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Colourful electrolysis vortex in a magnetic field

Colourful electrolysis vortex infosheet

Flowing particles in an electric current: electrons or ions

For an electric current to flow, electrically charged particles must move. Electrons move out of our sockets and through our cables. They flow through a metallic conductor that is covered or coated with insulating plastic for our protection. Plastics and other molecular materials do not conduct electrons, and therefore, do not conduct electric current. Metals conduct current with electrons.

Electric current must flow differently in water; water is a molecular substance, and electrons cannot move in it. In water, it is ions that conduct the electric current. Ions are charged particles of atoms or molecules that come from salts, acids, or bases in water. Tap water, our body fluids, or even soil moisture contain minerals, namely, salts, which provide ions, and therefore, electrical conductivity. Rainwater and demineralised water contain almost no ions and are less conductive.

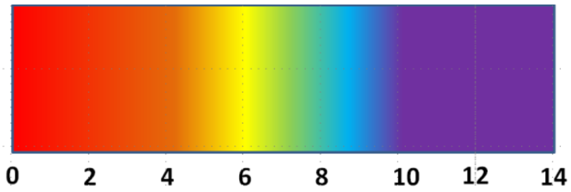
In this experiment, the salt ions Na^+, SO_4^{2-}, or NO_3^- are below or above water in the electrochemical series: they conduct the current required for electrolysis, but do not react.

Chemical reactions in the transition from electron current to ion current: electrolysis

If an aqueous solution containing ions comes into contact with a current-carrying electron conductor, an electric current can flow through the aqueous solution. To do this, however, the electron current must be transformed into an ion current, which requires a chemical reaction to take place: electrolysis. Water is split at the electrodes and small amounts of hydrogen and oxygen are produced:

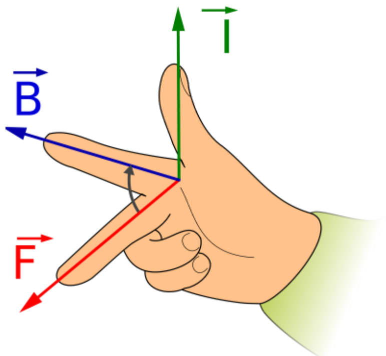
Positive electrode (anode)	$2H_2O \rightarrow O_2\ (g) + 4H^+\ (aq) + 4e^-$	
Negative electrode (cathode):	$2H_2O + 2e^- \rightarrow H_2\ (g) + 2OH^-\ (aq)$	(2×)
Total reaction:	$6H_2O \rightarrow 2H_2\ (g) + O_2\ (g) + 4H^+\ (aq) + 4OH^-\ (aq)$	

In addition to hydrogen and oxygen, new electrically charged ions, H^+ and OH^-, are also formed, which have an alkaline or acidic effect. This explains the colour change; the solution becomes acidic (H^+ ions) at one electrode and alkaline (OH^-) at the other, which changes the colour of the pH indicators around these electrodes. If the solution is mixed later, the H^+ and OH^- ions combine to give water and the solution becomes neutral again.



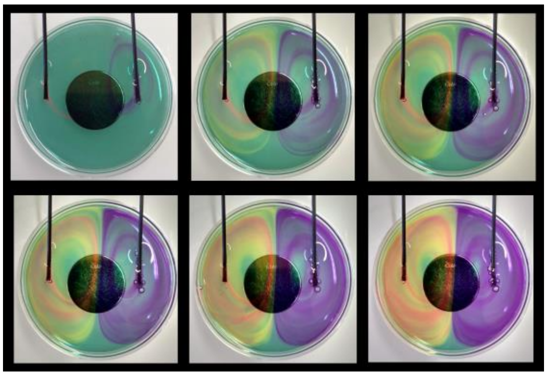
Universal indicator solution at different pH values
Image courtesy of the author

The movement can be explained by the Lorentz force (*F*) which is exerted by the magnetic field (*B*) on the electrolysis current (*I*), whereby the orientation follows the right-hand rule.



Orientation of the Lorentz force F in magnetic field B on current I: right-hand rule
Image: Canarris/Wikimedia Commons, CC BY-SA 3.0

The combination of pH changes and the effect of the magnetic field are what gives the colourful vortex!



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