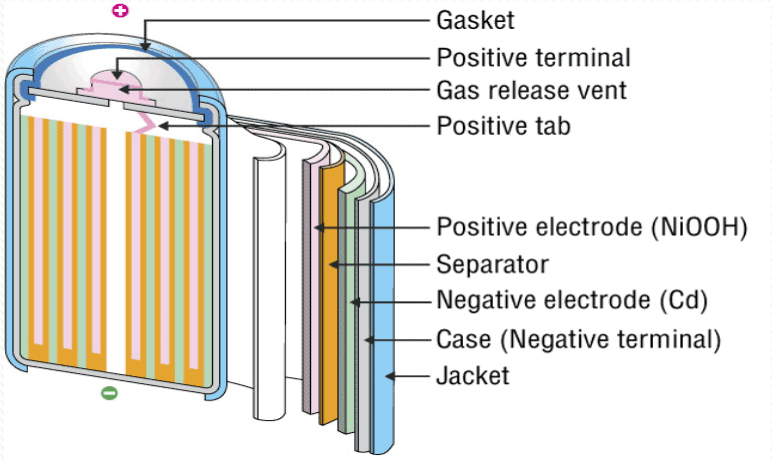
NICKEL-CADMIUM AND Li-ion BATTERY

INTRODUCTION

- The nickel–cadmium battery is a type of rechargeable battery using nickel oxide hydroxide and metallic cadmium as electrodes. Ni-Cd batteries are made in a wide range of sizes and capacities.
- Nickel(hydroxide)–cadmium systems are the most common small rechargeable battery type for portable appliances. The sealed cells are equipped with "jelly roll" electrodes, which allow high current to be delivered in an efficient way. These batteries are capable of delivering exceptionally high currents, can be rapidly recharged hundreds of times, and are tolerant of abuse such as over discharging or overcharging.
- It produces a voltage of about 1.4 V



INVENTIONS AND SCOPE

- Nickel-cadmium (NiCd)
- Invented by Waldemar Jungner in 1899. Developments were slow, but in 1932, advancements were made to deposit the active materials inside a porous nickel-plated electrode. Further improvements occurred in 1947 by absorbing the gases generated during charge, which led to the modern sealed NiCd battery.
- For many years, NiCd was the preferred battery choice for two-way radios, emergency medical equipment, professional video cameras and power tools. In the late 1980s, the ultra-high capacity NiCd rocked the world with capacities that were up to 60 percent higher than the standard NiCd.
- Since the disposal of battery is hazardous to environment alternative cells are being used such as paper battery

RECENT TRENDS

The primary trade-off with Ni–Cd batteries is their higher cost and the use of cadmium. This heavy metal is an environmental hazard, and is highly toxic to all higher forms of batteries.

Recently, nickel–metal hydride and lithium-ionbatteries have become commercially available and cheaper, the former type now rivaling Ni–Cd batteries in cost..

The batteries are more difficult to damage than other batteries, tolerating deep discharge for long periods.

Ni–Cd batteries typically last longer, in terms of number of charge/discharge cycles, than other rechargeable batteries such as lead/acid batteries.

Compared to lead–acid batteries, Ni–Cd batteries have a much higher energy density.

In consumer applications, Ni–Cd batteries compete directly with alkaline batteries. A Ni–Cd cell has a lower capacity than that of an equivalent alkaline cell, and costs more.

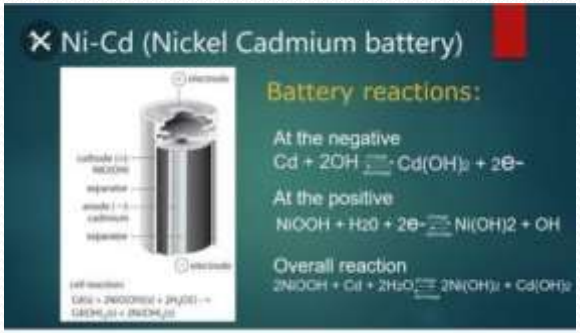
The capacity of a Ni–Cd battery is not significantly affected by very high discharge currents.

CELL REPRESENTATION AND CELL REACTION

A typical Ni-Cd battery is represented as

Cd| Cd(OH)2|| NiO(OH)| Ni(OH)2

Cell reaction while discharging



At Anode: oxidation of Cd metal

$Cd + 2OH^- \longrightarrow Cd(OH)_2 + 2e^-$

At cathode: reduction of NiO(OH)

$2NiO(OH) + 2H_2O + 2e^- \longrightarrow 2Ni(OH)_2 + 2OH^-$

Net Cell reaction:

$2NiO(OH) + 2H_2O + Cd \longrightarrow 2Ni(OH)_2 + Cd(OH)_2$

ADVANTAGES

- Fast and simple charging process
- It is compact and lighter than traditional batteries
- It has a longer life than lead storage batteries
- Available in a wide range of sizes and performance options
- Good low-temperature performance
- Only battery that can be ultra-fast charged with little stress

LIMITATIONS

- It is rather more expensive than a lead storage battery
- It has a lower energy density value
- Cadmium is a toxic metal. Cannot be disposed of in landfills
- Memory effect; needs periodic full discharges
- High self-discharge; needs recharging after storage

APPLICATIONS

- Ni-Cd cells are popularly used in many appliances because they are available in variety of sizes and capaciities.
- Few examples are:

❖Calculators

❖Electronic flash units

❖Transistors

❖Cordless appliances

LI-ION BATTERY DESCRIPTION

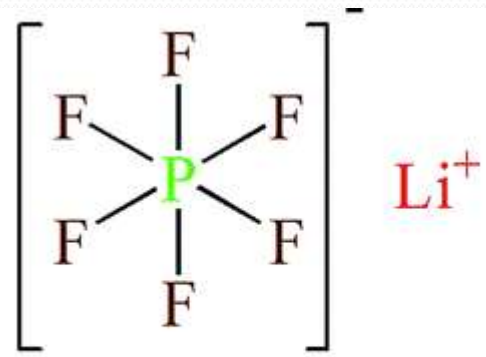
- A lithium-ion battery or Li-ion battery (abbreviated as LIB) is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging.
- The electrolyte, which allows for ionic movement, and the two electrodes are the constituent components of a lithium-ion battery cell.

ELECTROLYTES

- Role-

1. Ion conduction between cathode and anode.
2. They are generally, Lithium salts dissolved in organic solvent.

- Commercial electrolytes: $LiPF_6$ in Carbonate solvent.



$LiPF_6$

ANODE MATERIALS

- Requirements:

1. Large capabilites of adsorption.
2. High efficency of charge/discharge.
3. Low reactivity against electrolyte.
4. Fast reaction rate.
5. Low cost
6. Environment friendly

- Commercial anode materials:

Hard Carbon, Graphite

CATHODE MATERIALS

- Requirements:

1. A high discharge voltage
2. A high energy capacity
3. A high power density
4. Light weight
5. Low self discharge
6. Environment friendly

- Commercial cathode materials:

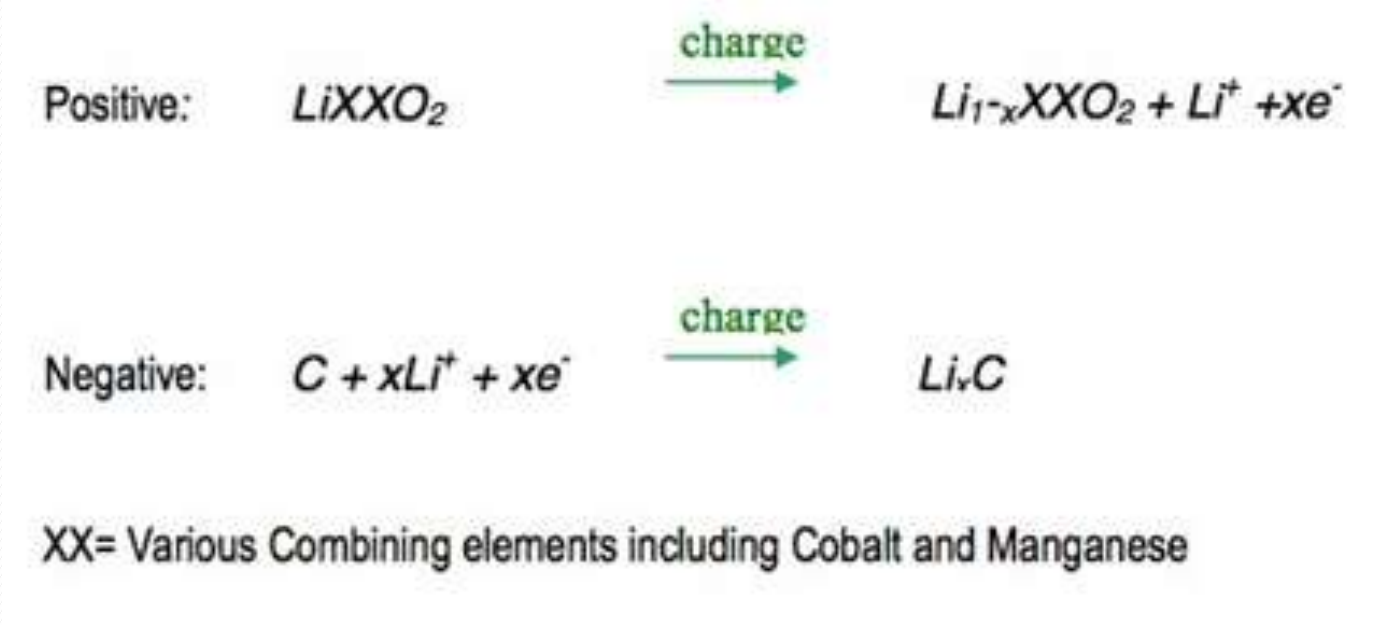
$LiCoO_2$, $LiFePO_4$ etc.

CHEMICAL REACTIONS

- Main essential components...
- Anode: Graphite [carbon] - C(s)
- Cathode: Lithium Cobalt Oxide - LiCoO2
- Electrolyte: Typically a combination of lithium salts - LiPF6, LiBF4, or LiClO4, in an organic solvent, such as either.
- Separator: The separator is a very thin sheet of micro perforated plastic. - CH2=CHCl

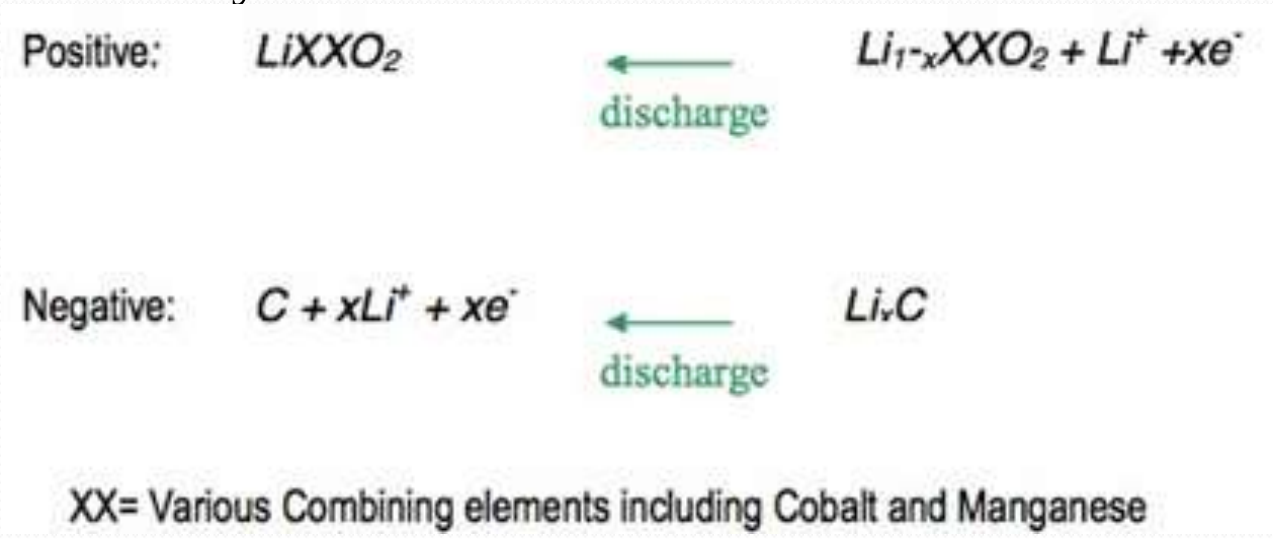
REACTIONS WHILE CHARGING

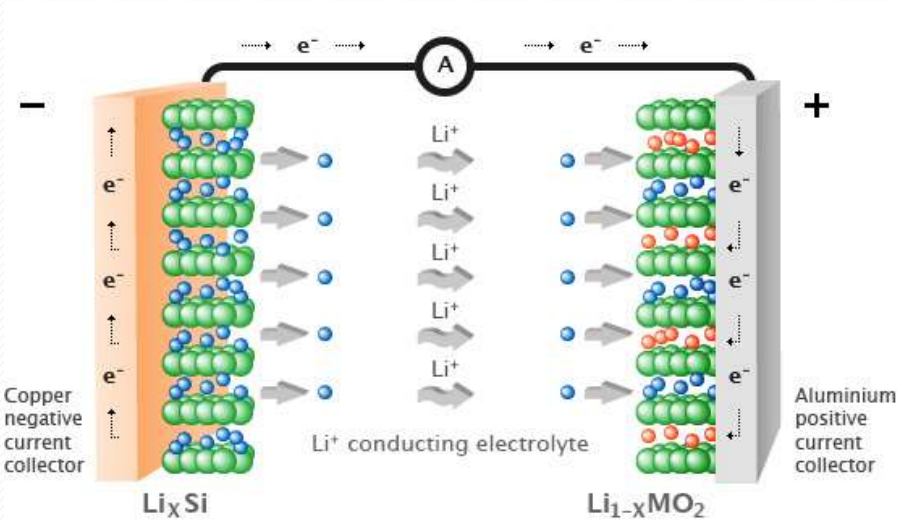
- On charge the positive electrode, cathode, material is oxidized, Li+ ions are de-intercalated from the layered lithium LiCoO2, pass across the electrolyte and are intercalated between the graphite layers in graphite by an electrochemical reduction reaction proceeding at the negative electrode.

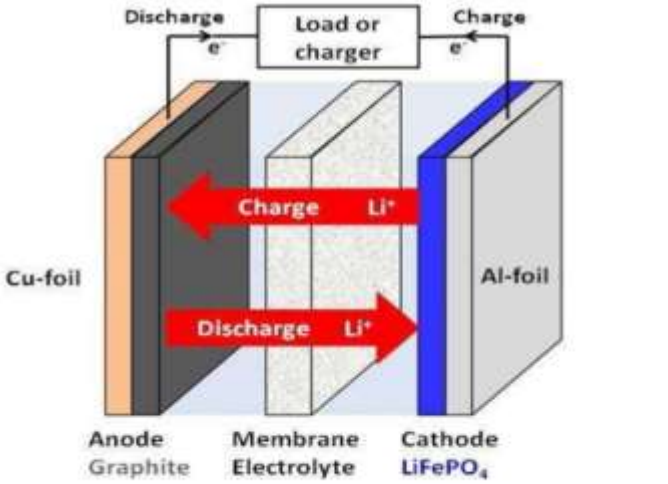


REACTIONS WHILE DISCHARGING

- When the cell is discharged, an oxidation reaction occurs at the negative electrode, Li+ ions are de-intercalated from the anode and migrate across the electrolyte to be re-intercalated into the cathode material, due to charge balance the equivalent number of electrons travel through the external circuit. A simultaneous electrochemical reduction reaction proceeds at the positive electrode and accepts electrons from the external circuit, Li+ ions from the electrolyte, to reform the starting material. A change from electronic current to ionic current occurs at the electrode/electrolyte interface.







Schematic representation of a Lithium-ion cell

Overall: $LiXXO_2 + C \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Li_yC + Li_{1-x}XXO_2$

XX= Various Combining elements including Cobalt and Manganese

Lithium-ion Battery	
Advantages	**Disadvantages**
Light-weight	Involves risk of bursting
Have higher energy density than other rechargeable batteries	Costly, compared to other batteries
Rate of charge loss is less	Complete discharge damage the battery
Have a greater number of charge and discharge cycles	Extremely sensitive to high temperatures (degrades very quickly, if exposed to heat)
Need not be discharged completely (due to absence of memory effect)	Very short lifespan (2 to 3 years from the date of manufacturing, even if not in use)
Operates at higher voltage than other rechargeable batteries (approx. 3.7 volt)	Not available in standard cells sizes (AA, C, and D) like others

APPLICATIONS

- Emergency Power Backup Or UPS
- Dependable Electric And Recreational Vehicle Power
- Solar Power Storage
- Reliable And Lightweight Marine Performance
- Solar Power Storage
- Surveillance Or Alarm Systems In Remote Locations
- Personal Freedom With Mobility Equipment
- Portable Power Packs That Eliminate Downtime

Mining

Space Applications

Consumer Electronics

Power Invertors

Electric Vehicles (EV, HEV, PHEV)

Energy Storage System

Lithium Ion Batteries

Defence /Military Applications

Marines and Submarines

Telecom Towers

Solar and Wind Energy Storage

Railways