

MODERN ANALOGS OF LITHIUM-ION BATTERIES

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Modern technology is completely dependent on electricity and its operation is based on a binary system: the presence of a signal is indicated as 1, its absence as 0. To generate a signal, energy is required, which means reliable and efficient power supplies are needed. These power sources must be compact enough to allow for device mobility, yet have a high capacity for long-term charge storage. Improving these power sources is a key factor in the development of technology, as their efficiency determines the performance, autonomy and functionality of modern devices.

The history of lithium-ion batteries goes back about 20 years, back in the 1970s there were prototypes of such power sources, but these batteries had low voltages and high fire hazards. Over the next 10 years the cathode was modified and it was not until 1991 that the first commercial battery was developed. It could withstand more than 1000 discharge cycles and had a higher capacity than its predecessor, the nickel-cadmium battery. This was the main reason for its prevalence. Nowadays, man cannot live without information, which makes small but power-hungry sources essential in everyday life. They are used almost everywhere from small gadgets to electric cars and electric airplanes.

Current problems with lithium-ion batteries include environmental problems associated with lithium mining. The main environmental issue remains water consumption. Lithium mining requires a significant amount of water, which can deplete water reservoirs and lower groundwater levels. Also, the process of extracting lithium from salt marshes involves evaporation of water, which also reduces water supplies. In addition, the lithium mining process releases a large number of harmful substances (acid mist and fluorinated gas) into the environment. And the products resulting from lithium processing can contain hazardous compounds that, if not disposed of properly, can contaminate soil and water

bodies. Climate change associated with greenhouse gas emissions is also an issue. While lithium-ion batteries can reduce CO₂ emissions during use, the extraction process involves energy use, which can translate into significant greenhouse gas emissions, especially if the energy sources are not renewable. When lithium-ion batteries reach the end of their useful life, they should be properly disposed of or recycled. However, in many countries there are no specialized collection points for battery recycling, so most people throw them in the regular waste. Lithium-ion batteries are composed of different materials (lithium, cobalt, nickel, manganese, etc.) that require complex processes to separate and recycle and extraction from the cell requires specialized technologies. If lithium-ion batteries are not disposed of properly, this can lead to the release of toxic substances (e.g., lithium or cobalt) into soil and water bodies.

Lithium-ion battery analogs are just beginning to enter the market due to the fact that the problems of today's lithium-ion batteries are minor compared to the benefits they provide. However, this does not mean that research into more affordable and environmentally friendly charge carriers is not being conducted. On the contrary, sodium-ion, potassium-ion, as well as silicon and magnesium batteries are already being used in some devices. The most common of them are sodium-ion batteries, although they operate at lower voltages 2.5 V (it is 1.5 times less than lithium-ion), but because of this they are more stable. And the cost of raw materials for them is 20-30 times less than the cost of raw materials for lithium batteries. Nevertheless, current research is aimed at increasing the energy density and competitiveness of sodium-ion batteries. Unlike their sodium counterparts, potassium-ion batteries can maintain almost the same charge density as lithium batteries. However, due to the large size of potassium ions, they have problems with high numbers of charge-discharge cycles that cause electrode degradation, thus reducing their lifetime. Also, a problem is the lack of similar processing infrastructure and integration into batteries. This makes the development of potassium-ion batteries more challenging. Magnesium analogs at this stage have a lower voltage, but an electrolyte capable of working at voltages up to 3 V has already been developed, and all the efforts are aimed at developing a cathode capable of matching this battery. Silicon batteries are already on the market, but it is worth knowing that this is a variation of the same lithium-ion batteries, but the cathode uses a nanostructured sili-

con-carbon composite material instead of graphite. This allows the batteries to heat up less and operate at sub-zero temperatures.

Since lithium is limited in quantity, scientists are looking for potential substitutes to be used in batteries, trying not to lose the main characteristics of lithium-ion batteries, namely high energy efficiency and durability. Potential substitutes for lithium-ion batteries in the future could be aluminum-ion batteries. Their advantage is that they can offer higher energy density and heat resistance. These batteries can be more environmentally friendly in the disposal process, as aluminum can be recycled and its reserves are not depleted as quickly as lithium. Another substitute for lithium-ion batteries could be solid-state batteries. They are a new category of battery technology that uses solid electrolytes instead of the liquid or semi-solid electrolytes used in traditional lithium-ion batteries. This improves the safety, performance and durability of batteries. Proton and topological batteries represent promising technologies in energy storage and conversion. Each has unique advantages (high conductivity, environmental resistance) and disadvantages (difficulty in manufacturing), and both areas continue to be actively developed. Recently, scientists from the UK have created a battery based on synthetic diamond, its peculiarity is the ability to capture electrons generated during the decay of carbon-14. Their velocity, obtained after decay, is converted into electric current. Humans are protected from the radiation generated during the decay process by diamond's non-radioactive walls. Since the decay of diamond takes thousands of years, this battery can be considered almost eternal.

As a result, lithium, though reluctantly, is giving way to new energy sources that can make the energy industry cheaper and more environmentally friendly. The main problem that scientists are dealing with is the multi-charge nature of analogs, as most of them degrade with a large number of charge-discharge cycles. Research in this area opens the way to more stable and durable solutions capable of replacing lithium in key areas.

References

1. Садовников, А. В. Литий-ионные аккумуляторы / А.В. Садовников, В.В. Макаrchук // Молодой ученый. – 2016. – № 23 (127). – С. 84-89. – URL: <https://moluch.ru/archive/127/35051/> (date of access: 30.03.25).