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M. Li*, A. Kanazhanov, K. Shalbayev
Satbayev University, Almaty, Kazakhstan
*e-mail: marialeed.0204@gmail.com

RECHARGEABLE BATTERIES. SOLID STATE ELECTRIC VEHICLE BATTERIES

Abstract. Most electric vehicles have a range of less than 300 miles, take more than an hour to recharge the battery, lose almost one-third of their cell capacity over 10 years, and pose a serious safety risk when handling flammable materials, resulting in an explosion. This article discusses the various types of electric car batteries, their operation, advantages and disadvantages. Solid-state batteries – the battery technology of the future, one of the most active areas of research of secondary batteries. The scientific community believes that lithium-ion batteries have reached their limit, solid-state batteries in recent years are seen as batteries that can inherit the state of lithium-ion batteries. The article presents the trend of introduction and widespread use of solid-state batteries in modern electric vehicles.

Keywords: battery, ecology, solid-state battery, li-ion battery.

Introduction. Electric vehicles appeared long before the introducing the first fuel engine, although they have recently become most popular. Currently, this type of vehicles is most widespread, though not everyone can afford it. Electric cars are not so common in Kazakhstan, but electric buses may already be found on the routes.

The wide demand is connected both with oil prices, and with maintaining the environment. It is a well-known fact that an electric vehicle is considered an environmentally-friendly transport that does not emit exhaust gases into the air. In addition, in the event of an RTA, an electric vehicle is more reliable than a car equipped with an ICE. Despite the fact that it has already been proven that electric vehicles also ignite, this happens once in a lifetime. Batteries were the source of ignition, mainly due to an accident, mechanical damage and a short circuit while recharging. Tesla developers are constantly upgrading the cars and perform gap analysis to improve and strengthen the battery compartment with new materials (aluminum and titanium).

At the moment the solid-state lithium batteries have already been invented, which do not contain liquids and are able to withstand high temperatures. Therefore it allows to minimize the risk of ignition.

ACC or accumulator storage battery is a direct current source. It usually consists of several rechargeable batteries and is intended for accumulation, storage and consumption of energy. Due to the reversibility of chemical procedures, namely the conversion of chemical energy into electrical one, the battery can be repeatedly charged and discharged.

The history of its creation originates in Italy, when Alessandro Volta experimentally created the first direct current source, later called the "Voltaic Pile". It was an incredible discovery when Volta has found that by lowering two metal plates made of copper and zinc into a container filled with acid, and by connecting them with a wire, a current could flow through the latter.

Rechargeable batteries find use in many industries. One can hardly imagine the modern world without the use of batteries. They are used in household appliances, motor cars and also serve as backup power sources.

General. ACC specification and its scope of application depend on both the electrode material and the electrolyte composition. There are more than 20 types of batteries, but the most common are the following: lead-acid, nickel-cadmium, nickel-salt, li-ion, nickel-metal-hydride, nickel-hydrogen, iron-nickel and silver-cadmium.

Each battery is optimized for various conditions and is intended to transfer a certain specific energy. Due to the use of various chemical elements for electrodes and electrolytes,

scientists are able to achieve the required specification of the battery for a particular scope of application.

A lead-acid battery is considered the most frequently used of all the above-mentioned. It has been invented away back in the 19th century by Gaston Plante. The name provides that the battery consists of lead and acid. It is tightly packed with lead and lead-oxide plates, which makes it heavier than other types of batteries. Unless a lead plate and a lead-oxide plate is put in sulfuric acid and connected to a light bulb using wires, the LED lights up when closing the circuit. The current flows from the lead-oxide cathode to the anode lead. The lead generates electrones which are then accepted by the lead oxide. This exchange procedure turns both plates into solid lead sulfate.

Commonly the battery either has a high energy density or power. The difference is that a battery with a high energy density may store a large amount of energy and lose it gradually. A high-power battery is designed to lose energy in a large amount quickly and immediately, for instance, to start a motor car.

However, a lead-acid battery is not very reliable to be used as a motor car battery. Unless the battery is fully discharged several times, it may be possibly destroyed. This is due to the baking by lead sulfate of the space between the plates inside the battery. This proves that the appropriate types of batteries are used depending on the application.

Thus, an electric vehicle should use li-ion batteries, since they have best performance. The li-ion battery has been invented away back in 1980. The design includes four elements, such as positively and negatively charged electrodes, a separator and a liquid electrolyte.

Battery specifications may be improved by the nano-structured materials: the cathode material is lithium-iron-phosphate. Its particles are small-sized, and permeated with channels of less than one nanometer, which allows to increase the rate of filling the material with lithium ions; the anode material is graphite with a layered structure, the lithium ions freely penetrate whereinto. Therefore the recharging time of the motor car is reduced.

Nevertheless, li-ion batteries are gradually taking a back seat, since the above-mentioned solid-state batteries have come to replace them. The battery creation has become a breakthrough in the field of batteries for electric vehicles.

The beginning was launched by the invention of Michael Zimmerman, working in the field of solid-state batteries. His invention allowed to increase the capacity of batteries, as well as make them safe and cobalt-free, despite the fact that the lack of the latter has logically made the battery explosive.

It was required to get rid of the liquid electrolyte. But before Zimmerman's invention noone could have successfully introduce a solid electrolyte for many years. Zimmerman has created a polyphenyl sulfide-based polymer fire-resistant material, which may carry electrons at a room temperature. The material itself may be machined, further it is strong enough and is able to withstand the effects of many chemicals.

The technology of solid-state lithium batteries uses a combination of lithium and sodium glass as a conductive material to replace the electrolyte of previous lithium batteries and significantly increase the energy density of lithium batteries, which is twice as large as that of li-ion batteries.

By 2030 the electric vehicles shall be mostly oriented towards the solid-state batteries, and li-ion batteries seize to be the main batteries for electric vehicles, despite the use in some electronic items.

When compared to standard li-ion batteries, the solid-state ones have the following four main advantages:

The first advantage is that it is light-weight. Following the use of the entire solid electrolyte, the corresponding li-ion battery material system is also changed. The fact is that there is no need to use a negative graphite electrode with intercalated lithium, but metal lithium

may be directly used as a negative electrode to significantly reduce the negative electrode material, and the amount of energy may significantly increase the electrode specific energy

The second advantage is that it is thin. Common li-ion batteries require separators and electrolytes, which make up almost 40% of the battery and 25% of its mass. Unless the solid electrolytes are replaced (mainly organic and inorganic ceramic materials), the distance between the anode and the cathode (filled with a diaphragm electrolyte by standard) may be reduced to 12 micrometers by any number of times, which shall significantly reduce the battery thickness.

The third advantage is that it has a flexibility prospect. Even fragile ceramic materials may be bent unless their thickness is only a millimeter or less, thus the material can become flexible. It significantly increases the flexibility of all solid-state batteries after they become thinner and lighter. Manufactured batteries may withstand hundreds to thousands of times of bending to ensure performance when proper packing procedure (not in a solid shell). There is no fading by default.

The fourth advantage is that is has a high-safety rate. Common lithium batteries may pose the following risks:

1) High currents may break through the diaphragm and cause a short circuit.

2) The electrolyte is the organic liquid, thus the oxidation and the scales formation occur at high temperature. The tendency to gas and combustion shall increase.

Any solid-state battery technology may directly solve the two above-mentioned issues.

However, the solid-state batteries still have to solve issues such as electrical conductivity, safety, stability and high cost.

In 2020 Tesla has produced a Quantum Scape solid-state battery with a huge capacity and charging speed. A solid-state battery is the very thing: a tightly compressed arrangement of solid materials, rather than the soft consistency which makes up a typical li-ion battery. Both the solid-state composition and the design present an electrochemical device that promise incredible results. There is little information about the material used, but one may suggest that it is made on a ceramic basis and uses four precursors.

The company also claims that the developers have eliminated all the issues related to the solid-state batteries. The cycle life was the one of such issues. Now the batteries retain more than 80% of their capacity after 800 cycles (386 thousand km).

Indeed, the result Tesla presented may be rightfully considered a large breakthrough in the field of batteries.

But not only Tesla has been working on the creation of solid-state batteries with high capacity and performance. In the spring of 2020, Samsung has presented its solid-state battery prototype.

Scientists have been working on the issues such as the cycle life and safety of the battery. They offered using a composite layer of silver and carbon for the anode. This allowed to increase the capacity, cycle life and overall safety of the solid-state battery prototype. The prototype has also proved to be 50% smaller than a li-ion battery in terms of dimensions.

This battery shall allow electric vehicles to drive up to 800 km without recharging, and the battery shall have more than 1000 cycles (charging/discharging).

Conclusion. The operation mode of a solid-state battery is the same as that of a li-ion battery, but a solid-state battery may be rightfully considered a new generation battery which replaces a liquid electrolyte with a solid one. It has a high resistance, therefore it shall never ignite or explode even in the event of a puncture. Experts report that the development of next-generation batteries, including fully solid-state ones, shall help to pave the way for the future market. Japan has formed a large-scale public-private consortium centered at Toyota and has initiated its commercializing for electric vehicle batteries.

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М. Ли*, А. Канажанов, К. Шалбаев
Satbayev University, Алматы, Қазақстан
*e-mail: marialeed.0204@gmail.com

АККУМУЛЯТОРЛЫҚ БАТАРЕЯЛАР.
ЭЛЕКТРОМОБИЛЬДЕРДІҢ ҚАТТЫ ДЕНЕЛІ АККУМУЛЯТОРЛЫҚ БАТАРЕЯЛАРЫ

Андатпа. Көптеген электромобильдердің жұмыс істеу қашықтығы 300 мильден аспайды, аккумуляторлық батареяны қайта қуаттауға бір сағаттан астам уақыт кетеді, олар 10 жылдың ішінде элементтер сыйымдылығының үштен бірін жоғалтады және жарылысқа алып келуі мүмкін жеңіл жанатын материалдармен жұмыс істегенде қауіпсіздікке қауіп төндіруі мүмкін. Мақалада электромобильдердің түрлі аккумулятор түрлері, олардың жұмысы, артықшылықтары мен кемшіліктері қарастырылған. Қатты денелі батареялар – келешектегі аккумуляторлық технология, қайталама батареяларды зерттеудегі белсенді бағыттардың бірі. Ғылыми қоғамның пікірінше, литий-ион батареясы өзінің шегіне жетті, қатты денелі батареялар соңғы жылдары литий-ион батареяларының жалғасы ретінде қарастырылуда. Заманауи электромобильге қатты денелі батареяларды ендіру мен кеңінен пайдалану тенденциясы қарастырылады.

Негізгі сөздер: батарея, экология, қатты денелі батарея, литий-ион батареясы.

***М.В. Ли, А.Е. Канажанов, К.К. Шалбаев**
Satbayev University, Алматы, Казахстан
*e-mail: marialeed.0204@gmail.com

АККУМУЛЯТОРНЫЕ БАТАРЕИ. ТВЕРДОТЕЛЬНЫЕ АККУМУЛЯТОРНЫЕ БАТАРЕИ ЭЛЕКТРОМОБИЛЯ

Аннотация. Большинство электромобилей имеют дальность действия менее 300 миль, на перезарядку аккумуляторной батареи уходит более часа, они теряют почти одну треть своей

емкости элементов в течение 10 лет и представляют серьезную угрозу безопасности при работе с легковоспламеняющимися материалами, что приводит к взрыву. В данной статье рассмотрены различные типы аккумуляторов электромобилей, их работа, преимущества и недостатки. Твердотельные батареи – аккумуляторная технология будущего, одно из самых активных направлений исследований вторичных батарей. Научное сообщество считает, что литий-ионные батареи достигли своего предела, твердотельные батареи в последние годы рассматриваются как батареи, которые могут унаследовать состояние литий-ионных батарей. Представлена тенденция внедрения и широкого использования твердотельных батарей в современном электромобиле.

Ключевые слова: батарея, экология, твердотельная батарея, литий-ионные батареи.