Lithium Batteries the different models with pros and cons of each

Overview

At DDB Unlimited we manufacture and design a complete line of battery enclosures for use in almost all areas of battery management from telecommunications, solar and green energy battery storage projects. Our sales and engineering staff are always being asked questions on Lithium battery technology and what is the best battery to use. This paper was written to inform you of the technology of Lithium batteries and the pros and cons of each type.

The Basics

A battery is made up of an anode, cathode, separator, electrolyte, and two current collectors (positive and negative). The anode and cathode store the lithium. The electrolyte carries positively charged lithium ions from the anode to the cathode and vice versa through the separator. The movement of the lithium ions creates free electrons in the anode which creates a charge at the positive current collector. The electrical current then flows from the current collector through a device being powered (cell phone, computer, etc.) to the negative current collector. The separator blocks the flow of electrons inside the battery.

Charge/Discharge

While the battery is discharging and providing an electric current, the anode releases lithium ions to the cathode, generating a flow of electrons from one side to the other. When plugging in the device, the opposite happens: Lithium ions are released by the cathode and received by the anode. Lithium-ion uses a cathode (positive electrode), an anode (negative electrode) and electrolyte as conductor. (The anode of a discharging battery is negative and the cathode positive. The cathode is metal oxide, and the anode consists of porous carbon. During discharge, the ions flow from the anode to the cathode through the electrolyte and separator; charge reverses the direction, and the ions flow from the cathode to the anode.

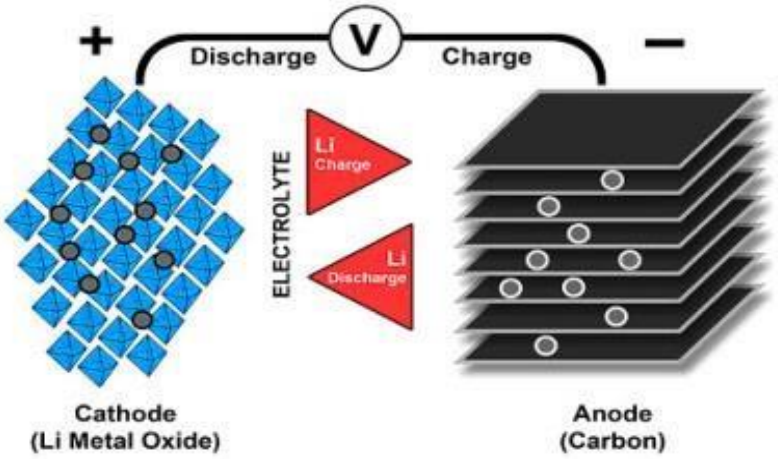

Figure 1 illustrates the process.

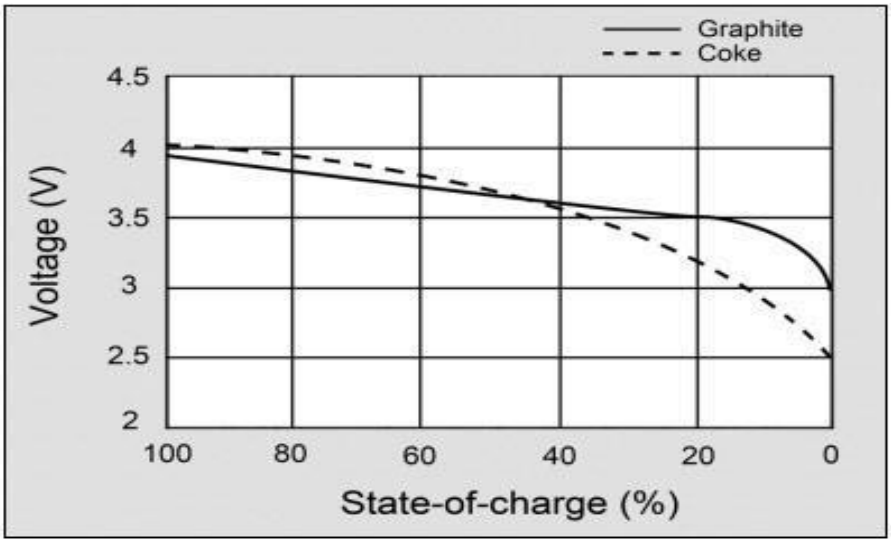

Figure 2 illustrates the voltage discharge curve of a modern Li-ion with graphite anode and the early coke version.

Energy Density VS. Power Density

The two most common concepts associated with batteries are energy density and power density. Energy density is measured in watt-hours per kilogram (Wh/kg) and is the amount of energy the battery can store with respect to its mass. Power density is measured in watts per kilogram (W/kg) and is the amount of power that can be generated by the battery with respect to its mass. To draw a clearer picture, think of draining a pool. Energy density is similar to the size of the pool, while power density is comparable to draining the pool as quickly as possible.

Lithium polymer and lithium cobalt oxide (LiCoO2)

It is one of the rechargeable battery types used in home electronics. • In Lithium-Ion battery, lithium ions move from negative electrode towards positive ones during discharge phase and back during charging phase. • The battery uses intercalated lithium compound as one of the electrode materials.

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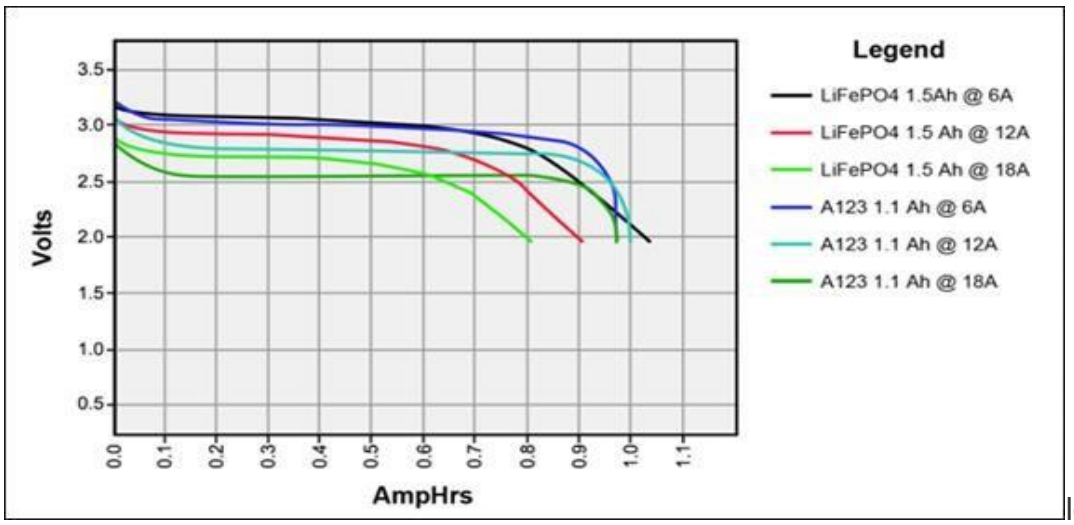
- It is one of the rechargeable battery types used in home electronics.
- In Lithium-Ion battery, lithium ions move from negative electrode towards positive ones during discharge phase and back during charging phase.
- The battery uses intercalated lithium compound as one of the electrode materials.
- The battery cell houses electrolyte and two electrodes. The electrolyte allows ionic movement.
- They have silent features such as higher energy density, lower self-discharge, and tiny memory effect. **LiFePO4 – Safe Lithium-ion Battery Type**

Following are the features of LiFePO4 battery. • The term LiFePO4 stands for lithium-ion phosphate. • It is one type of rechargeable battery also known as LFP battery. • It uses LiFePO4 as cathode and graphite carbon electrode with metallic grid as anode. The discharge voltage curves of Li-manganese, Li-phosphate and NMC are very flat, and 80 percent of the stored energy remains in the flat voltage profile. While this characteristic is desirable as an energy source, it presents a challenge for voltage-based fuel gauging as it only indicates full charge and charge; the important middle section cannot be estimated accurately Figure 1 reveals the flat voltage profile of Li-phosphate (LiFePO) batteries.



low

Figure 1: Discharge voltage of lithium iron phosphate.

Following are the features of LiFePO4 battery.

- The term LiFePO4 stands for lithium-ion phosphate.
- It is one type of rechargeable battery also known as LFP battery.
- It uses LiFePO4 as cathode and graphite carbon electrode with metallic grid as anode.
- It is used in vehicles, security lighting systems and as backup power due to lower cost, lower toxicity, long term stability and better performance.
- Cell voltage during operation is between 3 to 3.3 V.
- It offers volumetric energy density of about 220 Wh/dm^3.
- It offers more than 10 years and cycle durability of about 2000 cycles.

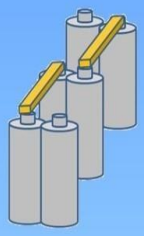
Advantages - Disadvantages

Features	LiFePO4 battery	Li-Ion battery
Energy density in Wh/Kg	90 to 120	150 to 180
V(nom)/cell	3.2 V	3.6 V
V(charging)	3.5 to 3.65 V	3.9 to 4.2 V
Area	Medium	Lower
Price	Medium	Higher
Advantages	• High Current rating • Good thermal stability • Safer compare to Li-Ion battery • Tolerant to full charge conditions	• High energy density • Long lifetime • Offers high voltage per cell of about 3.6 V and hence can be used for space savings requirements.
Disadvantages	• Offers Lower voltage per cell of about 3.2 V • High self-discharge which can cause balancing issues with aging	• It is fragile and hence requires protection for circuits. • Peak voltage is limited during charging. • It requires monitoring of temperature. • It is expensive

5 Types of Lithium–Ion Batteries

Lithium-Cobalt Oxide Battery

- Used mostly in handheld electronics (Cell phones, Laptops and Cameras)
- Risky specially when damaged
- Cobalt is scarce and expensive
- Low discharge rates
- Highest energy density (110-190) Wh/kg



Lithium-Iron Phosphate Battery

- Dramatically reduces the risks of overheating and fire.
- Offers much less volumetric capacity
- Used in power tools and medical equipment
- Longer-life and inherently safe
- Lower Energy Density (95-140) Wh/kg

Lithium-Nickel Manganese Cobalt Oxide Battery

- Longer life and inherent safety
- Cobalt is scarce and expensive
- Less prone to heating
- Used in Power tools, e-bikes and electric power trains
- Lower energy density (95-130) Wh/kg

Lithium-Titanate Battery

- Can operate at very low temp (-40°C)
- Rapid charge and discharge
- Used in Mitsubishi i-MiEV
- Lower inherent voltage 2.4 V (compared to 3.7 V)
- Lower energy density (30-110) Wh/kg

Lithium-Manganese Oxide Battery

- Lower cost
- Longer life and inherently safe
- Used in Hybrid Vehicles, Cell phones, Laptops
- High discharge rates
- Lower energy density (110-120) Wh/kg