Electronic Paper Power Supply

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Abstract

This experiment focuses on the possiblity to store energy in an electrochemical cell made as simple and cheapis as possible. The cells are made of transparencies with a polymer compound called Baytron P. To make the samples more conductive we add two different materials: polyvinyl alcohol and glycerine.

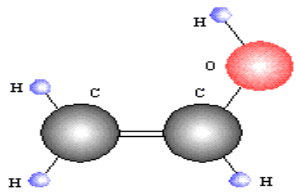
The samples are charged with a power supply, using different amounts of voltage, current and resistance. The signal is obtained from a voltmeter and convert into data by Labview. By this method, it is possible to observe the behavior of the electrochemical cells and compare the results with a capacitor or a battery.

Introduction

In the year 2000 the Nobel Prize in chemistry was awarded for the discovery of conductive polymers. Since their discovery in 1970, work has continued at a rapid pace and in recent years these materials have become comercially important. New technology is improving nano scale systems, and it is very important to develop a source of energy that can work at this scale.

Theory

Polyvinyl alcohol (better known as PVA) is a polymer made of monomers of vinyl alcohol. It is about 4400 carbon atoms per molecule combined with hydrogen atoms and OH groups. PVA is a white solid in the form of flakes with excellent tensile strength, moldability, impact strength, wear resistance and excellent electrical insulation. It is used as a raw material to produce coating material and adhesives, it is also used to produce pulp finishing agents, soil ameliorator, flims and polyvinyl butyral, etc.



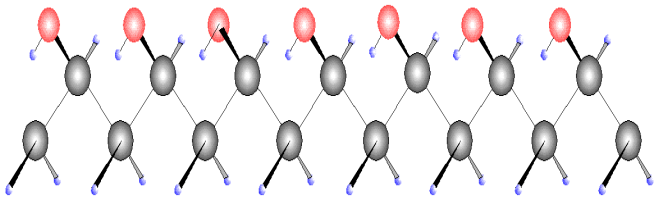
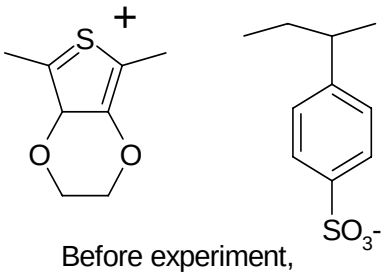


Figure 1. Vynil Alcohol **Figure 2**. Small part of Polyvinyl Alcohol chain

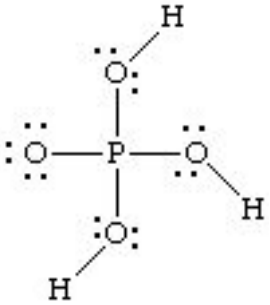
Baytron P is an aqueous dispersion of the instrinsically conductive polymer PEDT/PSS. It can be used to coat glass and plastics. This polymer is characterized by outstanding properties as high conductivity, high transparency, high stability and easy processing.

Another substance that is use in this experiment is phosphoric acid. Is one of the "Top-10" most important compounds in chemical manufacturing. Phosphoric acid is a weak triprotic acid. It has a central role in fertilizer production, but it is also use as a polishing agent for aluminum car trim and as an additive in soft drinks to give a touch of tartness.

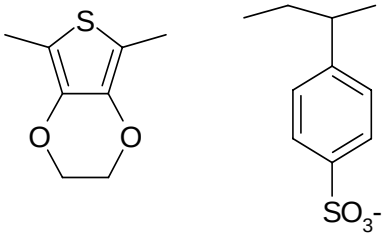
The chemistry of the process between mixture of the polyvinyl alcohol and the phosphoric acid is described below:



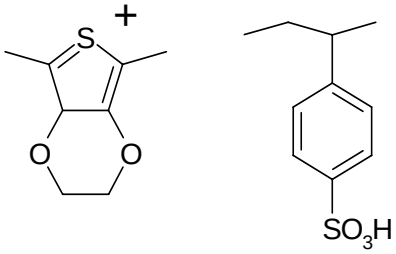
Before experiment, charges balance



Phosphoric acid



During charging, positive terminal attracts electrons, and reduces thiophene, making Baytron P negative...



During charging, negative terminal attracts protons from phosphoric acid, and neutralizes sulfonate, making Baytron P positive.

After charging stops, charge flows through system to restore neutrality, yielding a voltage and current.

The current and voltage can be calculate using the principles of Ohm's Law which says that the current is proportional to the change in the voltage so the ratio of *V* ti *I* is constant. For this cases the resistance remains constant as the potential difference changes. Using symbols, Georg Simon Ohm wrote the relationship as:

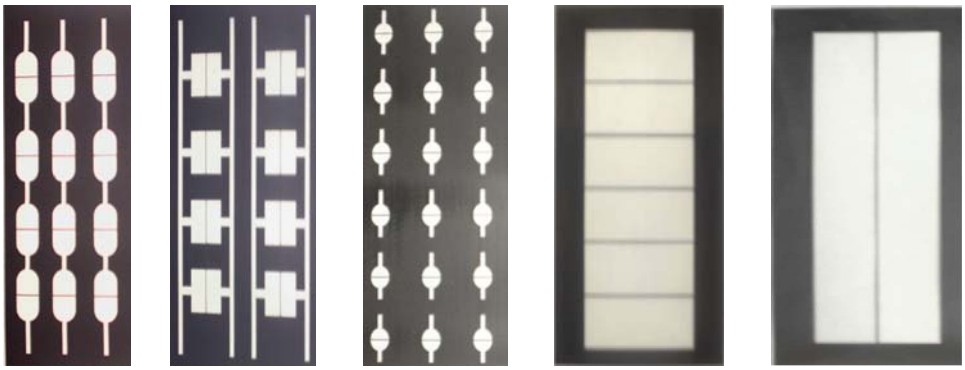
$$\boxed{V = IR}$$

Ohms' Law

Experimental Methods

The experiment is divided in two different parts: the preparation of the samples and the measurement of each one.

The first step is to make the sample in transparencies. Using Microsoft Word we created five different kind of samples including series and parallel shapes (fig. 1).



(a) (b) (c) (d) (e)

Figure 3. Electrochemical cells.

In the blank spaces we put Baytron P with a syringe. The toner around the blank spaces gives them form and doesn't allow the Baytron P to go outside. After the Baytron P covers the blank spaces, we let them dry for approximately 12 hours until it is convert completely into a thin layer. For the samples containing glycerine, we add 4 to 5 drops of glycerine into the Baytron P and then we continue with the process of filling the blank spaces of the transparencies.

In the meantime we prepare the solution of PVA:phosphoric acid. We use 5 g of Polyvinyl Alcohol 88% hydrolyzed, 5 mL Phosphoric Acid (H_3PO_4) 85% and 50 mL of H_2O. We start by putting these in a beaker with 50 mL H_2O in a hot plate with the stirrer

on. After a little while we add the 5 mL of Phosphoric acid and add very slowly the 5 grams of Polyvinyl alcohol.

After the transparencies are dry we use a Sonicator to take the toner off. The sonicator is filled with toluene and each of the samples is submerged for 5 seconds into it. This permits the toner to leave the transparencies. Two or three drops of the PVA:phosporic acid is added in the middle of the samples. After the PVA:phosphoric acid is dry the samples are ready to be charged and measured.

The process of measurement involve voltmeters, power supplies, current sources and other equipment that control the charge and signal obtained from the samples. The first step is to measure the control samples. There are two control samples: the transparency and the transparency with the Baytron P. To the other samples we start measuring the resistance and then charging them with different voltages and currents.

Results and discussion

The majority of the data obtain are in graphs that can be use for calculations of voltage, current, power and energy.

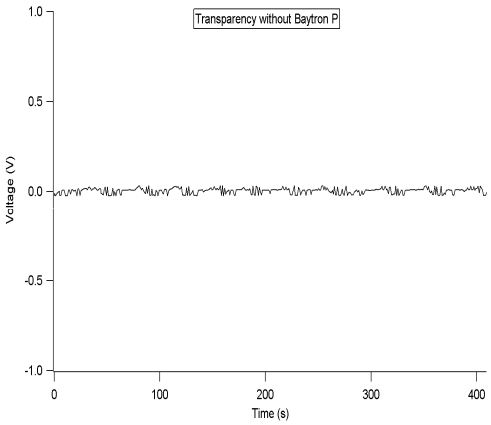


Figure 4. Control sample

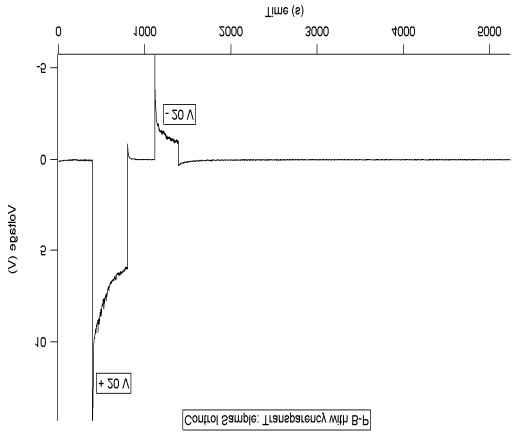


Figure 5. Control sample

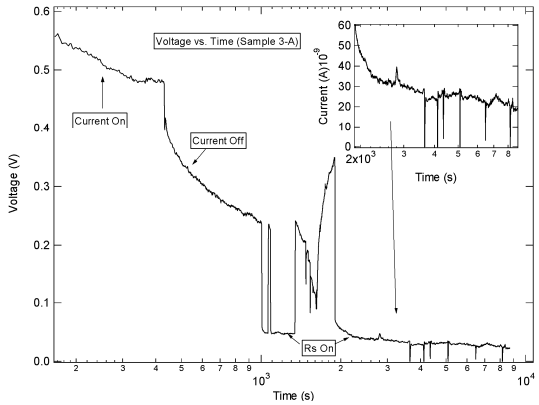


Figure 6. Sample 3-A

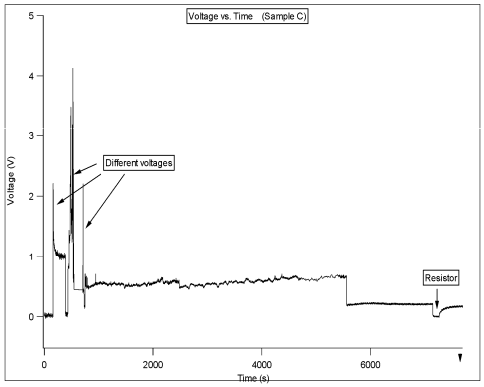


Figure 7. Sample C

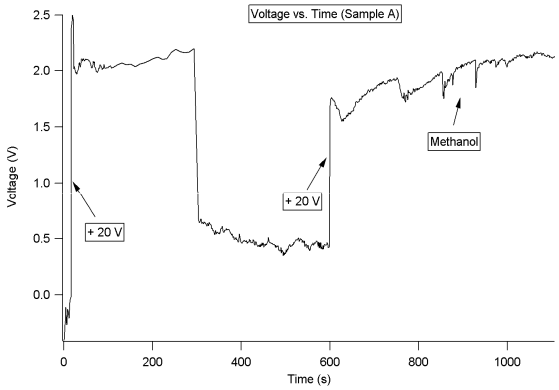


Figure 8. Sample A

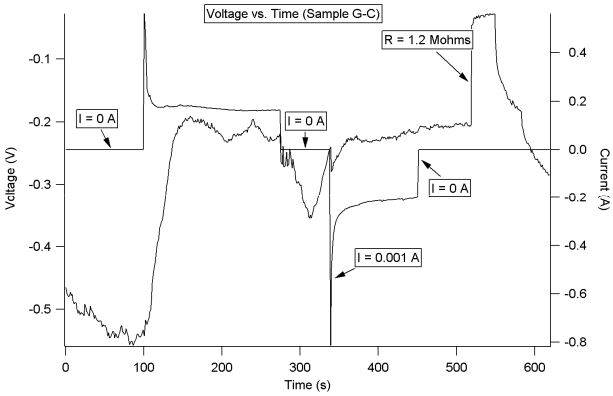


Figure 9. Sample G-C (glycerine sample)

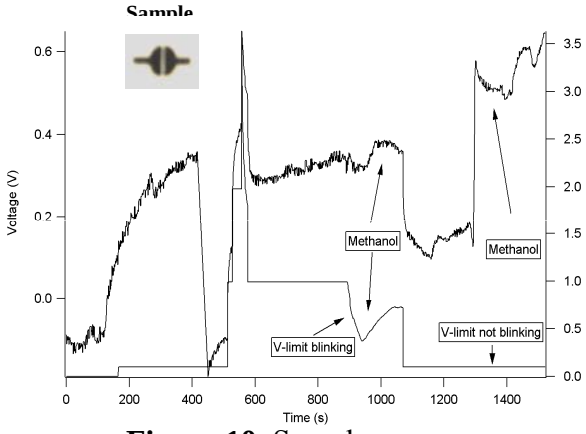


Figure 10. Sample expose to other reactantb

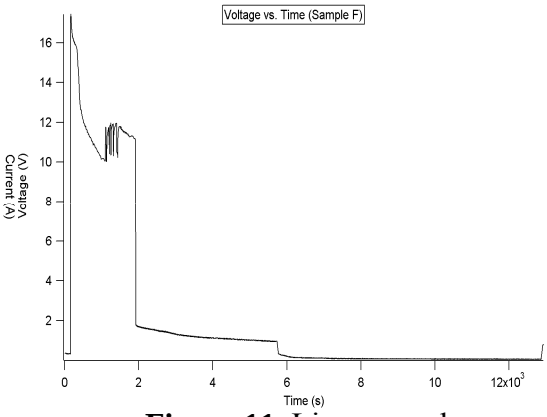


Figure 11. Linear graph of sample F

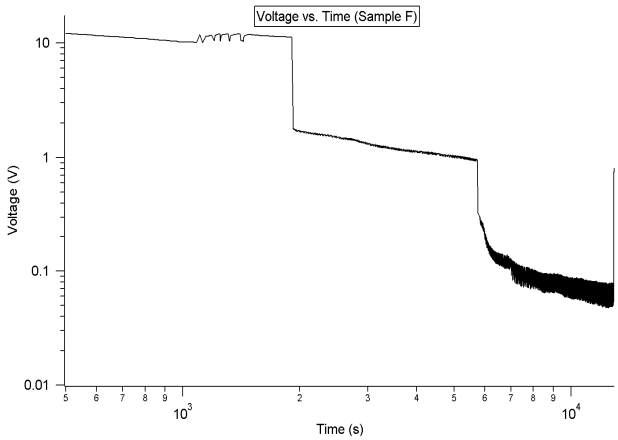


Figure 12. Logarithmic graph of Sample F

The first control sample (fig. 4) gives the certainty that the transparency doesn't conduct. There is no change in voltage or current when you apply any amount of energy to it. The second control sample (fig. 5) is the transparency with Baytron P. We can see that the sample conducts current through it but it can't store anything. When you disconnect the power supply the sample loses the current.

With the sample 3-A (fig. 6) we start measuring the resistance which is 30 KΩ. After we knew the exact resistance of the sample we introduced a resistor of 1.2 MΩ that let us calculate a power of 2.085 W.

In sample A (fig.8) we can see that the PVA:phosphoric acid is sensitive to some other reactants such as methanol.

The sample G-C (fig. 9) represents the samples with glycerine and Baytron P. We observed the same behavior as the other ones. It's completely sensitive to the current source and discharged almost everything when we turned off the power supply.

The sample in figure 10 was exposed to methanol. It shows sensitivity to the reactant and exhibits changes in current and voltage when the methanol is about 5 centimeters away from it.

In order to obtain data that can give us an idea of how useful this procedure can be, we converted the linear graph in figure 11 to a logarithmic graph in figure 12. This conversion let us calculate the energy stored in the sample which is 4.1 mJ. Also we calculate that this sample has 2.6 e^{17} electrons in it.

As discuss in the theory section the flow of electrons taking place during the charging and discharging steps.

Conclusions

According to the results obtained from this experiment we can say that Baytron P is not good for connecting materials. The resistance of the B-P makes more difficult the movement of current through the sample and is completely dependent on the distance where you put the connections. The use of glycerine gives the same response as the Baytron P alone. Under some circumstances such as a high current limit for the sample, the cell shows some reaction to organic compounds as methanol and acetone but not to water. It also work as a sensor for body heat.

This experimentation is reproducible in any small scale and shape. These samples show some promise as a nano power source and as an organic vapor detector.

Acknowledgements

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http://wwwchem.csustan.edu/chem2000/EXP2/bkg.htm