Electrowetting Optics

Using Electricity to Create Precise Instrumentation

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What is Electrowetting?

Electrowetting is defined to be the modification of the surface tension, or wettability, of conducting liquids by generating a controllable electric field around it. The applications of electrowetting can be seen in budding technologies used in tablet screens and in precision laser optics. The purpose of this research has been to attempt to recreate the basics of known electrowetting effects.

Theory & Current Uses

In commercial liquid lens systems the surface tension of the droplet can be adjusted by an increase in voltage. As the applied voltage increases, the surface tension increases and the droplet flattens toward the positively charged electrode. As the droplet flattens, the effect of refraction decreases allowing light to pass straight through without distortion.

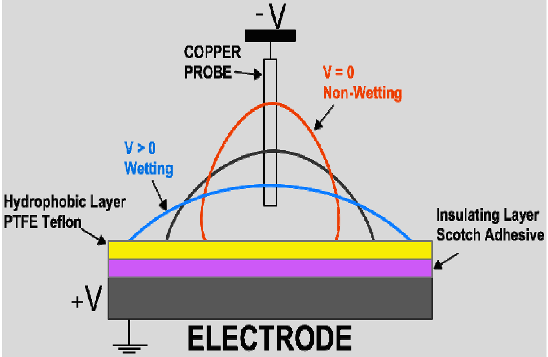
The electric field is generated using two oppositely charged conducting metals set close enough to each other to allow electrons to travel from the negative charged metal to the positive charged one. This experiment utilizes a conducting mixture of salt water to facilitate the transfer of electrons. When subject to high enough voltage, the electrons in the salt water get attracted to the electrode. As the voltage increases, the effect of the electric field becomes stronger and the electrons of the droplet are pulled closer to the electrode.

An important concern is the use of high current power supply. If the current through the droplet becomes too large, hydrolysis occurs. In this situation, the oxygen and hydrogen atoms of the water separate which subsequently leads to the hydrogen atoms igniting and generating a violent, sparking reaction.

Materials

The general materials used for the experiment are listed below:

- ❖Hewlett-Packard 6209B DC Power Supply
  - ✧ 0-320VDC, 0-0.1A
- ❖Aluminum Sheet Metal
  - ✧ Cut to a 3"x3" square
- ❖Teflon PTFE Thread Seal Tape
  - ✧ 0.003" thick
- ❖Scotch Tape
- ❖Deionized water
- ❖Table Salt
- ❖Copper Wire Leads



Apparatus

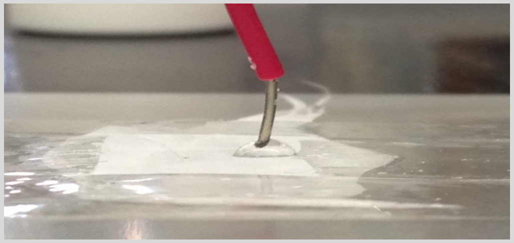
To create the desired effect, an electric field must be created between two oppositely charged conductors. In this case, the Aluminum metal was used as the positively charged electrode, represented in the diagram above as the grey rectangle labeled "ELECTRODE". The copper wire lead was then used as the negatively charged probe, placed into the conducting droplet.

The droplet itself was created by mixing deionized water with common table salt. Multiple mixtures were prepared with varying degrees of salinity with a maximum sample of roughly 20% salt content.

A droplet was then placed on top of the PTFE hydrophobic layer with the negatively charged probe placed just into the droplet.

It is important not to touch the probe to the electrode or else a large current will be generated and the resulting electric field will not be strong enough to generate the proper effect.

Salinity of Droplets Tested	
Vial	Salinity (g/thousand)
1	30
2	50
3	70
4	90
5	100
6	120
7	140
9	10
10	200

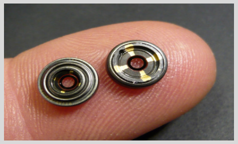


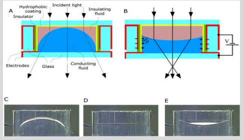
Results

While the dramatic effects seen in commercial lenses and highly produced laboratory demonstrations were not able to be observed, our apparatus was capable of producing a minor wetting adjustment as is shown in the picture at the bottom of the middle column.

To achieve this result, a voltage of 115VDC and 0.7mA was necessary, with the image showing sample 10. However, because the effect observed was so minute, it was not possible to declare an effective voltage range that could induce the wetting effect.

Possible reasons for why the conducted experiment did not prove as successful as others found in other research would most likely be attributed to the insulating/hydrophobic layer combination. In observed laboratory demonstrations, the researchers utilized dielectrics such as Silicon Oxide as a dielectric insulator and premium quality liquid Teflon that was mechanically applied either through spin coating or microscopic processes to the electrode. The thinness of these layers directly affect both the influence of the electric field as well as any subsequent abilities to prepare functional prototypes for commercial use.





Plans for Further Research

The original intent of this research was to assess the possibilities of variable liquid lens solutions that could be implemented as an alternative to glass lenses such as those found in cameras. It is the goal of further research to develop an array of micro wells of conducting fluid that operate using electrowetting techniques to reproduce an image. This array may be built using flexible materials and could bring forth the ability to produce products such as an unobstructed full panoramic camera. Something that is not possible with static, glass lenses.

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