Lithium Ion Battery

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Outlines

Batteries with nonaqueous electrolyte

- **Lithium ion Battery**

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Lithium ion Battery

Invented in 1980 by American physicist Professor John Goodenough .

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Li-ion Battery

Lithium Ion Polymer Battery - 850mAh

Motorcycle battery

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Li-ion Battery

Solar energy

Phone Battery

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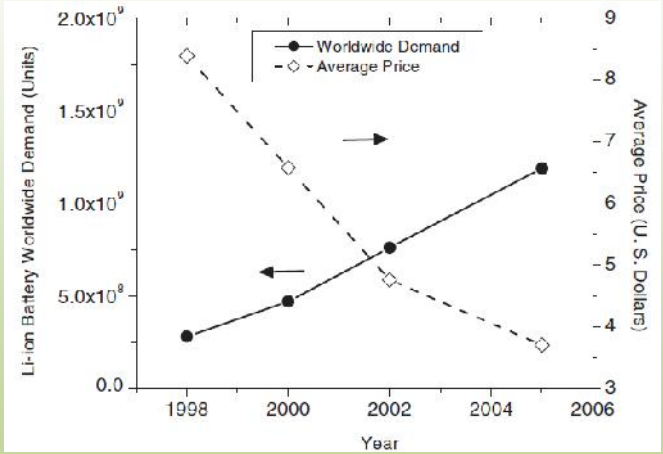
Current and anticipated worldwide demand and average price for Li-ion batteries.



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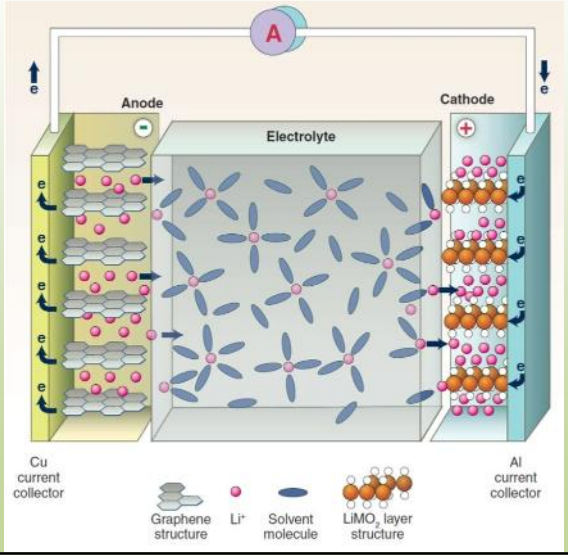
Li-ion Battery: Main Components



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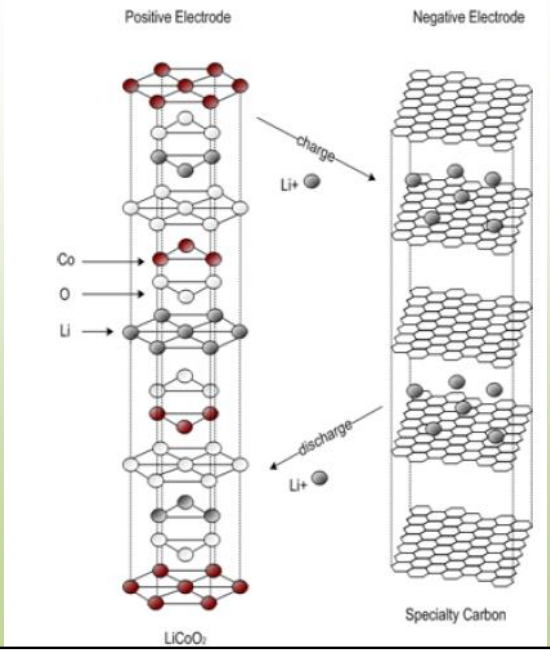
Li-ion batteries

• Positive electrode: Lithiated form of a transition metal oxide (lithium cobalt oxide- $LiCoO_2$ or lithium manganese oxide $LiMn_2O_4$)

• Negative electrode: Carbon (C), usually graphite (C_6)

• Electrolyte: solid lithium-salt electrolytes ($LiPF_6$, $LiBF_4$, or $LiClO_4$) and organic solvents (ether)



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Requirements for Li-ion :
Positive Electrode Materials

- High free energy of reaction with lithium
- Can incorporate large quantities of lithium
- Reversibly incorporates lithium without structural change
- High lithium ion diffusivity
- Good electronic conductivity
- Insoluble in the electrolyte
- Prepared from inexpensive reagents
- Low cost synthesis

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Requirements for Li-ion separators

- High machine direction strength to permit automated winding
- Does not yield or shrink in width
- Resistant to puncture by electrode materials
- Effective pore size less than 1 m
- Easily wetted by electrolyte
- Compatible and stable in contact with electrolyte and electrode materials

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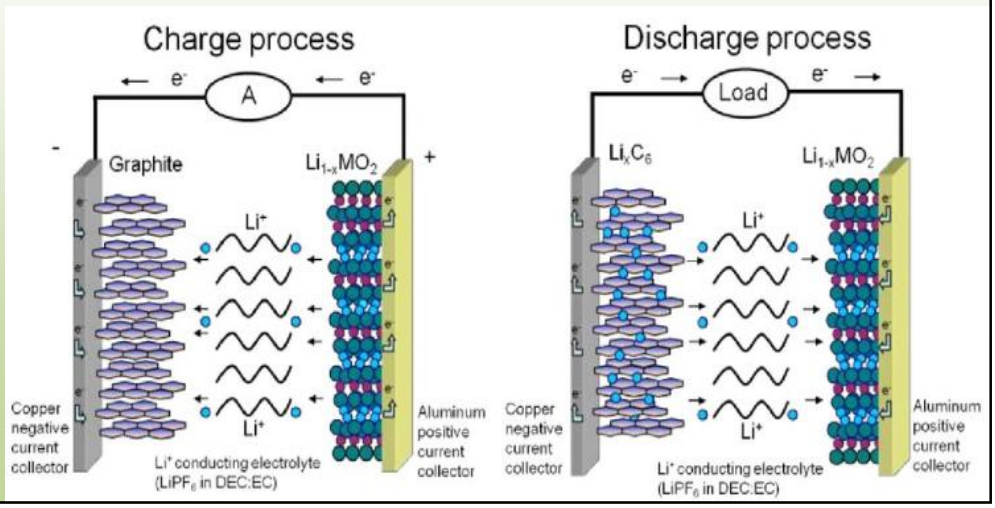
Li-ion Battery: Working Principle



Li-ion batteries

- Chemical reaction (Charging)
  - Positive electrode: $LiCoO_2 \longrightarrow Li_{1-x}CoO_2 + xLi^+ + xe^-$
  - Through electrolyte
  - Through load
  - Negative electrode: $xLi^+ + xe^- + 6C \longrightarrow Li_xC_6$
  - Overall: $LiCoO_2 + C_6 \longrightarrow Li_{1-x}CoO_2 + C_6L_x$

- In the above reaction *x* can be 1 or 0

- With charge the Co is oxidized from Co^{3+} to Co^{4+}. The reverse process (reduction) occurs when the battery is being charged.

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Advantages of Li-ion Batteries

- Sealed cells; no maintenance required
- Long cycle life
- Broad temperature range of operation
- Long shelf life
- Low self-discharge rate
- Rapid charge capability
- High rate and high power discharge capability
- High coulombic and energy efficiency
- High specific energy and energy density
- No memory effect

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Disadvantages of Li-ion Batteries

- Moderate initial cost
- Degrades at high temperature
- Need for protective circuitry
- Capacity loss or thermal runaway when overcharged.
- Venting and possible thermal runaway when crushed
- Cylindrical designs typically offer lower power
- density than NiCd or NiMH

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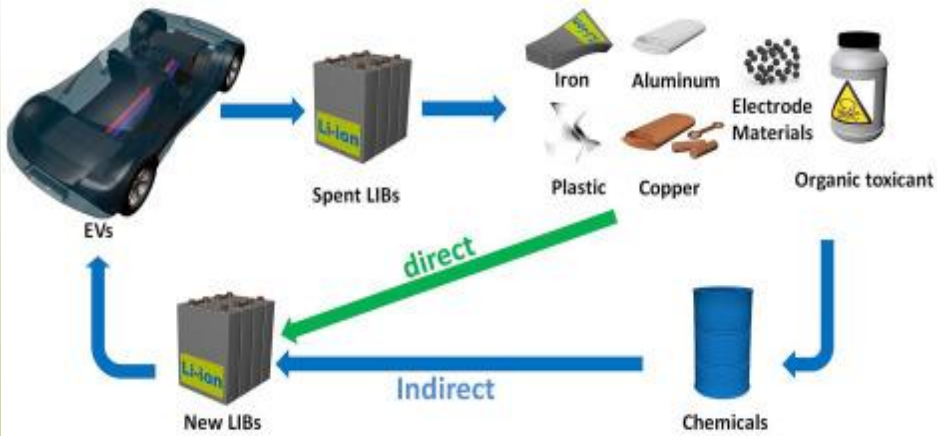
Recycling of lithium-ion batteries



Li-ion batteries video 6.35 min Tesla Motor

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Different SI Units For Batteries

- **Ampere (A or amp) :** (unit of electric current)

Refers to the amount of constant current (electric charge) that produces a force equal to 2×10-7 newton per meter on two straight parallel conductors.

- **Ampere hour (Ah or amp hr): (** unit of electric charge)

A steady flow of 1 ampere for 1 hour (straight) is 1 Ah. The equivalent is 3600 coulomb.

- **Coulomb (C):(** unit of electric charge)

Accumulated per second of a 1 amp current is measured as 1 coulomb (C).

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Different SI Units For Batteries

- **Farad (F):** (electric capacity)

One farad is the ability of the conductor to store 1 C (coulomb) of charge for every volt of potential difference between the two conductors.

- **Faraday (Fd):(** unit of electric charge)

1 Fd is equivalent to the product of a charge on a single electron and Avogadro's constant.

- **Joule (J):** (energy)

A joule is the amount of energy exerted as the force of 1 newton is applied over a displacement of 1 meter. 1 joule is also equal to the energy of 1 watt per second.

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Different SI Units For Batteries

- **Ohm (Ω)** : (unit of electrical resistance)

One ohm is the amount of resistance that needs a potential difference of 1 volt per ampere.

- **Siemens (S):** (unit of electric conductance)

One siemens is when a conductor carries a current of one ampere per volt of potential.

- **Volt (V):** (unit of electrical potential)

A volt represents a potential of one joule per coulomb of charge.

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Different SI Units For Batteries

- **Henry (H)**: (electric inductance)

1 H usually requires a flux of 1 weber per ampere of the current induced.