

Summary of the Development Status of New Energy Vehicle Batteries

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Abstract

The global energy crisis is becoming more serious, and how to explore renewable resources and make efficient use of waste heat energy has become a hot topic. The rapid development of electric vehicles has reduced environmental pollution and energy waste to some extent, which is consistent with China's double-carbon goal. Nowadays, new energy vehicles are undergoing rapid development, and battery technology is a critical technical issue for the popularisation and development of new energy vehicles. This paper analyses and summarises the characteristics of various battery types used in the development of new energy vehicles, such as lead-acid batteries, nickel-hydrogen batteries, lithium-ion batteries, sodium-ion batteries, and so on, by reading and sorting through relevant literature.

Keywords

Automobile Battery; LFP Battery; Ternary Lithium Battery.

1. Introduction

The use of new energy vehicles has been internationally recognised as a more environmentally friendly mode of transportation. Its widespread use has avoided the exhaust emissions of traditional cars powered by oil, effectively reduced pollution to the atmosphere, and has obvious advantages for the long-term development of the environment. At the moment, new energy vehicle battery technology is an important barrier to overcome in the development and popularisation of new energy vehicles.

The first electric vehicle appeared in the mid-nineteenth century, but it received little attention due to its immature technology. The true development period occurred at the end of the twentieth century. The use of lead batteries greatly improved the performance of electric vehicles, but it was never put into production. Electric vehicles were popularised and had a market share until the discovery of Ni-MH batteries in the early twentieth century. The use of lithium-ion batteries significantly improved the performance of new energy vehicles by 2006. Following that, various lithium-ion batteries, such as the most popular ternary lithium batteries and lithium iron phosphate batteries, were continuously developed in response to people's demands for battery capacity and environmental protection. However, lithium-ion batteries are relatively expensive. With the increasing demand for new energy vehicles, a low-cost battery is desperately needed to meet the demand, and Na ion batteries were created to meet that demand. I believe that as science and technology advance, Na ion batteries will gain a significant market share.

The use of batteries in automobiles reduces people's use of fossil energy and the environmental damage caused by automobile operation, which is consistent with our country's current development concept. In the history of electric vehicles, there have been many different types of batteries. This paper primarily introduces three types of batteries that will be important in

the development of electric vehicles in the future: lead-acid batteries, nickel-hydrogen batteries, lithium-ion batteries, and sodium-ion batteries.

2. Lead-acid Battery

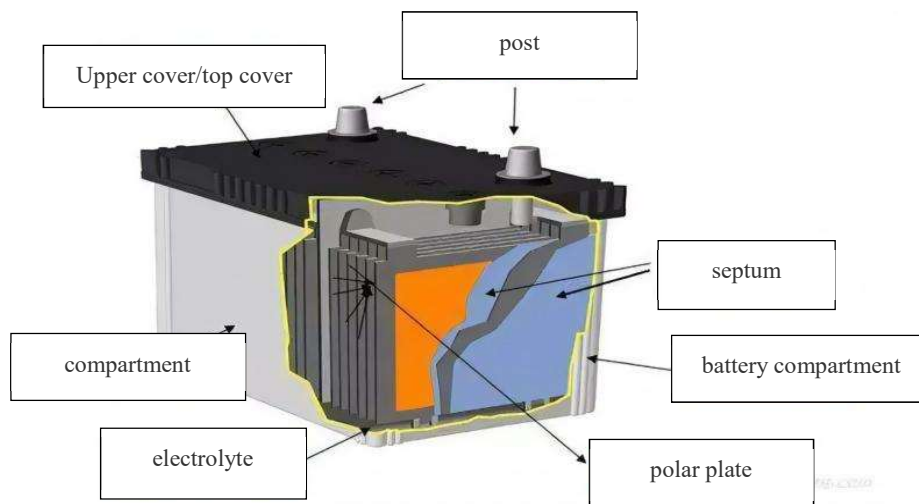


Figure 1. Lead-acid battery

The lead-acid battery, which is primarily composed of lead oxide, sponge lead, and sulfuric acid aqueous solution, first appeared in 1859. The basic components of a lead-acid battery are shown in Figure 1. Lead-acid batteries are widely used in everyday life and are indispensable in traditional automobiles. Furthermore, due to their relatively simple production technology and lower capital investment, lead-acid batteries have a competitive advantage in the market and are widely used in sightseeing buses, short-distance buses and other modes of transportation. However, the lead-acid battery has some drawbacks. The lead-acid battery will be damaged during charging and discharging due to its structure and material properties. Furthermore, the molar mass of lead is large, and the energy density of lead-acid storage batteries is low, and their service life is short, causing users unnecessary trouble and wasting money. As a result, as science and technology advance, more and more high-performance batteries enter the market, limiting the application scope of lead-acid storage batteries.

3. Ni-MH Battery

In comparison to other batteries, the Ni-MH battery has distinct advantages in its use. It has a long life and does not emit any harmful substances to the environment while in operation. When compared to lithium-ion batteries, Ni-MH batteries use hydrogen storage alloys such as vanadium and nickel as cathode and nickel hydroxide as anode, which has much better performance than lead-acid batteries and can provide stable and reliable electric energy for electric vehicles. Ni-MH batteries, like other batteries, have drawbacks. Their energy density is low, and they have a memory effect, so they do not have a large market in the field of pure electric vehicles. However, due to its economic and environmental benefits, it has been used in the field of hybrid vehicles with low battery performance requirements [1]. It is also critical to the operation of deep space detectors and power grids.

In response to the shortcomings of the Ni-MH battery, Zhang Xiaoyang improved its high-temperature performance by adding Y₂O₃ to the positive electrode [2], Gong Liping and others successfully developed a Ni-MH battery with good high-temperature performance by improving the negative electrode material [3], and Yang Ting added NaOH to the electrolyte to improve the discharge efficiency of the Ni-MH battery at high temperature [4].

4. Lithium Ion Battery

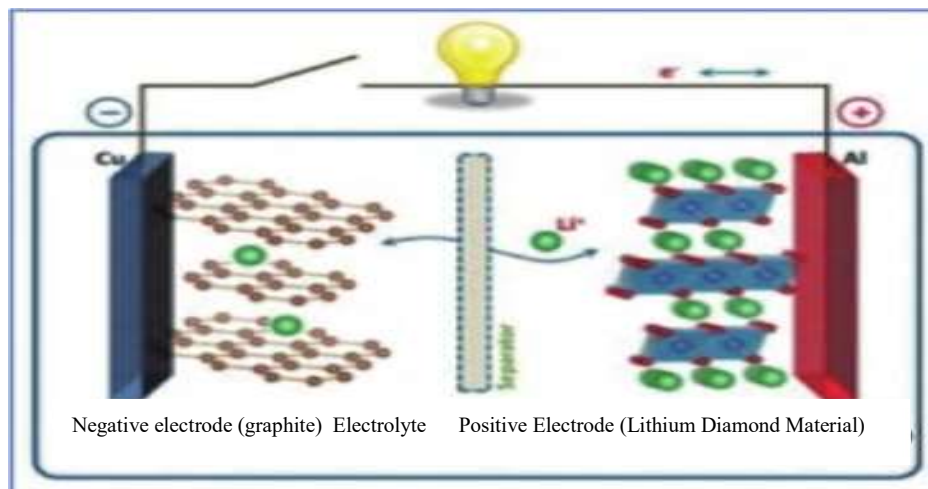


Figure 2. Working principle diagram of lithium ion battery

Lithium-ion batteries use transition metal oxide as the cathode, graphite as the anode, and lithium salt as the electrolyte, and are not only small in size but also structurally stable. The principle of operation of a lithium-ion battery is shown in Figure 2. In comparison to Ni-MH batteries, Li-ion batteries have a smaller volume, a longer life, and no memory effect. Likewise, lithium-ion batteries have flaws such as high cost and poor safety performance.

At the moment, the best type of battery is a lithium-ion battery. Due to the shortcomings of lithium-ion batteries, researchers primarily improve their capacity and safety by adding other metal ions to the cathode. Nowadays, the most widely used lithium iron phosphate battery and ternary lithium battery are examples of successful lithium-ion battery optimisation.

4.1. Ternary Lithium Battery

Nickel, cobalt, and manganese are ternary elements in ternary lithium batteries that play a special role in the cathode material army of ternary lithium batteries. Nickel is a type of metal with high activity, and its main function is to improve the energy density of the battery; however, too much content will result in a mixed discharge of nickel ions and lithium ions, and the battery capacity will decrease. Cobalt is an active metal that primarily inhibits the mixed discharge of nickel ions and lithium ions in batteries. Manganese ion is a type of weakly active ion that contributes to the battery's stability and safety. At the same time, manganese ion is inexpensive and simple to obtain, which can significantly reduce the cost of the battery. The three components are mixed in a specific proportion at the battery's positive electrode, resulting in an excellent power performance for the ternary lithium battery.

However, ternary lithium batteries have obvious flaws: their battery voltage is significantly reduced in low temperature environments, and their discharge time is significantly reduced as environmental temperature decreases [5]. It will also decompose at high temperatures of 250-300°C, and the reaction of ternary lithium battery is extremely strong. When oxygen molecules are released, they can easily explode in a high-temperature working environment. Furthermore, the safety performance is poor, and it is easy to cause a battery short circuit and spontaneous combustion if the vehicle is bumped while driving. The most obvious flaws of ternary lithium batteries are their lack of safety and their sensitivity to environmental temperature.

Although ternary lithium batteries have excellent power performance, their shortcomings are obvious, and there is currently no good solution. Every year, there are incidents of spontaneous combustion in electric vehicles powered by ternary lithium batteries. Relevant researchers are still in the research and development stage for ternary lithium battery optimisation. Huang Lili

and colleagues conducted experiments on various battery separators under conditions of short circuit abuse and battery heating [6]. When the thickness of the film determines the thermal stability of the separator, the mechanical strength of the film and the energy density of the battery are heavily influenced by the melting point of the film substrate. As a result, in a specific temperature range, the microporous polymer diaphragm can use its heat sealing performance to seal the pores before melting, improving internal resistance and preventing corrosion. Prevent the entry of lithium ions and electrons into the battery, thereby preventing the electrochemical reaction and delaying the internal short circuit.

4.2. Lithium Iron Phosphate Battery

The anode material in a lithium iron phosphate battery is ferrous lithium phosphate, and the cathode material is graphite. When compared to ternary lithium batteries, lithium iron phosphate batteries have a longer service life, with a cycle life of more than 3,000 times and a lifespan of seven to eight years. In high temperature working environments, lithium iron phosphate batteries are safer than ternary lithium batteries. Because the cathode material of ferrous lithium phosphate does not involve precious metals in the acquisition of raw materials, and the cobalt element of ternary lithium battery greatly increases its cathode cost, the cathode cost of lithium iron phosphate battery is one-third that of ternary lithium battery.

The lithium iron phosphate battery, on the other hand, is not without flaws. For various reasons, the uniformity of a single lithium iron phosphate battery is poor, and after many charging and discharging cycles, its non-uniformity is easily expanded, resulting in power performance fluctuations when the batteries are connected in series. At the same time, because the lithium iron phosphate battery has better stability than the ternary lithium battery, its power performance at low temperatures is greatly reduced, resulting in slightly lower power performance than the ternary lithium battery. Nonetheless, the power performance of a lithium iron phosphate battery is far superior.

Short-circuit deflagration is also a risk with lithium iron phosphate batteries. According to the data, there is no discernible difference between the number of ternary lithium batteries and lithium iron phosphate batteries in electric vehicles with spontaneous combustion each year, indicating that lithium iron phosphate batteries continue to have safety issues. Concerning battery safety, BYD has developed a lithium iron phosphate battery with blades and introduced a more reasonable battery carrying technology [7], which has significantly reduced the volume of electric vehicles, causing the battery capacity of the blade battery to differ from the traditional battery, but the vehicle's cruising range has not changed significantly. Furthermore, the flawless performance in the acupuncture experiment has rendered many traditional batteries obsolete [8], and the use of lithium iron phosphate batteries with blades has significantly increased the safety of electric vehicles. It even collaborated with its rival Tesla and became a supplier of Tesla blade batteries [9,10].

5. Sodium Ion Battery

The high cost of lithium-ion batteries makes meeting the demand for new energy vehicles in the future society difficult. People only recently discovered sodium-ion batteries. Sodium-ion batteries have a lower cost and excellent charging and discharging performance in high and low temperature environments when compared to other types of batteries. The principle of operation of a sodium-ion battery is shown in Figure 3. Furthermore, because sodium-ion batteries use non-toxic and harmless aqueous solutions as electrolytes, there is no risk of spontaneous combustion, and their safety performance is superior. It is an excellent battery for electric vehicles. But, at the same time, it has some flaws. When compared to the popular lithium-ion battery at this stage, it has a lower energy density, a larger battery designed for practical application, and a slightly shorter battery life. The cycle life of sodium-ion batteries is

clearly inferior to that of lithium-ion batteries. As a result, the application of sodium ion batteries is currently very limited, and it now has a remarkable effect in the application of mini-cars with small overall mass and single mileage [11].

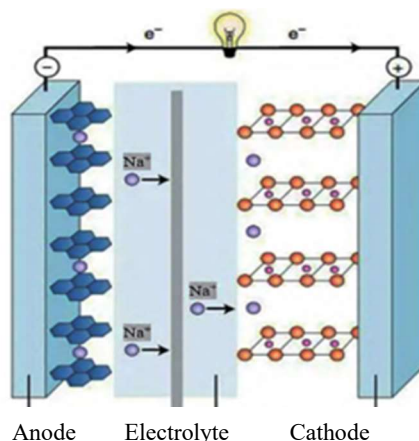


Figure 3. Working principle diagram of sodium ion battery

6. Conclusion and Prospect

6.1. Conclusion

The promotion and development of electric vehicles is a general trend of social development under the goal of achieving double carbon, as well as an inherent requirement of the automobile industry to pursue its own development. As a result, it is necessary to research it. This paper examines four significant battery types in the history of electric vehicles, as well as two popular lithium-ion batteries.

Lead-acid battery: the battery developed in the earliest period of electric vehicles has low energy density and low cost. At present, it has been gradually eliminated in the electric vehicle market.

Ni-MH battery: It is improved on the basis of Ni-Cd battery, which has no harm to the environment during operation, and basically does not need maintenance during operation. The battery has a long service life and can work under high and low temperature conditions. Although it is not widely used in pure electric vehicles because its power performance is different from that of ternary lithium batteries. However, it still plays an important role in power grid work, aerospace and hybrid vehicles.

Lithium-ion battery: the most popular battery type at present, represented by ternary lithium battery and lithium iron phosphate battery.

Ternary lithium battery: high energy density, good charge and discharge performance, and the battery has no memory effect, which is very suitable for the current cruising range requirements of electric vehicles. However, its cycle life is generally short and its safety needs to be strengthened, so it is one of the mainstream batteries at present.

Lithium iron phosphate battery: The cost of lithium iron phosphate battery is obviously lower than that of ternary lithium battery, and its cycle life is generally longer than that of ternary lithium battery, but its power performance is different from that of ternary lithium battery. It has always been a state of chasing after each other in the market, but with the introduction of BYD blade lithium iron phosphate battery, the battery safety problem has been completely solved, and it is believed that lithium iron phosphate battery will have a better development.

Sodium ion battery: It is a newly emerging battery for electric vehicles with good development prospects. Its raw materials are cheap and easy to get, and its safety is good. Although its power

performance is not as good as that of lithium-ion battery, its application scope is still limited, but it is believed that with the development of technology, sodium-ion battery will become one of the mainstream batteries in the future.

6.2. Outlook

Li-ion batteries are currently the only ones in the field of electric vehicle batteries due to their excellent power performance and safety technology such as "blade batteries," but their cost problem and the exploitation of metallic lithium are difficult to solve. At this time, sodium ion batteries were invented, and metal sodium is very easy to obtain, effectively lowering the cost, and there is no hard problem of resource scarcity. It is expected that as science and technology advance and sodium ion battery technology improves, sodium ion batteries will eventually replace lithium ion batteries and become the norm.

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