Fuel cell basics

technology types

What is a fuel cell?

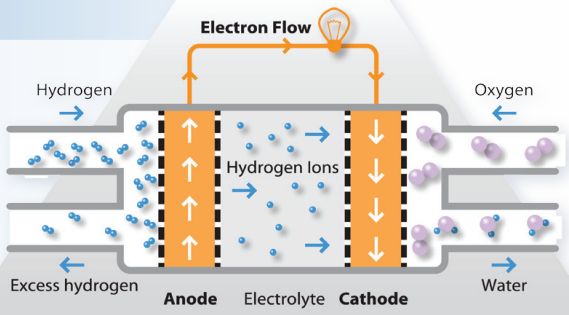
A fuel cell is like a battery in that it generates electricity from an electrochemical reaction. Both batteries and fuel cells convert chemical energy into electrical energy and also, as a by-product of this process, into heat. However, a battery holds a closed store of energy within it and once this is depleted the battery must be discarded, or recharged by using an external supply of electricity to drive the electrochemical reaction in the reverse direction.

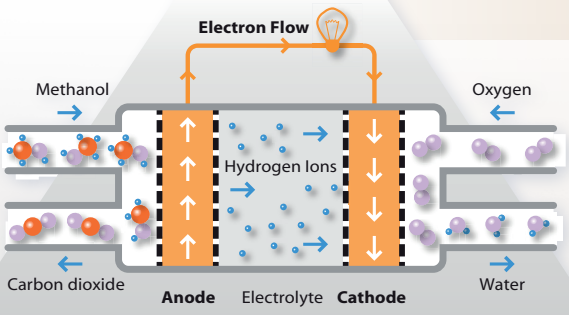
A fuel cell, on the other hand, uses an external supply of chemical energy and can run indefinitely, as long as it is supplied with a source of hydrogen and a source of oxygen (usually air). The source of hydrogen is generally referred to as the fuel and this gives the fuel cell its name, although there is no combustion involved. Oxidation of the hydrogen instead takes place electrochemically in a very efficient way. During oxidation, hydrogen atoms react with oxygen atoms to form water; in the process electrons are released and flow through an external circuit as an electric current.

Fuel cells can vary from tiny devices producing only a few watts of electricity, right up to large power plants producing megawatts. All fuel cells are based around a central design using two electrodes separated by a solid or liquid electrolyte that carries electrically charged particles between them. A catalyst is often used to speed up the reactions at the electrodes. Fuel cell types are generally classified according to the nature of the electrolyte they use. Each type requires particular materials and fuels and is suitable for different applications.

PEMFC – Proton Exchange Membrane Fuel Cells

- Electrolyte: water-based, acidic polymer membrane
- Also called polymer electrolyte membrane fuel cells
- Use a platinum-based catalyst on both electrodes
- Generally hydrogen fuelled
- Operate at relatively low temperatures (below 100°C)
- High-temperature variants use a mineral acid-based electrolyte and can operate up to 200°C.
- Electrical output can be varied, ideal for vehicles



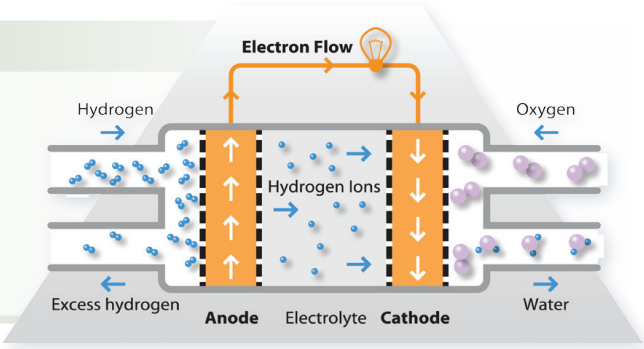


Direct Methanol Fuel Cells – DMFC

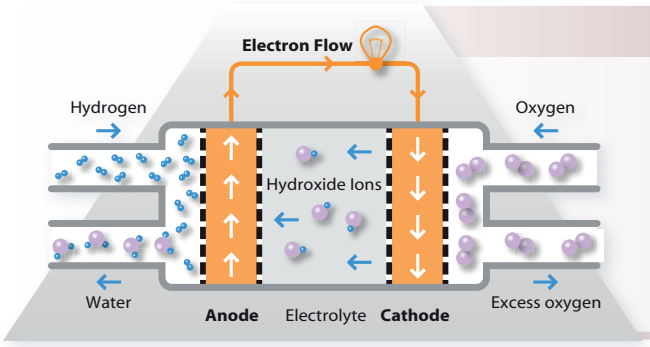
- Electrolyte: polymer membrane (like PEMFC)
- Use a platinum–ruthenium catalyst on the anode and a platinum catalyst on the cathode
- This catalyst can draw hydrogen atoms from liquid methanol, which is used as fuel instead of hydrogen, giving the cell its name.
- Operate in the range from 60°C to 130°C
- DMFC are convenient for portable power applications with outputs generally less than 250 W

PAFC – Phosphoric Acid Fuel Cells

- Electrolyte: liquid phosphoric acid in a bonded silicon carbide matrix
- Use a finely dispersed platinum catalyst on carbon
- Quite resistant to poisoning by carbon monoxide
- Operate at around 180°C
- Electrical efficiency is relatively low, but overall efficiency can be over 80% if the heat is used
- Used in stationary power generators (100 kW to 400 kW)



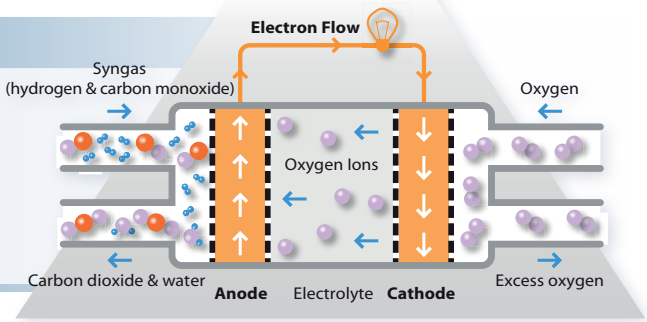
Alkaline Fuel Cells – AFC



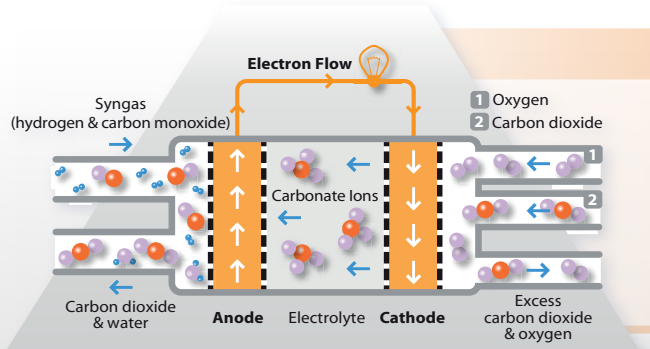
- Electrolyte: alkaline solution such as potassium hydroxide in water
- Commonly use a nickel catalyst
- Generally fuelled with pure hydrogen and oxygen as they are very sensitive to poisoning
- Typical operating temperatures are around 70°C
- Can offer high electrical efficiencies
- Tend to have relatively large footprints
- Used on NASA shuttles throughout the space programme

SOFC – Solid Oxide Fuel Cells

- Electrolyte: solid ceramic, such as stabilised zirconium oxide
- A precious metal catalyst is not necessary
- Can run on hydrocarbon fuels such as methane
- Operate at very high temperatures, around 800°C to 1,000°C
- Best run continuously due to the high operating temperature
- Popular in stationary power generation



Molten Carbonate Fuel Cells – MCFC



- Electrolyte: a molten carbonate salt suspended in a porous ceramic matrix
- A precious metal catalyst is not necessary
- Can run on hydrocarbon fuels such as methane
- Operate at around 650°C
- Best run continuously due to the high operating temperature
- Most fuel cell power plants of megawatt capacity use MCFCs, as do large combined heat and power plants

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