Experiment C-1
Producing Electricity

Chemistry

Objectives

- To learn how a lemon and some common household materials work as an electrochemical cell.
- To measure the lemon cell's voltage with different combinations of electrodes and determine which electrodes are more efficient.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-201 Voltage logger sensor ±20V

Equipment and Accessories

▪ Black crocodile clip cable
▪ Red crocodile clip cable
▪ Carbon pencil (C)
▪ Aluminum foil strip (Al)
▪ Iron nail (Fe)
▪ Copper cable (Cu)

- The items above are included in the NeuLog Utility accessories, UTL-KIT.

Materials

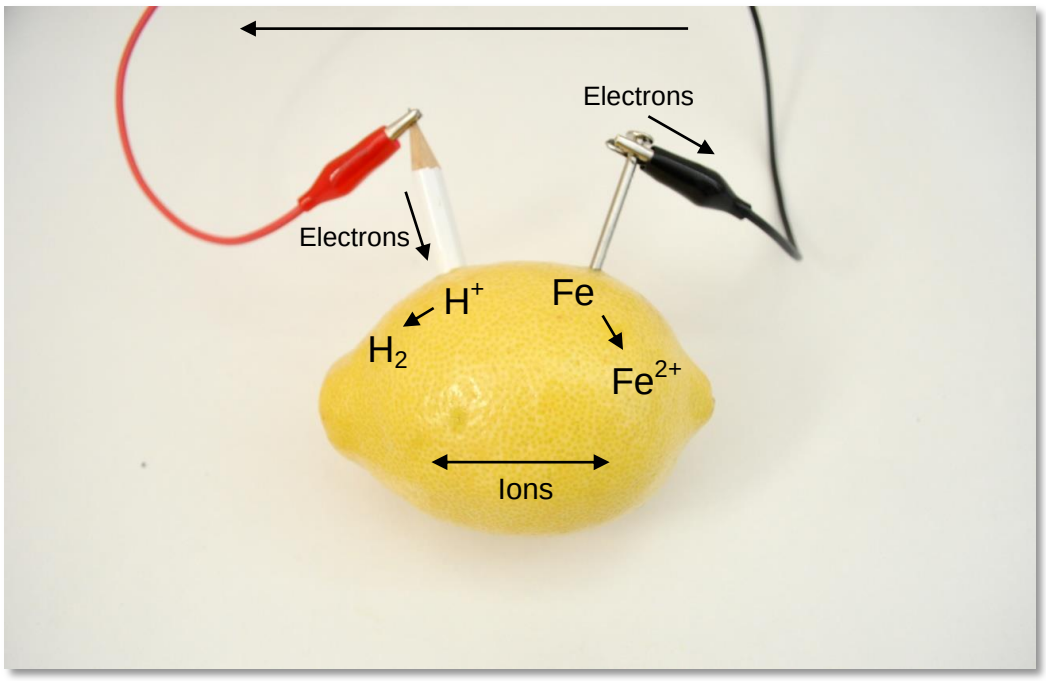
▪ Lemon (or vinegar)

Introduction

In 1800 Alessandro Volta discovered that electricity could be produced by using a series of metal disks of two kinds, separated by cardboard disks, soaked in an acid solution. This was the first battery, which is a device that converts chemical energy directly to electrical energy. A battery is a package of one or more electrochemical cells. These often consist of two different electrodes inside a solution called an electrolyte and are connected amongst them by a conductor.

It is possible to use fruits and vegtables in order to make a battery since they contain acids and various ions. A lemon is often used due to its relativly high concentration of citric acid.

Iron (Fe) and carbon (C) can be used as electrodes when inserted into the lemon. An electrical wire conncets the two electrodes outside the lemon.



At the Fe electrode, Fe atoms are converted to Fe^{2+} ions which are released to the lemon. The electrons flow to the C electrode (through the cables) where hydrogen (H^+) ions from the lemon's acid are reduced to H_2 gas. The carbon electrode conducts the electrons and does not participate in the actual reaction. Positive and negative

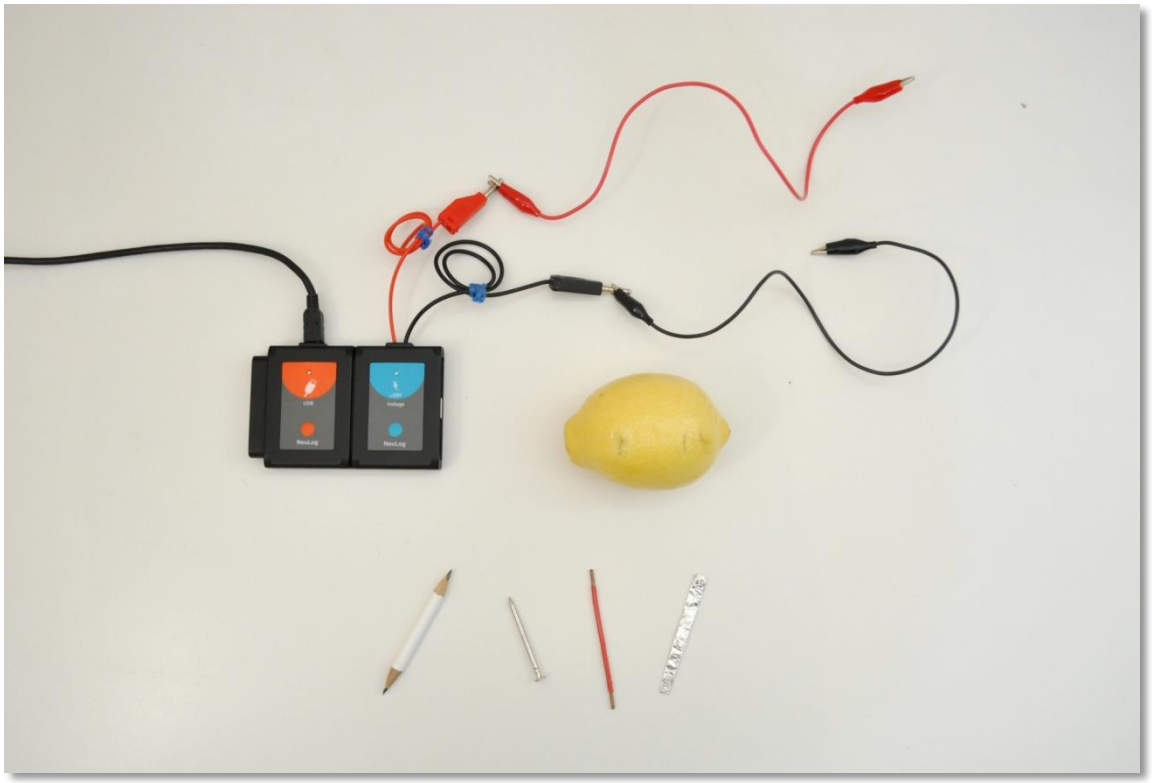
ions move through the solution in order to balance the charge difference. Iron and carbon can be replaced by other electrodes.

In this experiment, you will build simple electrochemical cells using a lemon (or vinegar) as the electrolyte and different materials as electrodes. You will measure the voltage produced when you introduce the different electrodes into the lemon and observe how different combinations of electrodes produce different voltages.

Procedure

Experiment setup

1. Set up the experiment as shown in the picture below.



2. Make sure you have a carbon pencil, an aluminum foil strip, an iron nail and a copper cable.

3. Make two separate cuts in the lemon (2 cm apart, approximately). You can use the nail to make the cuts.

4. Connect the red crocodile clip cable to the red cable of the voltage sensor.

5. Connect the black crocodile clip cable to the black cable of the voltage sensor.

6. Make sure that the red and black cables do not touch each other.

Sensor setup

7. Connect the USB-200 module  to the PC.

8. Check that the voltage sensor 

is connected to the USB-200 module.

Note:

The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

9. Run the NeuLog application and check that the voltage sensor is identified.

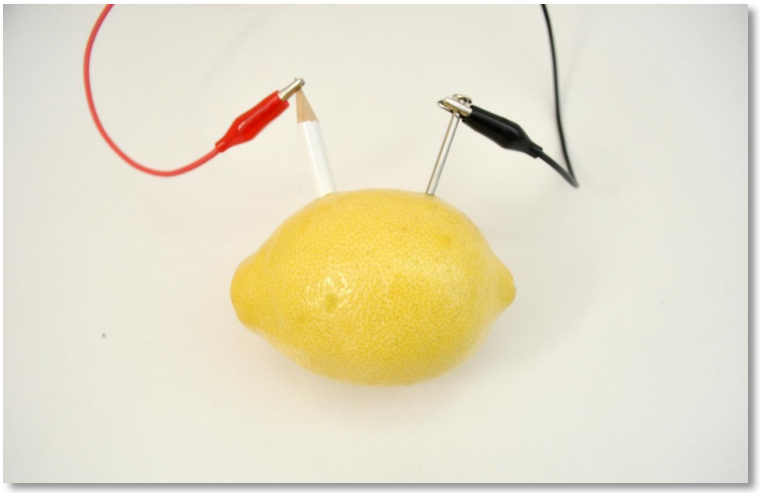
Testing and measurements

10. Before conducting the experiment, click on the **Single Step** icon  and measure the voltage with nothing connected to the cables.

11. Click on the **Table** icon  on the bottom part of the screen. A table will be displayed for data record.

12. Insert the carbon pencil (C) into one cut of the lemon and the iron nail (Fe) into the second cut.

Connect the red crocodile clip to the pencil and the black crocodile clip to the nail.



13. When the reading stabilizes, click on the **Single Step** icon  to insert the measurement in the table.

14. Remove the nail and insert the aluminum foil strip (Al).

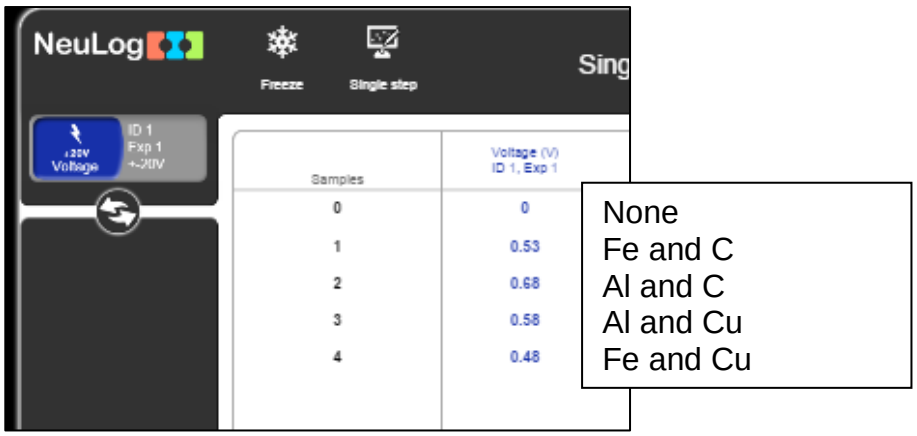
    Connect the black crocodile to the aluminum foil.

15. Click again on the **Single Step** icon  to insert the new measurement into the table.

16. Replace the electrodes and conduct measurements according to the following table:

Measurement number	Electrodes connected to the black crocodile clip cable	Electrodes connected to the red crocodile clip cable	Voltage [V]
1	None	None	
2	Iron nail (Fe)	Carbon pencil (C)	
3	Aluminum foil strip (Al)	Carbon pencil (C)	
4	Aluminum foil strip (Al)	Copper cable (Cu)	
5	Iron nail (Fe)	Copper cable (Cu)	

17. Your data should be similar to the following.



18. Click on the **Export** Icon and then on the **Save value table (.CSV)** button to save your graph.

19. Click on the icon to go back to the table.

20. Fill the table above with your results.

21. We can see that we were able to create a battery from a lemon and two electrodes. Every pair of electrodes produced a different voltage.

Challenge research

22. Repeat the experiment, but this time reverse the crocodile clip cables.

Measurement number	Electrodes connected to the black crocodile clip cable	Electrodes connected to the red crocodile clip cable	Voltage [V]
1	None	None	
2	Carbon pencil (C)	Iron nail (Fe)	
3	Carbon pencil (C)	Aluminum foil strip (Al)	
4	Copper cable (Cu)	Aluminum foil strip (Al)	
5	Copper cable (Cu)	Iron nail (Fe)	

Summary questions

1. Which electrode was better - Fe or Al? Explain.

2. Which electrode was better - C or Cu? Explain.

3. According to the previous answers, what combination would give the best electrochemical cell? Why?

4. After you inversed the crocodile clips, did your result change? Explain.