
# Aluminium/air Cell

The aluminium/air cell uses salt water as the electrolyte, and so it can be used anywhere, even in primary school science lessons. The chemistry is relatively simple, but it is also a very interesting battery system with great potential for electric vehicles and other larger scale users of electric power, as the battery materials are comparatively easily to recycle.

The cell consists of an anode near the base of a beaker (about 10cm high), which holds the electrolyte, and a cathode, which is simply inserted into the anode. The cell will drive small electric motors, and although its operating voltage is only about 1 volt, it will still drive higher voltage motors, including the 9V Technic LEGO motors.

Technical Data

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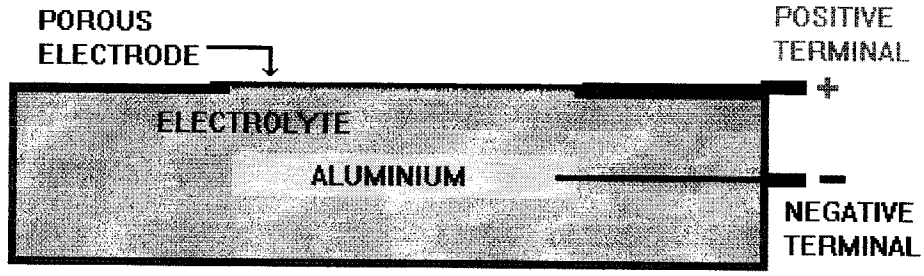
| Electrolyte:- | 75 cm3 salt solution (e.g. sea water)<br>(KOH solution can also be used.) |
| Cathode:- | Non-precious metal catalyst with PTFE on nickel mesh |
| Anode:- | Special high purity aluminium alloy (AB50) |
| Typical performance:- | At least 400 mA at 0.9 volts |

**Structure**

The structure of an aluminium/air battery is very simple. A piece of aluminium is immersed in an electrolyte near a porous electrode. This porous electrode has air on one side, and the electrolyte on the other. This is shown in the diagram below.




The electrolyte can be common salt (NaCl) solution or an alkali solution such as potassium hydroxide. Sea water can be used. The choice of electrolyte is fairly flexible, but only special alloys of aluminium can be used. *With ordinary alloys the aluminium immediately becomes coated with a protective layer, or simply dissolves as aluminium oxide, giving off hydrogen gas.*

**The Chemistry**

The aluminium reacts with OH- ions to form aluminium hydroxide and release three electrons. The OH- ions are present either because the electrolyte is an alkali solution, or because they are produced at the other electrode (see below). The reaction is :-

$$Al + 3OH^- \longrightarrow Al(OH)_3 + 3e^-$$

These electrons form the electric current produced by the battery. The equation above shows why aluminium/air cells are so good. The valency of aluminium is three, so three electrons are released. Since three electrons are released for each aluminium atom we get a lot of electricity

At the porous electrode the water in the electrolyte reacts with oxygen from the air, and absorbs the electrons produced at the aluminium electrode.

$$O_2 + 2H_2O + 4e^- \longrightarrow 4\,OH^-$$

Cations are formed, and so this electrode is called the Cathode. It attracts negative electrons, and so is the Positive terminal of the battery. (Yes, the cathode is the positive electrode!)

The electrons produced at the aluminium electrode (the anode) pass round the external circuit connected to the battery, and both the above reactions carry on until the aluminium is used up, or the circuit is broken. The overall reaction is:-

$$4Al + 3O_2 + 6H_2O \longrightarrow 4\,Al(OH)_3$$

With salt water electrolyte the open circuit voltage of the cell is about 1.2 volts, but the normal operating voltage is about 0.7 or 0.8 volts. With KOH solution the voltages are about 0.5 volts higher.

If the cathode is covered (e.g. with water) so the oxygen can't get to it anymore, a slightly different reaction occurs. Electrons are still absorbed, but oxygen is not used, and hydrogen gas is evolved:-

$$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$$

Electrons are still absorbed, but the voltage produced by the cell is far lower, typically about 0.5 volts.

**Applications**

The energy density of the aluminium/air battery is excellent, even better than the Lithium battery, yet it is not greatly used in practice. The main reason for this is the side reactions that take place between the electolyte and the aluminium. These involve the corrosion of the aluminium and the production of small amounts of hydrogen gas. This begins as soon as the aluminium is in contact with the electrolyte. The reactions are very slow, but in the time a typical battery might spend in storage before use much harm will have been done. In other words, if the battery is stored with its electrolyte it has a very short shelf life. However, there are applications where the electrolyte can be stored separately, and added when the power is needed. This type of battery is usually called a ***reserve battery***, and is the one market where the aluminium/air battery has had some success.

Large aluminium/air batteries are used as back-up power supplies in many telephone exchanges. When not is use the electrolyte is stored in a tank outside the battery. When there is a power cut it is automatically released into the battery, which starts up. Compared to lead/acid batteries they store about 5 times as much energy in a given volume, and can be recharged by replacing the aluminium electrodes, which in a well designed battery need not be too difficult.