Experiment 3: Lemon Battery

To create a lemon battery, we will need the following items: a lemon, an iron nail and a copper coin. Insert the iron nail and copper coin into the lemon. The lemon contains citric acid.

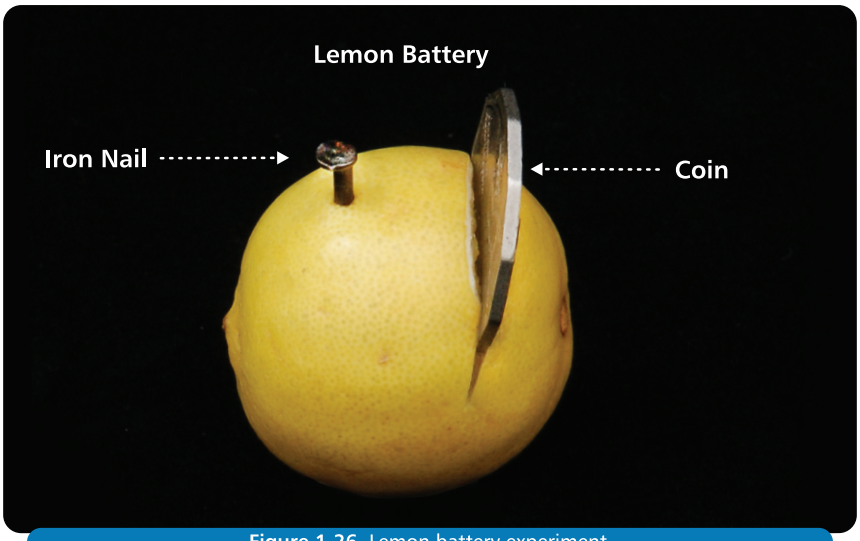

Figure 1-26. Lemon battery experiment.

DYK?

The iron nail has a coating of zinc on its surface. This process of coating zinc on iron is called **galvanization** and is done to protect iron against rusting.

Zinc reacts with citric acid and produces electrons. Thus, zinc becomes positively charged as it loses electrons. All these electrons accumulate on the surface of zinc. Since like charges repel each other, these electrons experience a mutual force of repulsion; they want to move away from each other, but they have nowhere to go.

Now, what if we connect this piece of zinc to a surface which has a deficiency of electrons? The coin is made up of copper and is dipped in citric acid. Citric acid contains positive hydrogen ions, which attract electrons from zinc.

So, if we connect an external wire between the iron nail and the coin, a transfer of electrons takes place. Free electrons from zinc move away from zinc due to repulsion, pass through the wire, and go to the copper coin. At the side of the coin, hydrogen ions gain these electrons from the copper surface and form hydrogen gas.

Copper does not participate in the chemical reaction. It only provides a greater surface area for the transfer of electrons to the hydrogen ions of the acid (lemon juice).

In this experiment, we inserted two strips of different metals in an acid solution. The metal strips are called **electrodes**, and the acid solution is called an **electrolyte**. In the case of the lemon battery, one of the electrodes is an iron nail, which has a zinc coating on its surface. The second electrode is the coin, which is made up of copper. The electrolyte is the lemon juice, which contains citric acid.

Thus, in a simple battery, we will find two electrodes dipped in an electrolyte. There is a transfer of electrons through the wire from zinc to copper, both dipped in citric acid, through a chemical reaction. The process is called an **electrochemical reaction** and forms the basis of a lemon battery.

Why did the electrons move from zinc to copper?

We know that electrons move due to a potential difference. There is a potential difference between zinc and copper electrodes. In figure 1-27, the meter shows a small voltage reading of 0.55 V across the two electrodes of the lemon battery. The coin acts as positive terminal and the nail as the negative terminal of the battery.

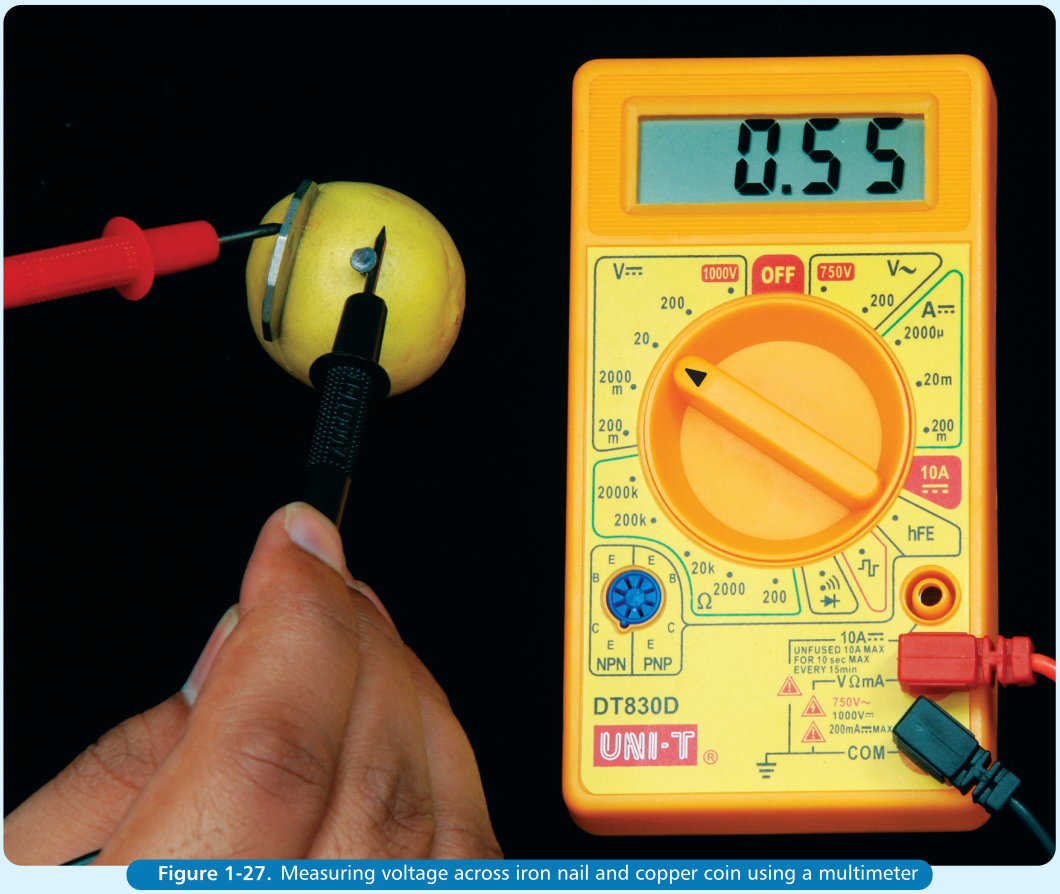

Figure 1-27. Measuring voltage across iron nail and copper coin using a multimeter

The positive terminal of the battery is called the **anode**, and the negative terminal is called the **cathode**.

Since the zinc electrode has more negative electrons, zinc is the area of more negative charge. This area is called the cathode.

Since the copper electrode has more positive hydrogen ions, copper is the area of more positive charge. This area is called the anode.

Thus, there is a movement of electrons from cathode to anode. This movement of electrons creates current in an opposite direction from the anode to the cathode.

What if the zinc acid reaction stops ?

If the zinc acid reaction stops, the battery is exhausted. As the reaction progresses, a time comes when there is no more zinc left to react with the acid. Thus, the zinc is exhausted and the chemical reaction stops. The battery cannot provide current. The battery will allow the flow of electrons from one electrode to the other when its terminals are connected externally. The battery becomes dead when the electrodes are fully used, as there is no chemical reaction taking place.

Q BOX

The battery cannot be recharged easily because the chemical reactions are not easily reversible. In a rechargeable battery, we choose appropriate materials for electrolyte and electrodes that allow reversible chemical reactions.

DY K?

The 12 V car battery is a rechargeable battery. It is a lead-acid battery with two electrodes, lead and lead oxide, each dipped in sulphuric acid. Another example is a nickel-cadmium battery.

Copper-Zinc Battery

A basic battery consists of two electrodes of two different metals dipped in electrolyte. A chemical reaction takes place when the electrodes are connected through an external circuit. This reaction occurs due to transfer of electrons from one electrode to the other. The electrodes are chosen such that one metal electrode has a greater tendency to lose electrons than the other. For example, zinc has a greater tendency to lose electrons than copper.

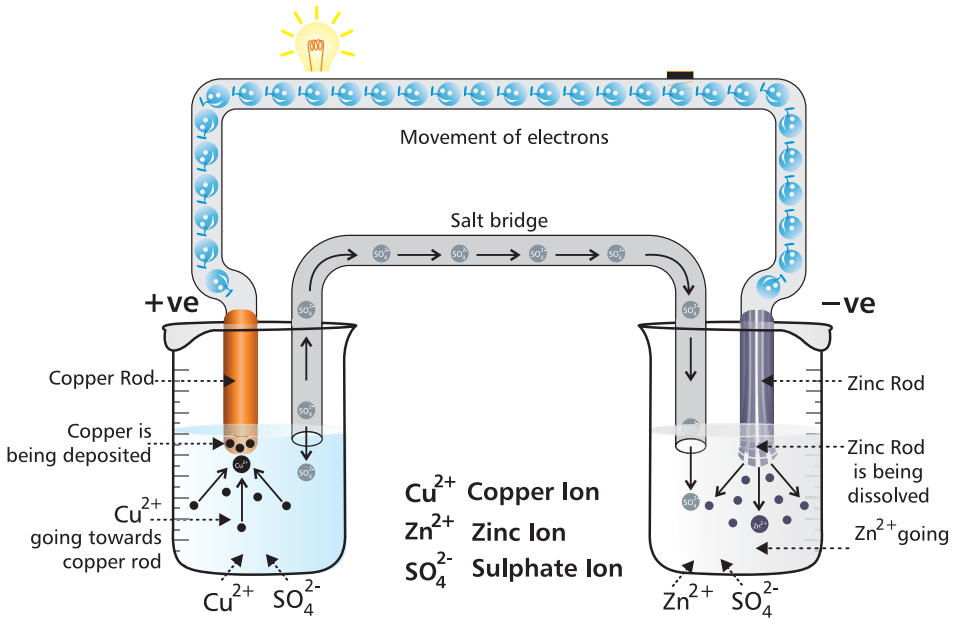

Figure 1-28.. A Copper-Zinc Battery

Figure 1-28 shows a typical copper-zinc cell. Zinc and copper electrodes are dipped in their respective acid (sulphate) solutions. This means that the zinc electrode is dipped in zinc sulphate solution in one chamber, and the copper electrode is dipped in copper sulphate solution in another chamber. The two chambers are linked by a porous medium called a salt bridge so that transfer of ions can take place from one metal solution to the other.

The zinc chamber contains zinc (positive) and sulphate (negative) ions. Similarly, the copper chamber contains copper (positive) and sulphate (negative) ions.

When zinc reacts with zinc sulphate solution, it releases electrons and zinc ions are formed, which eventually go into the solution. So, the zinc electrode gets dissolved, and electrons are released. This electrode is called the cathode and represents the negative terminal of the battery.

Now if we connect an external wire between the two electrodes, a transfer of electrons will take place from zinc to the copper electrode.

At the copper electrode, copper ions from the solution gain these electrons and form copper, which gets deposited on the copper electrode. This process is called **electroplating**. The copper electrode is called the anode and represents the positive terminal of the battery.

Overall, zinc gets dissolved, and copper gets deposited due to transfer of electrons. This is the basic reaction of the battery and is called an electrochemical reaction. It is due to this reaction that negative charge transfer can take place from the negative terminal to the positive terminal of the battery, and thus electricity is formed. Here, chemical energy is converted into electrical energy.

As discussed before, the battery applies an electrical force called voltage to shift electrons from its negative terminal its positive terminal. This force is due to a potential difference, which gets created when two different metals or conductors are connected. In this case, the metals used are copper and zinc.

Electricity is produced at steam (thermal) or hydraulic power plants or nuclear power stations. One of the big power production companies is NTPC (National Thermal Power Corporation) Limited, which runs steam power plants all across the nation. Presently, NTPC generates power from coal and gas.

With an installed capacity of 36,014 MW, NTPC is the largest power generating major in India.