

## Ni-Metal Hydride (NiMH) Batteries: Benefits Guide

Benefit	Description
Higher Capacity	NiMH batteries offer significantly higher capacity than standard alkaline and NiCd batteries, making them ideal for high-drain devices.
Environmental Benefits	NiMH batteries contain fewer toxic materials than NiCd, making disposal and recycling less harmful.
Rechargeability	These batteries support hundreds of charge cycles, leading to cost savings and waste reduction over time.
Low Maintenance	Unlike NiCd, NiMH batteries have no memory effect, so they don't require full discharge before recharging.

### Nickel-Metal Hydride (NiMH) Battery

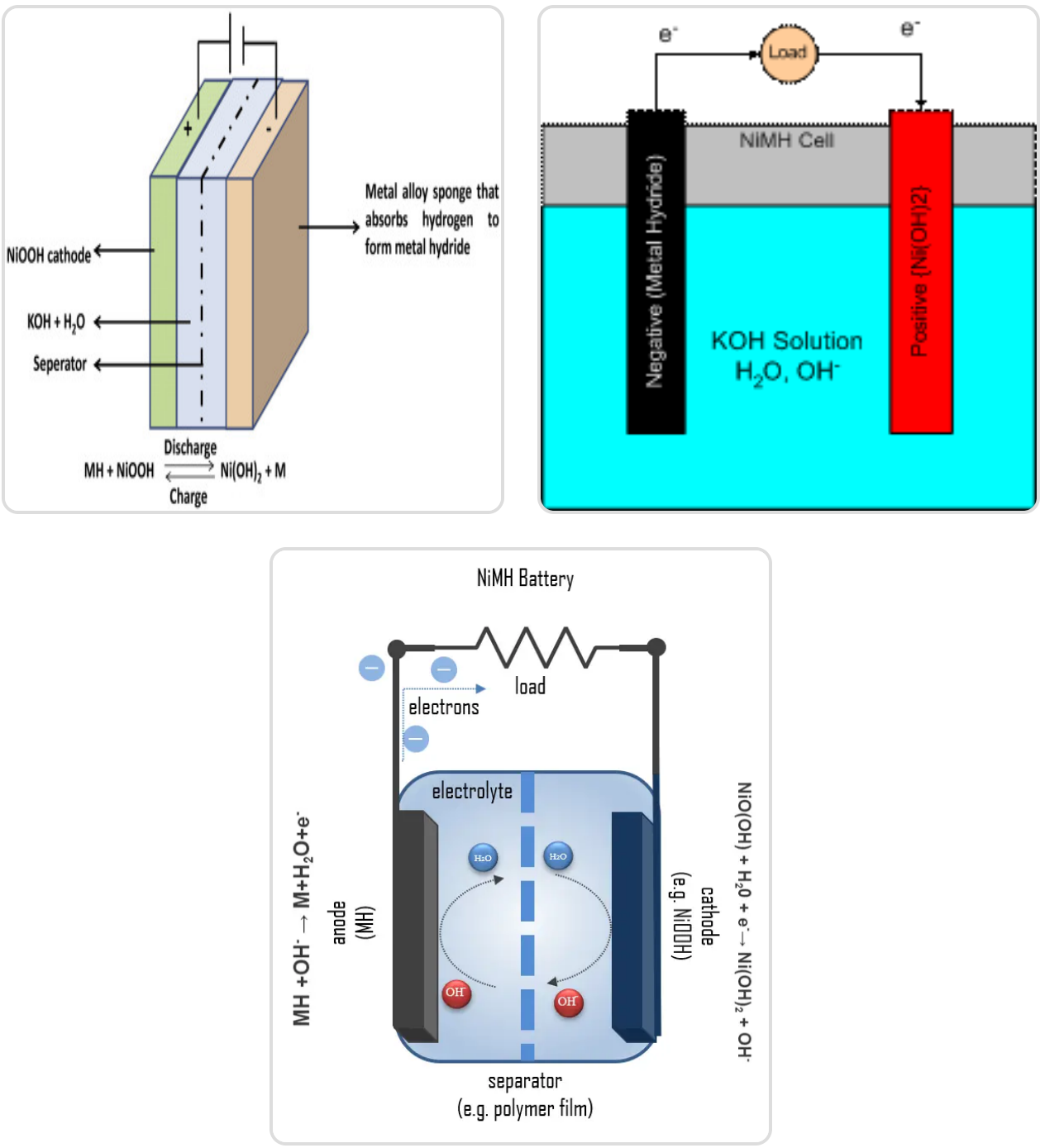
Section	Description
What is NiMH Cell?	A rechargeable cell using nickel and metal hydride compounds for electrodes, known for higher capacity and eco-friendliness.
Working Principle	The anode is made of hydrogen-absorbing alloy, while the cathode consists of nickel hydroxide, with reversible electrochemical reactions.
Advantages & Disadvantages	Higher voltage and capacity, slow discharge; prone to damage from overheating or short-circuiting.
Applications	Used in AA/AAA batteries, consumer electronics, hybrid vehicles, and formerly in electric cars like Toyota Prius.
Safety Concerns	Possible H2 gas buildup, heating hazards, and corrosive chemicals; must be leakproof and waterproof.
Recycling & Disposal	Contains recyclable metals, but REE components often go to waste. Disposal must be handled per regulatory norms.
Conclusion	Once popular, now replaced by Li-ion in many applications; ongoing research aims to improve lifespan and safety.

### Nickel-metal Hydride Battery vs Cell

Nickel-metal Hydride Cell	Nickel-metal Hydride Battery
A single electrochemical unit that converts chemical energy to electrical energy. It consists of one positive and one negative electrode with an electrolyte.	A combination of multiple NiMH cells connected in series or parallel to provide a higher voltage or capacity. Used in devices requiring more power than a single cell provides.
Typically provides a lower voltage, usually around 1.2V.	Voltage depends on the number of cells connected. For example, a NiMH battery with 4 cells provides approximately 4.8V.
Primarily used in lower-power applications or as individual cells in AA, AAA formats.	Commonly used in higher-power applications like electric vehicles, power tools, and electronics requiring larger energy capacity.

## Nickel-Metal Hydride Battery

Aspect	Details
Overview	NiMH is a rechargeable battery introduced in 1989 with higher energy capacity than NiCd batteries, widely used in hybrid vehicles and portable electronics.
Chemistry	Composed of a Ni(OH) <sub>2</sub> cathode, metal hydride anode, KOH electrolyte, and separator, using reversible redox reactions for charge and discharge.
Electrode Material	AB5 intermetallic alloy containing rare-earth and transition metals, optimized for enhanced hydride-forming properties.
Operating Voltage	Nominal cell voltage of 1.2-1.32V with a specific energy of approximately 80 Wh/kg.
Applications	Used in AA, AAA batteries, hybrid electric vehicles, digital cameras, remote controls, and consumer electronics.
Advantages	Higher energy density, no toxic cadmium, low memory effect, and suitable for high-drain applications.
Disadvantages	Sensitive to overcharging, overheating, and incorrect polarity; also susceptible to deep discharge and voltage depression.
Safety Concerns	Produces H <sub>2</sub> gas, which can lead to pressure buildup; requires leakproof casing and protection against high current.



### Other Types of Batteries

The following list summarizes notable electric battery types composed of one or more electrochemical cells. Four lists are provided in the table below: size and format, chemistry (primary and secondary cells), applications, and voltage.

### Why Are Alkaline Batteries (AAA or AA) Made to Be 1.5V While Rechargeables Are 1.2V?

In general, batteries convert stored chemical energy into electrical energy through an electrochemical process. This process provides a source of electromotive force, allowing currents to flow in electric and electronic circuits.

#### Primary vs Secondary Batteries

**Primary (single-use or alkaline) batteries** have cells that produce an open circuit voltage of 1.5V when fresh. **Secondary (rechargeable) batteries** like NiMH or NiCd have cells with an open circuit voltage of 1.2V.

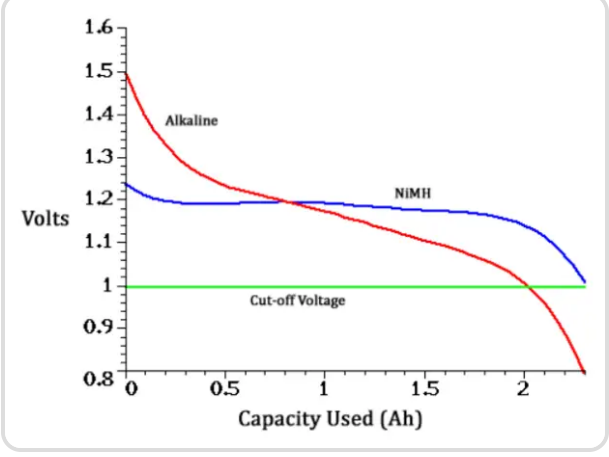
#### Performance in Devices

Alkaline and rechargeable batteries can be used interchangeably in most devices, despite their different voltages. The difference is due to their chemistry:

- Alkaline cells gradually drop from 1.5V to around 1.0V as they are used.
- Rechargeable cells maintain a steady 1.2V during discharge and drop sharply only when nearly empty.

#### Device Compatibility

Since many devices operate within a voltage range of 1.0 to 1.5 volts, both alkaline and rechargeable batteries can function similarly. However, **1.2V rechargeable batteries** tend to have a lower output impedance, providing a more consistent voltage, which may enhance performance over alkalines in certain cases.



Sizes	Chemistry	Application	Voltage
AA battery	<b>Primary Battery</b> Alkaline battery Lithium metal battery Zinc-carbon battery Zinc-chloride battery Silver-oxide battery Zinc-air battery	UPS Battery Electric car battery 12V car battery – SLI battery Motorcycle battery Marine battery Laptop battery Cell phone battery Flow battery	1.2V battery 3V battery 6V battery 9V battery 12V battery 24V battery
AAA battery	<b>Secondary Battery</b> Lithium-ion battery NiMH battery NiCd battery Lead-acid battery AGM battery Gel battery		
AAAA battery			
C battery			
D battery			
cr1220 battery			
cr1620 battery			
cr1632 battery			
cr2016 battery			
cr2032 battery			
cr2025 battery			
18650 battery			
21700 battery			

### Characteristics of Nickel Metal Hydride Batteries

NiMH batteries are widely used due to their unique characteristics. Here's a breakdown of their parameters, essential for determining their suitability for various applications.

Parameter	Description
Cell Voltage	The open circuit voltage for NiMH batteries is typically 1.2V, due to the potential difference between the electrodes.
Cut-off Voltage	Defines the minimum allowable voltage, typically 1.0V per cell for NiMH batteries, marking the "empty" state.
Capacity	The capacity, ranging from 2000 to 2700 mAh for AA-sized NiMH batteries, indicates the total charge it can hold.
C-rate of Battery	C-rate measures how fast a battery is discharged/charged relative to its capacity. High C-rate NiMH batteries can be charged at 1C within an hour.
Self-discharge	NiMH batteries have high self-discharge rates, losing about 20% in the first 24 hours and approximately 10% per month thereafter.
Degradation	Occurs with each charge-discharge cycle, typically resulting in 700-1000 life cycles due to electrolyte migration and material detachment.
Depth of Discharge (DOD)	Represents the percentage of energy withdrawn from the battery. For example, using 40% of a 100 Ah battery results in a 40% DOD.
Alkaline vs. Rechargeable Voltage	Alkaline batteries typically start at 1.5V and decrease over time, while NiMH rechargeable batteries maintain a consistent 1.2V until nearly depleted.

### Why Are Alkaline Batteries (AAA or AA) Made to Be 1.5V While Rechargeables Are 1.2V?

In general, batteries convert stored chemical energy into electrical energy through an electrochemical process. This process provides a source of electromotive force, allowing currents to flow in electric and electronic circuits.

#### Primary vs Secondary Batteries

**Primary (single-use or alkaline) batteries** have cells that produce an open circuit voltage of 1.5V when fresh. **Secondary (rechargeable) batteries** like NiMH or NiCd have cells with an open circuit voltage of 1.2V.

#### Performance in Devices

Alkaline and rechargeable batteries can be used interchangeably in most devices, despite their different voltages. The difference is due to their chemistry:

- Alkaline cells gradually drop from 1.5V to around 1.0V as they are used.
- Rechargeable cells maintain a steady 1.2V during discharge and drop sharply only when nearly empty.

#### Device Compatibility

Since many devices operate within a voltage range of 1.0 to 1.5 volts, both alkaline and rechargeable batteries can function similarly. However, **1.2V rechargeable batteries** tend to have a lower output impedance, providing a more consistent voltage, which may enhance performance over alkalines in certain cases.