LITHIUM ION BATTERIES

Group 7

History

- British chemist M Stanley Whittingham, now at Binghamton University
- Whittingham used titanium(IV) sulfide and lithium metal as the electrodes
- Rechargeable lithium battery could never be made practical
- Titanium disulfide was a poor choice:
    - This has to be synthesized under completely sealed conditions because when exposed to air, titanium disulfide reacts to form hydrogen sulfide compounds, which have an unpleasant odour and are toxic to most animals
    - Also, very expensive
- Safety issues - metallic lithium electrodes, as lithium is a highly reactive element; it burns in normal atmospheric conditions because of spontaneous reactions with water and oxygen
- Research moved to develop batteries in which, instead of metallic lithium, only lithium compounds are present, being capable of accepting and releasing lithium ions

Construction

Positive Electrode	*Negative Electrode*	*Electrolyte*
Metal Oxide	Carbon	Lithium Salt & Organic Solvent
lithium cobalt oxide/ lithium iron phosphate/ lithium manganese oxide	Graphite	ethylene carbonate or diethyl carbonate containing complexes of lithium ions

NOTE - electrochemical roles of the electrodes reverse between anode and cathode, depending on the direction of current flow through the cell

A material made of carbon, typically graphite. Future battery anodes may be made with silicon. Researchers are attempting to replace this with pure lithium.

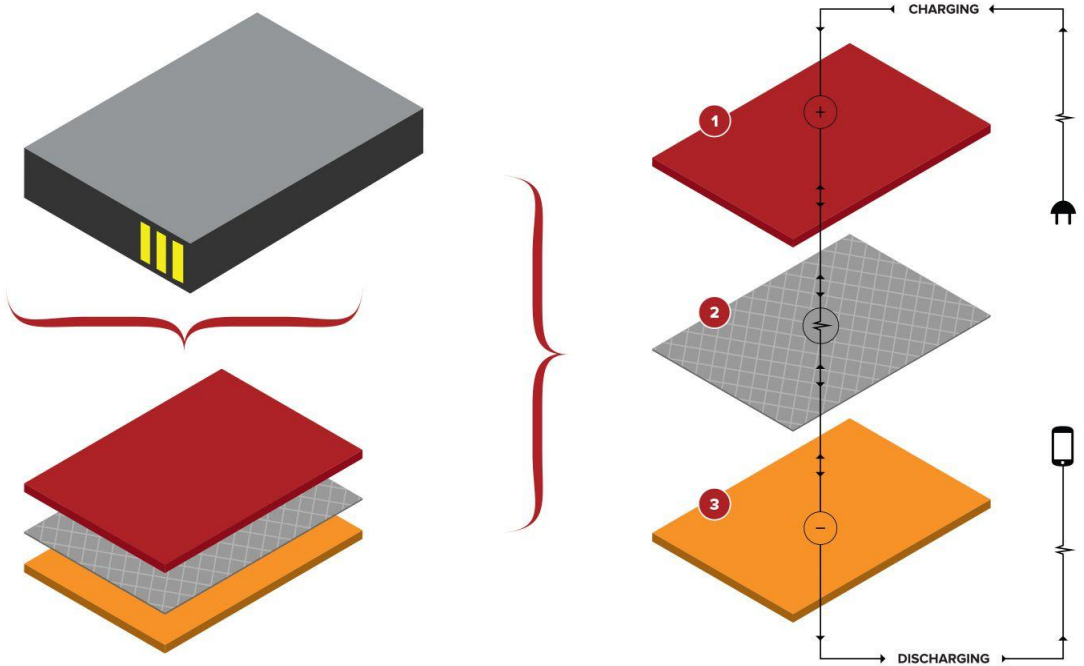
1. ANODE

A membrane that prevents the two materials from touching one another, but allows the passage of lithium ions. Usually made of a polymer.

2. SEPARATOR

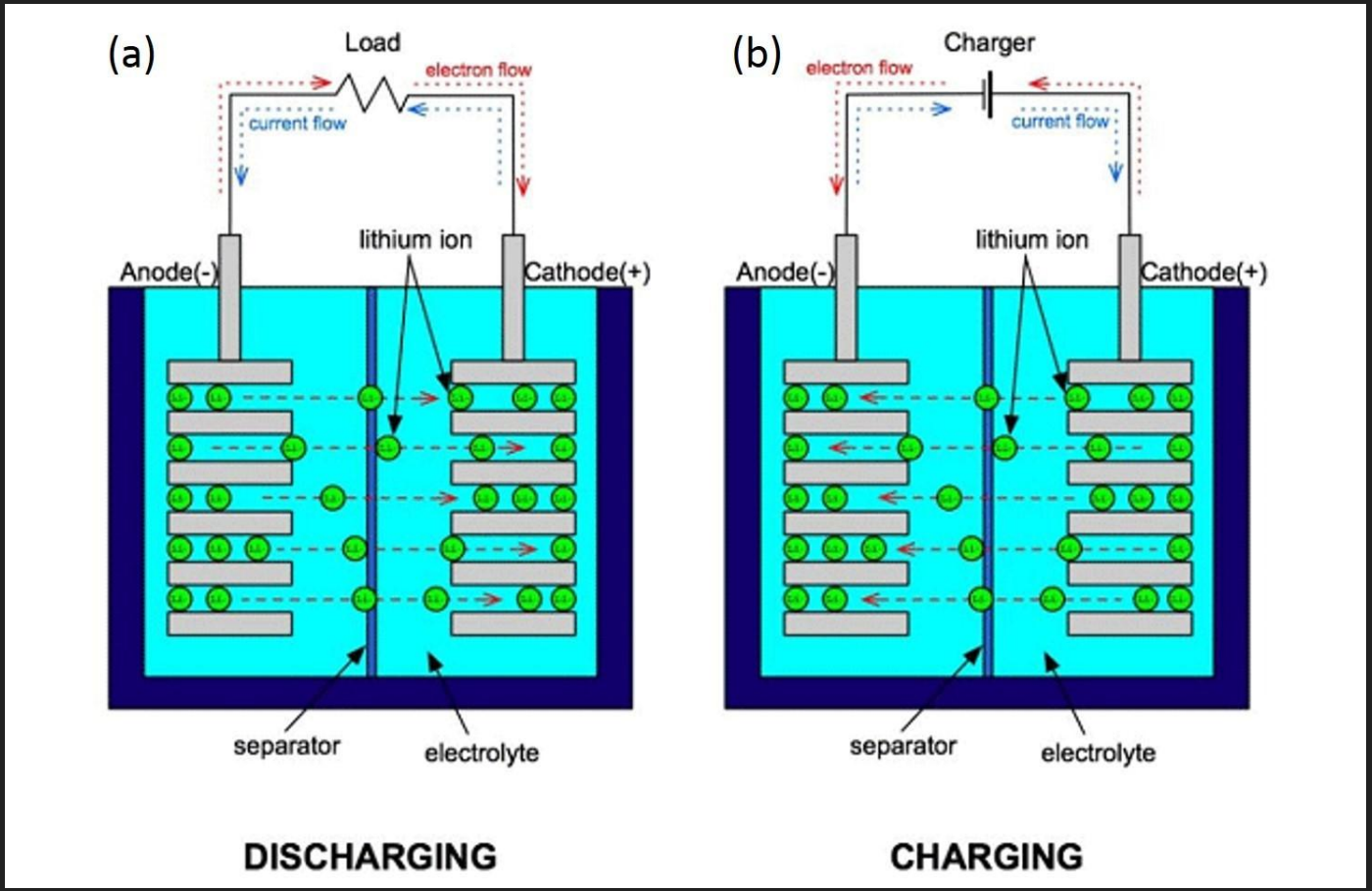
A material made of some combination of lithium, cobalt, nickel, manganese or other materials. Some researchers are attempting to replace this with purified air.

3. CATHODE



- Depending on materials choices, the voltage, energy density, life, and safety of a lithium-ion battery can change dramatically.
- Recently, novel architectures using nanotechnology have been employed to improve performance
- Pure lithium is highly reactive. Hence, a non-aqueous electrolyte is typically used, and a sealed container rigidly excludes moisture from the battery pack
- Lithium-ion cells are supplied as part of a battery pack with *temperature sensors, voltage converter/regulator circuit*, *voltage tap*, *battery charge state monitor* and the main connector

Electrochemistry



- Reactants in the electrochemical reactions are the negative and positive electrodes and the electrolyte providing a conductive medium for lithium ions to move between the electrodes
- Electrical energy flows out from or in to the battery when electrons flow through an external circuit during discharge or charge respectively
- Both electrodes allow lithium ions to move in and out of their structures with a process called insertion (intercalation) or extraction(deintercalation) respectively
- During discharge, the (positive) lithium ions move from the negative electrode (usually graphite) to the positive electrode (forming a lithium compound) through the electrolyte while the electrons flow through the external circuit in the same direction
- When the cell is charging, the reverse occurs with the lithium ions and electrons moved back into the negative electrode in a net higher energy state

Reaction

$$CoO_2 + Li^+ + e^- \rightleftharpoons LiCoO_2$$

$$LiC_6 \rightleftharpoons C_6 + Li^+ + e^-$$

$$LiC_6 + CoO_2 \rightleftharpoons C_6 + LiCoO_2$$

$$Li^+ + e^- + LiCoO_2 \longrightarrow Li_2O + CoO$$

$$LiCoO_2 \longrightarrow Li^+ + CoO_2 + e^-$$

Li-Ion & Li-Polymer

	Lithium Ion	Lithium Polymer
Energy Density	High	Low
Aging	Loses Capacity	Retains Capacity
Chance of Explosion	Likely when Overcharged	Safe
Price	Cheaper	Expensive
Charging Duration	Longer	Comparatively Shorter
Weight	Heavier	Lighter
Conversion Rate	85% - 95%	75% -90%

Performance

- Cyclic life is the number of charge/discharge cycles a battery can perform before its capacity falls below 80% of its initial rated capacity
- Any Li-Ion battery life is measured based on how many times can you discharge it from 100% to 0%
- Temperature is a major factor in battery performance, Good Conditions($18^{o}C$ -$32^{o}C$) . Neither too hot nor too cold
- A battery can only store a certain quantity of electricity. The closer it gets to being fully charged, the slower it must be charged

Advantages

- Rechargeable
- Higher energy density than other rechargeable batteries
- Light weighted
- Produce higher voltage when compared to other batteries
- More resistance to overcharge
- No liquid electrolyte, no leakage
- Doesn't take much time to get charged and discharged
- Tiny memory effect
- High energy density
- Based on lithium cobalt oxide, which prevents risks

Disadvantages

- High-priced.
- Not available in standard cell types.
- Not safe as they contain flammable electrolyte.
- Getting charged too quickly might cause short circuit and lead to explosions.

Applications

- Cameras & calculators
- Cardiac pacemakers and other implantable devices
- Telecommunication equipments, instruments, portable radios, TVs, pagers etc.
- Operate laptops, computers, mobile phones and aerospace applications
- Battery electric vehicles (eg: motorcycles, bicycles, scooters, skateboards etc)
- Military Applications

Q&A