Batteries

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6 April 2019

The Electrochemical Series

Element	Volts
Li	-3.03
K	-2.92
Ca	-2.87
Na	-2.71
Mg	-2.37
Al	-1.66
Zn	-0.76
Fe	-0.44
Pb	-0.13
H	0
Cu	+0.34
Ag	+0.80
Au	+1.5

History

1800 – first true battery was invented by Alessandro Volta

Before the development of electric generators and electrical grids around the end of the 19th century, batteries were the main source of electricity.

Batteries are electrochemical cells – produce electricity by a chemical reaction.

Primary cells – once active elements consumed, cannot be recharged.

Secondary cells – rechargeable.

First Practical Batteries

Daniell cell – 1836

Bird’s cell – 1837

Porous pot cell – 1838

Gravity cell – 1860 – lower internal resistance and used in telegraph systems until 1950s

Rechargeable Batteries

Lead-acid battery – 1859 Gaston Plante

Early 1930s a gel electrolyte was used in portable vacuum tube radios

1970s – SLA battery

Dry cells

Leclanche cell – 1866 – a battery that consisted of a zinc anode and a manganese dioxide cathode with a little added carbon wrapped in a porous material dipped in a jar of ammonium chloride. The dry cell form was used to power early telephones.

1.4 V per cell and used successfully in telegraphy, signalling and electric bell work.

The dry cell form was used to power early telephones but long conversations were not possible as the chemistry gradually increased internal resistance. This effect was reversible when the cell was allowed to rest, so only good for intermittent use.

Zinc-Carbon Cell

Development of a successful dry cell took from approximately 1812 to 1886. The electrolyte, ammonium chloride, was mixed with plaster of Paris to create a paste. Carl Gassner obtained a German patent in 1886 but the first commercial product used coiled cardboard and was marketed in 1896.

NiCd, the first alkaline battery.

In 1899 in Sweden, Waldemar Jungner invented this battery using a potassium hydroxide electrolyte. Didn't reach the USA until 1946. The NiCd cell had a better energy density than lead-acid cells but were more expensive.

Modern Times

NiFe – invented in 1899 by Jungner at the same time as his Ni-Cd cell but found it inferior and never patented it. Edison took up the design and patented it in 1903 hoping to use it in his electric cars because it was lighter than the Pb-acid cells. Problems with battery life and leakage took a while to overcome by which time the gasoline powered Model T Ford was marketed.

Edison's Ni-Fe cell achieved great success in other applications subsequently.

Modern Times (2)

Until the late 1950s the Zn-C battery continued to be popular despite its relatively short life. Then in 1955 Lewis Urry working for Union Carbide was tasked with finding a way to extend the life of Zn-C batteries. By 1959 the modern Alkaline battery hit the market with a manganese dioxide cathode, a powdered zinc anode and an alkaline electrolyte (potassium hydroxide). A small amount of mercury was also needed to control side reactions at the zinc anode – this is reduced in modern cells.

In 1989 the NiMh battery appeared on the market as a variation of the 1970s nickel-hydrogen battery (communication satellites). What is the metal? - complicated, either rare earths or titanium, vanadium etc. The electrolyte is usually potassium hydroxide.

Modern Times (3)

Lithium is the metal with the lowest density and greatest electrochemical potential and energy-to-weight ratio.

Although experimentation with Li batteries began in 1912, commercial batteries did not appear until the 1970s – these were 3 V primary cells for cameras and small devices.

1980 $LiCoO_2$ cathode and graphite anode with solid electrolyte
1985 Li-ion battery (Japan) – rechargeable and more stable
1991 Sony commercialised this type
1996 $LiFeSO_4$ first described
1997 Li-polymer released

LiFeSO4 Battery

Longer life cycle than other Li-ion batteries.
Very constant discharge voltage – V/cell stays close to 3.2V until 80% exhausted.
Four cells give 12.8V – good safety characteristics.
Must not charge at over 3.6V/cell – best to used purpose designed charger. Must not discharge below 2.5V/cell.
No Co and so no thermal runaway.
Energy density 14% lower than LiCoO2 battery.
Lower degradation when stored in fully charged state.
Still expensive in the UK.

In Summary: perhaps the best portable battery at the moment for portable amateur radio use or station stand-by supply.

LiFeSO4 Battery