PowerPoint Presentation on

TYPES OF BATTERIES

& Energy Conversion and Storage

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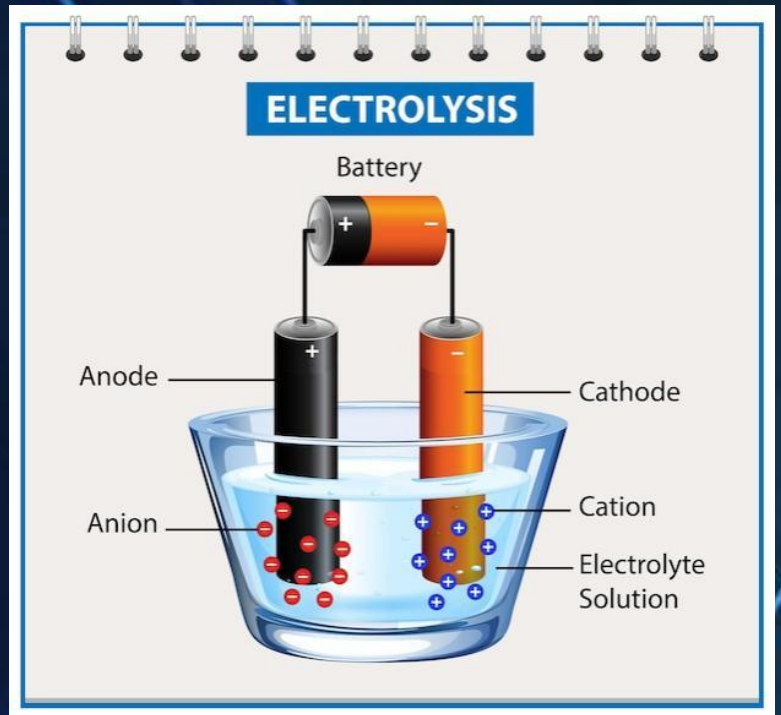
BATTERIES

A Device which contains many electrochemical cells either in series or in parallel which store chemical energy and converts it to Electrical Energy on demand is called as an Electrochemical Battery



Principle Components

- Anode:
- Cathode:
- Electrolyte
- Separator

Types Of Batteries

1. Primary Battery: A device where electrochemical reactions are irreversible

Ex: Dry cell

2. Secondary Battery: A device where electrochemical reactions are reversible

Ex: Lithium ion Battery

3. Tertiary Battery: A device where electrochemical reactions Continue after adding certain additives.

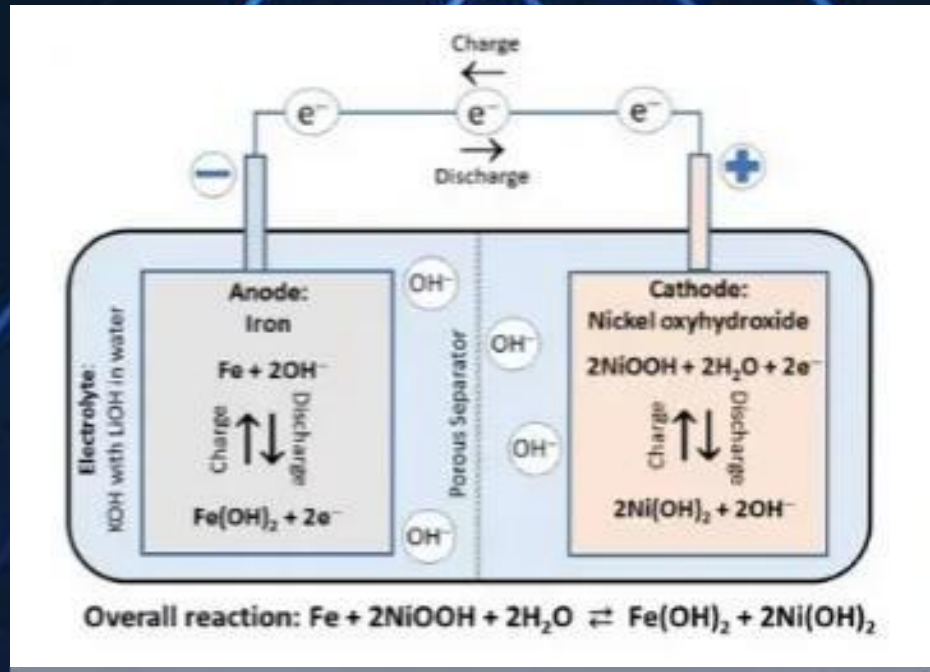
Ex: UPS

1. Nickel Iron Battery

- Anode: Iron
- Cathode: Nickel(III) Hydroxide
- Electrolyte: KOH
- Separator: Polypropylene

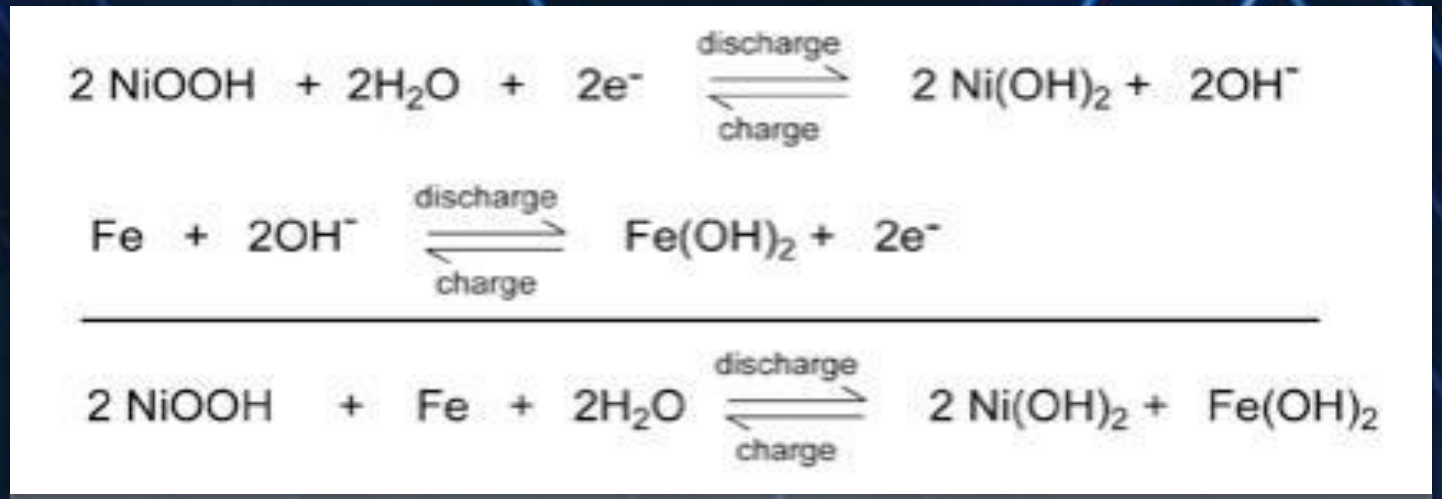
Working:

Ni(OH)3, during charging, the nickel compound on the positive plates oxidizes to nickel peroxide, while the charging process changes the iron compound on the negative plates to spongy iron.



In the fully charged condition, the active material of the positive plates is nickel hydroxide [Ni(OH)3], while that in pockets of the negative plate is iron, Fe. When the cell delivers current to load, the active material of the positive plate changes from Ni(OH)3 to Ni(OH)2 and that of the negative plate changes from iron to Ferrous hydroxide (Fe(OH)2).

At Cathode:



At anode:

Overall Reaction:

Advantages

- The weight of this battery is lower because they need less amount of electrolytes and plates are also lighter.
- The service life of the battery is much higher.
- They are not affected by vibrations, jolts or shocks

Disadvantages

- Initial cost is high due to need of costly materials
- Low efficiency

Applications

Used in industrial trucks for propulsion purpose and mine locomotives where high mechanical strength is in display

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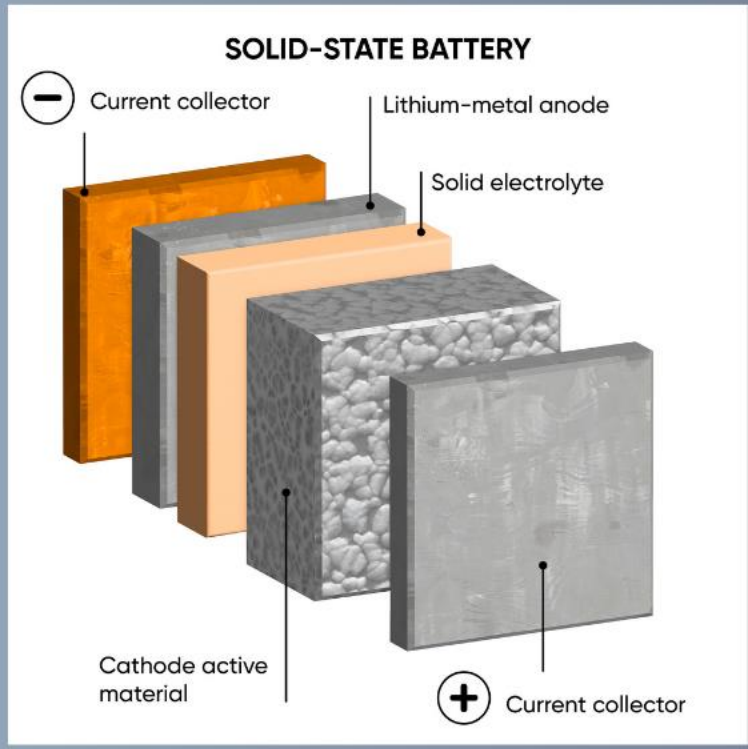
SOLID STATE BATTERY

OVERVIEW AND REDOX REACTIONS

What are Solid-State Batteries?

A solid-state battery uses a *solid electrolyte* for ion conduction between the anode and cathode, instead of the traditional liquid or gel electrolytes in lithium-ion batteries.



Advantages

- Higher energy density.
- Enhanced safety due to the non-flammable nature of the solid electrolyte.
- Improved thermal stability and cycle life.

Anodic Reaction (Metallic Lithium)

$$Li \rightarrow Li^+ + e^-$$

Cathodic Reaction (Li oxide / sulfides):

$$Li^+ + e^- + \text{Cathode Material} \rightarrow Li(\text{Material})$$

Electrolyte : Ceramics

PERFORMANCE STATISTICS AND APPLICATIONS

Performance Statistics

- **Energy Density:**
- Thin-film type: 300–900 Wh/kg
- Bulk type: 250–500 Wh/kg
- **Cycle Life:** 10,000–100,000 cycles
- **Operating Temperature:** -50°C to 125°C
- **Nominal Voltage:** 2.5 V to 4.6 V

Applications

- **Electric Vehicles (EVs):**
Longer range, faster charging (15 minutes to 80% charge).
- **Consumer Electronics:**
Compact design for smartphones, laptops.
- **Wearable Devices and Medical:**
Used in pacemakers and RFID technology.

Nickel cadmium battery

- **Anode**: Cadmium (Cd) reacts with hydroxide ions (OH^-) to form cadmium hydroxide ($Cd(OH)_2$).
- **Cathode**: Nickel oxyhydroxide (NiOOH) reacts with water to form nickel hydroxide ($Ni(OH)_2$).

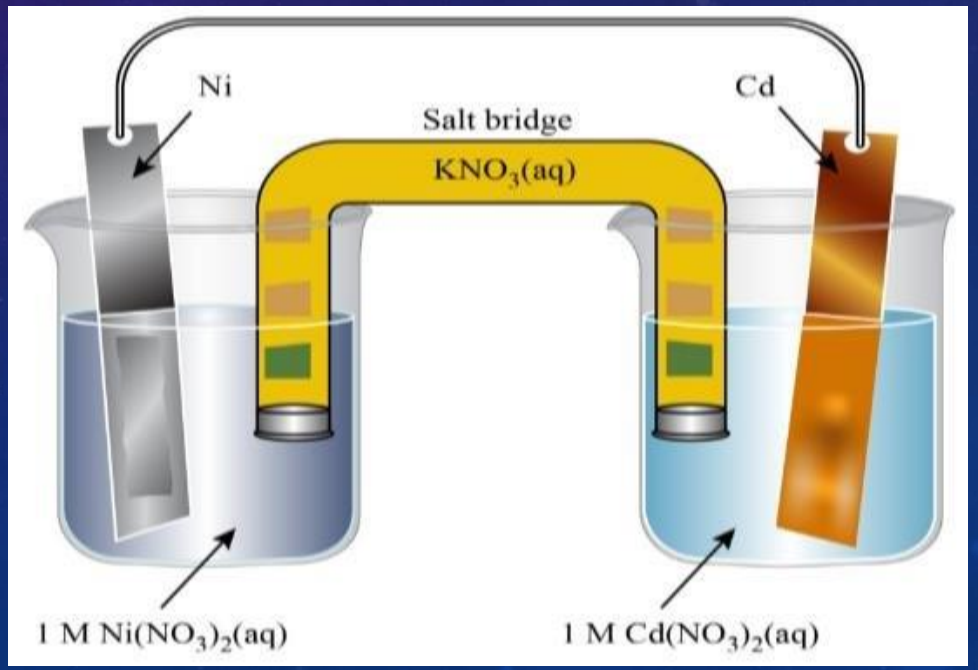
Anode and Cathode Reactions in Ni-Cd Batteries

- **Anode Reaction (Negative Electrode):**

  $Cd + 2OH^- \rightarrow Cd(OH)2 + 2e^-$

- **Cathode Reaction (Positive Electrode):**

  $NiOOH + 2H2O + 2e^- \rightarrow Ni(OH)2 + 2OH^-$



Advantages of Ni-Cd Batteries

- **High Cycle Life:** N-iCd batteries are known for their ability to undergo a high number of charge and discharge cycles (typically 500-1,000 cycles), making them durable and long-lasting for many applications.
- **Good Performance at Low Temperatures:** Ni-Cd batteries can operate in low-temperature environments, which makes them suitable for applications in harsh or cold climates.

Disadvantages of Ni-Cd Batteries

- **Memory Effect:** One of the main disadvantages of Ni-Cd batteries is the "memory effect." If a Ni-Cd battery is repeatedly charged before it is fully discharged, it "remembers" the smaller capacity and loses its ability to hold a full charge. This phenomenon reduces the effective capacity of the battery over time.
- **Toxicity of Cadmium:** Cadmium is a toxic heavy metal, which makes Ni-Cd batteries harmful to the environment if they are not disposed of properly. Improper disposal can lead to soil and water contamination.

1.Sintered Ni Cd battery

What is sintering ?

Sintering is a process in material science where a solid material is compacted and densified using heat and pressure, Without melting it . This process involves bonding particles together through atomic diffusion, resulting in a strong and rigid structure.

Construction

1. Positive Plate(cathode): Nickel oxide hydroxide (NiOx) is sintered onto a steel grid.
2. Negative plate(anode):Cadmium (Cd) is sintered onto a steel grid.
3. Separator : A porous material Separate the plates to prevent short circuits.

Anode reaction

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

Cathode reaction:

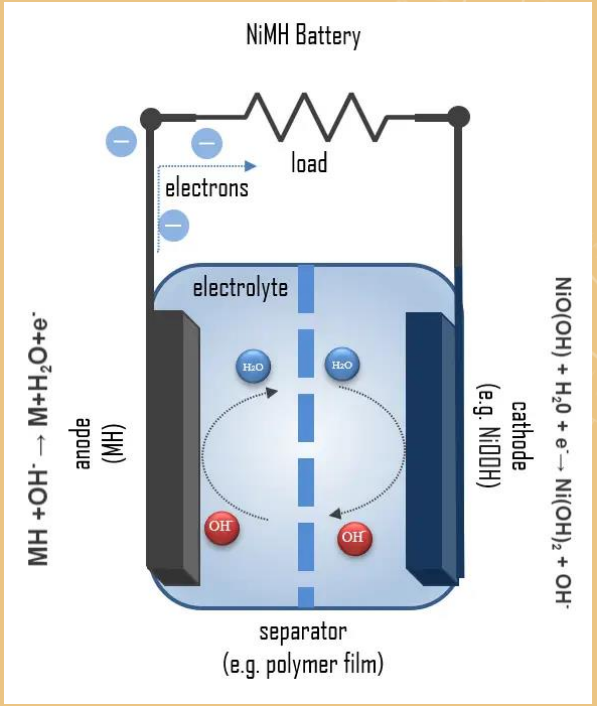
$2NiOx(s)+2H2O(I)+2e^- \longrightarrow 2Ni(oH)2(s)+2OH^-(s)+2OH^-(aq)$

- Working principle
  1. Chemical reaction : Nickel oxide hydroxide(NiOx) reacts with cadmium (Cd) to produce electricity.
  2. Electrolyte: Potassium hydroxide (KOH) facilitates ionic conduction.
- Applications : Aviation systems, industrial tools, emergency lighting, and backup power.
- Advantages
  - Higher energy density compared to pocket NiCd batteries.
  - Can handle overcharging and fast charging.
  - Durable with a long operational life.
- Disadvantages
  - Contains cadmium, which is environmentally hazardous.
  - More expensive then other operational life.

Introduction to NiMH Batteries

What is a NiMH Battery?

- A **Nickel-Metal Hydride (NiMH) Battery** is a rechargeable battery where the anode uses a hydrogen-absorbing alloy, and the cathode uses nickel oxyhydroxide (NiOOH).
- Evolved from Ni-Cd batteries, offering higher capacity and reduced toxicity.



Anodic Reaction (Oxidation)

$$MH + OH^- \rightarrow M + H_2O + e^-$$

Cathodic Reaction (Reduction)

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

Nominal Voltage: ~1.2 V per cell.

Applications and Advantages

Applications :

- **Consumer Electronics**: Digital cameras, remote controls, and toys.
- **Automotive**: Widely used in hybrid vehicles like the Toyota Prius.
- **Industrial**: Backup power systems and medical devices.

Advantages :

- Higher energy density than Ni-Cd batteries.
- Safer and more environmentally friendly (no cadmium).
- Robust performance across various temperatures.

Alkaline Battery

An **alkaline battery** is a type of primary battery where the electrolyte has a pH value above 7. Typically these batteries derive energy from the reaction between zinc metal and manganese dioxide.

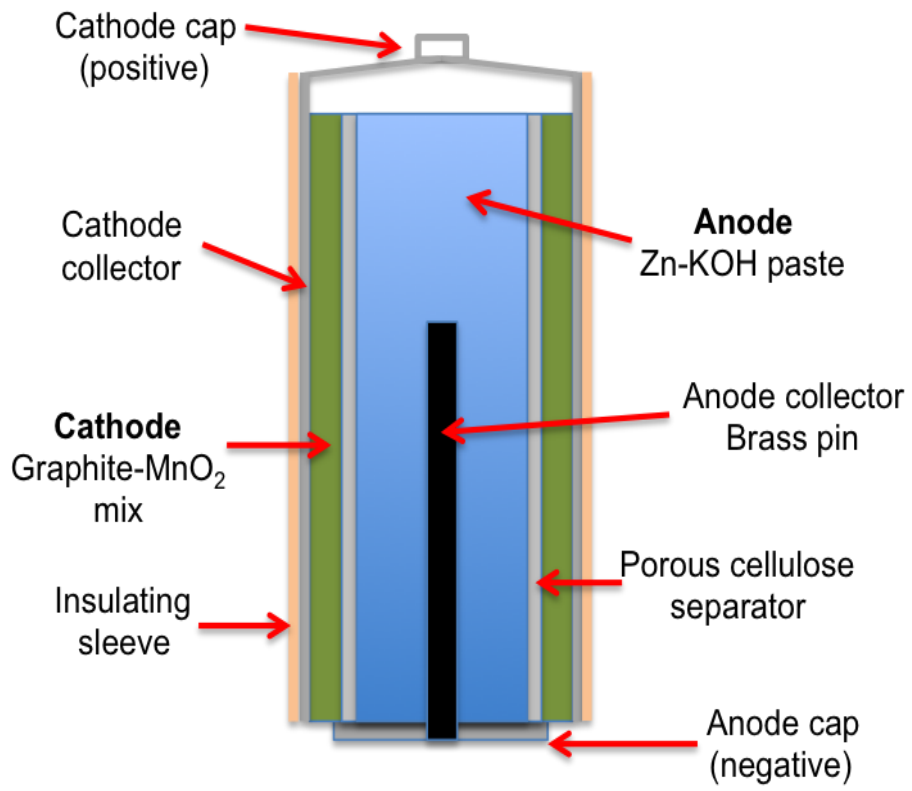
Construction:-

Anode:-Zinc

Cathode:-Manganese dioxide

Separator:-Polypropylene

Electrolyte:-KOH



Working:-

Anode	$Zn_{(s)} + 2OH^-_{(aq)} \rightarrow ZnO_{(s)} + H_2O_{(l)} + 2e^-$	- 1.28 V
Cathode	$2MnO_{2(s)} + H_2O_{(l)} + 2e^- \rightarrow Mn_2O_{3(s)} + 2OH^-_{(aq)}$	+0.15 V
overall	$Zn_{(s)} + 2MnO_{2(s)} \rightleftharpoons ZnO_{(s)} + Mn_2O_{3(s)}$	+1.43 V

1. **Zinc Oxidation:-** Zinc reacts with hydroxide ions to form zinc oxide and release electrons.
2. **Manganese Dioxide Reduction:-**Manganese dioxide reacts with water and electron to form manganese oxide hydroxide and release hydroxide ions.
3. **Zinc and Manganese Dioxide:-**The overall reaction involves the oxidation of zinc the reduction of manganese dioxide resulting in the generation of electricity.

Common Uses:-

Flashlights, Toys, Remote Controls , Radios, Other Portable devices

Advantageous:-

1. Alkaline Batteries are reliable and consistent in their performance.
2. They are widely available in various sizes and formats.
3. They are cost effective compared to rechargeable batteries.

Disadvantageous:-

1. Alkaline Batteries are disposable and cannot be reused.
2. They contain toxic materials like mercury and lead, which can harm the environment if not disposed of property.
3. They have limited energy storage capacity compared to rechargeable batteries.

Safety Precautions:-

1. Handle alkaline batteries with care to avoid damage or leakage.
2. Dispose of alkaline batteries property to avoid environmental harm.
3. Avoid mixing alkaline batteries with other type of batteries.
4. Keep alkaline batteries out of reach of children and pets.

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THANK YOU