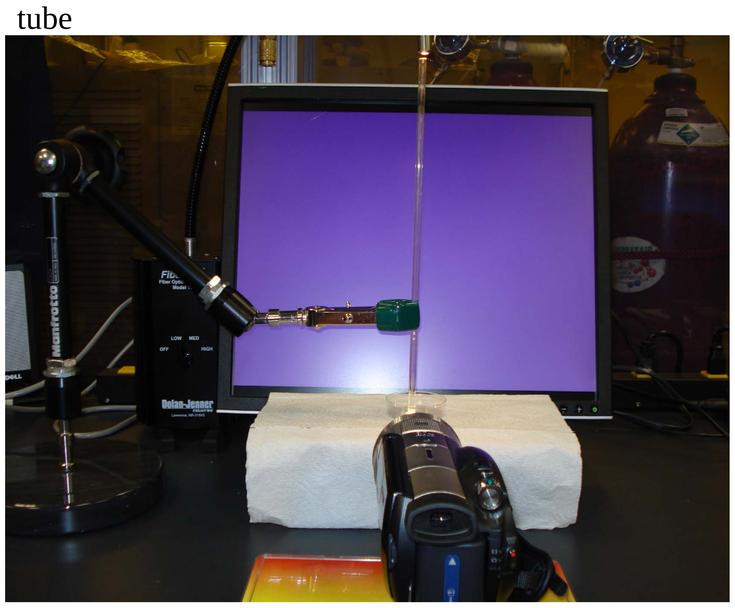

Figure 2. experimental setup

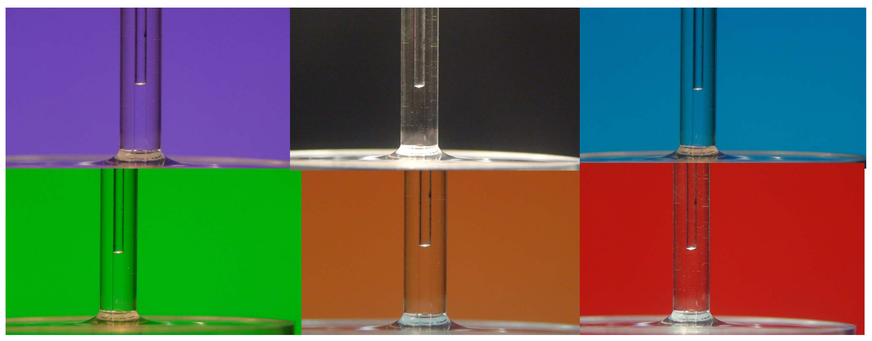

Figure 3. Color calibration

Results:

Ninety Pictures (ten of each solution) were taken and ran through vision assistant to get there height and contact angle. These were then plugged into equation one to get the surface tension. The first graph shown in figure 4 is the average height for each solution.. Figure 5 shows the freezing point for each solution[2], the solutions surface tension and its average contact angle found by using vision assistant.

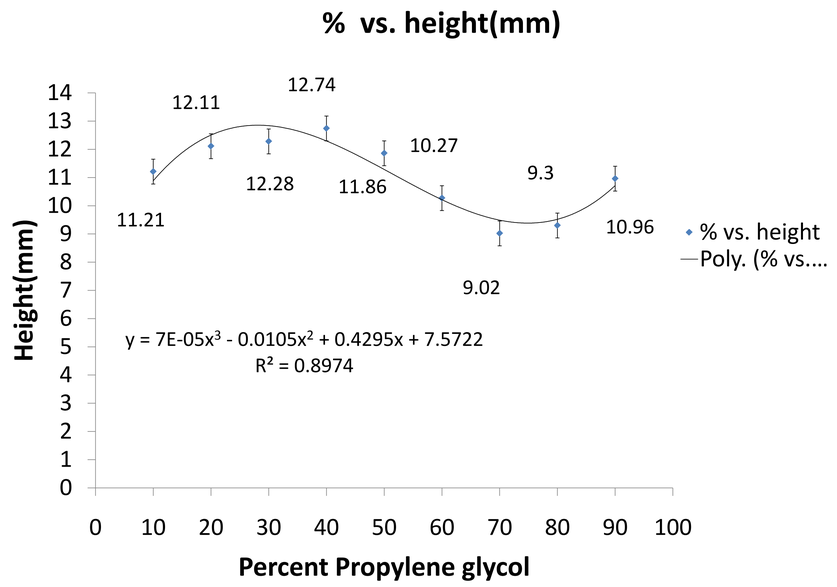

Figure 4. height vs. percent graph fit by a third order polynomial

percent	surface tension(N/cm)	contact angle(deg.)	freezing point(C)
10	0.0547	54.99	-3
20	0.0624	52.39	-7
30	0.0599	51.44	-12
40	0.0248	48.21	-20
50	0.0261	43.62	-32
60	0.0214	44.53	-51
70	0.0339	38.1	-62
80	0.0433	49.04	-71
90	0.0412	41.55	-80

Figure 5. surface tension chart

Conclusion:

These results show that there is a relationship between the height and percent propylene glycol as shown in figure 4. I believe more trials would show the same thing. The results as seen in figure 5 show that a number of different solutions would be well suited for the cube satellite and being used as propellant.

References/Acknowledgements

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

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

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