Ice-Tray Battery WIP

Keywords: 2017, Acid, Battery, Chemistry, Copper, Electrochemistry, Engineering, LED, Zinc

Meta Description

Build an actual, working battery, using simple materials commonly found at home.

Learning Objectives

Understanding how voltaic batteries works.

Understanding how chemical energy can be turned into electrical energy.

Key Terms

Electrochemistry
The study of the chemical processes and reactions that results in a movement of electrons.

Electrode
A conductor that allows electrons to enter or leave an object.

Electrolytes
A material (usually liquid) that contains ions and thus conducts electricity.

Galvanization
A process used to prevent rusting by adding a layer of zinc to a surface of iron or steel.

Ion
A particle with an electrical charge which can be positive or negative.

Lead
Leads are short metal wires extending out from electronic components which allow them to be plugged into a breadboard.

Light Emitting Diode (LED)
A polarized two-lead device which lights up.

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Oxidized
The chemical process that results in the loss of electrons.

Polarised
Device An electrical device which only allows current flow in a single direction.

Voltaic battery
The first known battery, also known as the voltaic pile. It consists of several layers of copper and zinc, separated by a cloth soaked in salty water.

Method

Step 1
Wrap the bare copper wire 5 times around the upper part of one of the galvanised nails.

Step 2
Repeat the above step for all 5 nails.

Step 3
Fill 6 wells of the ice tray with distilled white vinegar.

Step 4
Place a nail in each of the wells of the tray. A circuit is created by making sure that the copper wire attached to each nail is in contact with the vinegar of the adjacent well. The last well will have only the copper wire from the previous well in it.

Step 5
Place the LED such that its leads are in the the first and final well; the first well contains the nail whilst the last well contains only copper wire.

Step 6
If the LED does not light up switch the the position of the legs of the LED. LEDs are polarity sensitive devices and only allow current to flow through them in one direction.

Precautions

1. The wires and nails of different wells should not be in contact, otherwise the circuit is shorted and the electrons will simply flow from one metal to the other and not through the electrolyte (vinegar)
2. In each well, the only material separating the two metals should be the electrolyte, vinegar.

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3. Care should be taken when handling the vinegar especially in the presence of children,because it can cause eye irritation.
4. Safety specs must be worn during the demonstration.

Narrative

Set up all material needed on a table and start by wrapping the galvanized nails with the copper wire. Repeat this process for all nails, then fill the ice-tray with vinegar and place the nails such that the galvanized nail is in one well and the copper attached is in the adjacent well in the ice-tray. Place the *legs* of the LED light in the first and last well and observe what happens. Explain what is going on and also the fact that the LED is polarity sensitive and so it can be switched on and off by reversing the position of its *legs.*

Questions

Why does vinegar need to be used rather than just water?
Vinegar is more conductive and makes ion-flow from one electrode to the next easier.

Should the metal electrodes strictly be copper and zinc?
NO, but the metals should be such that ions can migrate from one electrode to the other.

Why the LED didn't light up when it was connected the wrong way round?
LED stands for Light Emitting Diode. Diodes only allow electricity to flow in one direction.

Why copper was used to bridge the wells in the ice tray?
Copper is an excellent conductor and allows current to flow freely.

For how long will the battery work?
The energy of the system is comes from the chemical change when zinc dissolves in vinegar. If the zinc in the electrode or the hydrogen ions in the vinegar are all used up the battery stops working. Typically such such batteries won't run for too long.

Brief Explanation

Such batteries are made of two different metals suspended in acidic solution. In this case the metals are copper and zinc – zinc is found in the galvanization on the surface of the nail. The vinegar is mostly water, with some acetic acid dissolved in it, and this acts as a very good medium for ions to migrate.

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Copper holds onto its atoms more strongly than the zinc does and thus when place in a good electrolyte electrons flow from zinc to copper. Once the LED is placed in the ice tray, the circuit is complete and electrons flow through the LED which converts the electrical energy into visible light.

Detailed Explanation

When the electrodes are placed in the vinegar, zinc atoms enter the electrolyte (vinegar) as ions , leaving two electrons behind in the metal,

$$Zn \; ? \; Zn^{2++} \; 2e^{?} \qquad [1]$$

If the electrolyte is just water the reaction is halted, however the acetic acid in vinegar makes positive hydrogen ions readily available. Indeed, while zinc ions are dissolving in the vinegar, two hydrogen ions combine with two electrons from the copper electrode forming hydrogen molecules. In fact during the demonstration small bubbles can be observed accumulating around the copper wire.

$$2H^{++} \; 2e?? \; H_2 \qquad [2]$$

The above ionic reactions takes place because copper is more electronegative than zinc.

The electrons used in this reaction are transferred from the zinc electrode through the circuit. At the zinc electrode, most of the electrons travel through the connected wires but some of them react with copper ions forming copper atoms which can be observed building up on the galvanized nail (zinc). The copper looks black because it is immediately oxidized to black copper oxide.

The battery stops working either when the hydrogen ions in the vinegar are all used up or when the zinc electrode is fully corroded.

The energy of the system is comes from the chemical change when zinc dissolves in vinegar.

Applications and Research

Application
The battery in this demonstration is one of many types used to store chemical energy and convert it to electrical energy. Although there are fundamental differences between batteries, the main concept of electrochemical cells, as explained in the ‘How it Works’ section remains the same. The application of batteries ranges from small ones used in television remote controls to batteries powering cars and even homes!

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Research
In Austria, research is being carried out on next generation lithium-ion batteries. The aim of the project is to develop high capacity environmentally-friendly batteries, mostly for the automotive industry.

Investigation

- Investigate the lifespan of the battery with different concentrations of vinegar. This can be done by diluting the same volume of vinegar with different amounts of water for each test.
- Investigate the voltage produced by varying the number of wells of the ice-tray used to make the battery.



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Education

Secondary
Post Secondary
University
Informal

Time Required

~30 minutes
Preparation: 15 minutes
Conducting: 5 minutes
Clean Up: 15 minutes

Cost

10 – 25 €

Recommended Age

6 – 9
10 – 12
13 – 16
>16

Number of People

1 participant

Supervision

Required

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Location

Indoors
Outdoors
Laboratory

Materials

5 Copper wire pieces (13 cm long)

Distilled white vinegar

Ice tray with at least 6 wells

1 Led light

5 Nails

Safety specs

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Sources

Chapter 3: Electrochemistry

Electrochemical Cells

Ice-Tray Battery

Five Volt Lithium Ion Batteries with Silicon Anodes produced for Next Generation Electric Vehicles

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Additional Content

How Batteries Work (Beginners)

Ice-Tray battery (Beginners)

Chapter 3: Electrochemistry (Intermediate)

Making a Lemon Battery and How Does it Work? (Intermediate)

Chemical Modification of Graphite Electrode Materials for Vanadium Redox Flow Battery Application—part II. Acid Treatments (Advanced)

Manufacturing Method of Chemical Battery Electrode and Battery (Advanced)

Cite this Experiment

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