Study on preparation and properties of cathode materials for new energy vehicle batteries

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Abstract: Under the background of serious exhaust pollution and increasing depletion of oil resources, the automotive industry has explored a lot in the development and application of new energy pure electric. Power battery system components are energy storage and output devices for new energy vehicles, which represent the power safety performance of new energy vehicles. With the increase of the number of new energy electric vehicles, the inconsistency problem in the power battery is gradually exposed, which affects the service life of the power battery and reduces the safety and reliability of new energy vehicles. This paper studies the preparation and properties of negative electrode materials for new energy vehicle batteries. The prepared samples are studied, and the test and evaluation system of power battery is formulated. It will not only control the battery management module at the battery module level, but also have certain requirements for the design structure of the battery itself. Through the testing of all aspects of the battery test and evaluation system, we can have an objective understanding of the negative electrode materials of new energy vehicle batteries. After research, the results of this paper are remarkable and suitable for application to society.

1. Introduction

Accelerating the cultivation and development of new energy vehicles, mainly electric vehicles, can not only effectively alleviate the pressure of energy and environment, but also drive the transformation and upgrading of the automotive industry and cultivate new economic growth points [1]. As the power source of new energy vehicle battery, the performance of positive and negative materials of power battery determines the key factor of new energy vehicle development. The vigorous development of new energy vehicles such as hybrid electric vehicles, pure electric vehicles and fuel cell electric vehicles has brought great development opportunities to the battery industry. Among them, lithium-ion batteries and sodium ion batteries for new energy vehicles have the same storage mechanism, and compared with lithium-ion batteries, sodium ion batteries have the advantages of low cost and rich sodium source reserves. However, because the sodium ion radius (0.102nm) of the latter is much larger than that of lithium-ion (0.076nm), In the process of practical application, finding host materials that can stably insert / remove sodium ions has become the key to the application of sodium ion batteries in new energy vehicles [2]. Lithium ion batteries and sodium ion batteries have the same storage mechanism. Compared with lithium ion batteries, sodium ion batteries have the advantages of low cost and rich sodium source reserves. However, because the radius of sodium ions (0.102nm) is much larger than that of lithium ions (0.076nm), finding host materials that can stably insert / remove sodium ions in practical applications has become the key to the application of sodium ion batteries in new energy vehicles [3]. At present, fe7se8 with low cost, high conductivity and high theoretical capacity has a good application prospect as a negative electrode material for sodium ion batteries. It is necessary to further develop the negative electrode materials of sodium ion batteries with high cycle stability and durability to buffer the volume expansion and conductivity reduction in the process of sodium formation [4].

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2. New energy battery test and evaluation system

2.1 Performance requirements of battery cathode materials for new energy vehicles

At present, the domestic production of negative electrode materials for new energy vehicle batteries has increased year by year, but the speed of improvement in performance is slow. In the application process of battery, with the increase of current density, the specific capacity of battery cathode materials gradually decreases, and the generation rate is low, and some battery cathode materials have unstable performance [5]. In order to cope with the worldwide environmental pollution problem and the increasingly prominent contradiction between fuel supply and demand, countries have raised the development of new energy vehicles as a national strategy. The global automotive industry has deployed the development of new energy vehicles, and vigorously developed and applied automotive energy-saving technologies while accelerating technology research and development and industrialization. Energy saving and new energy vehicles have become the development direction of the global automotive industry, which is also an important strategic plan to achieve the development of the automotive industry [6].

As for the driving of new energy vehicles, the performance of cathode materials has a great impact on the driving stability of vehicles, resulting in some problems after the new energy vehicles are put into the market and increasing the maintenance workload. In the past, the object used in the construction of power battery implementation standards is relatively single, and does not fully reflect the comprehensive use performance of the battery, so it can not meet the design requirements of new energy vehicle power battery system. The proposal of the concept of new energy has solved the limitation of traditional automotive energy supply resource types, alleviated environmental and resource pressures to a certain extent, and promoted the development of the automotive industry [7]. This kind of energy power mainly comes from power batteries. Therefore, it is particularly important to improve the energy supply power by improving the performance of battery cathode materials and cathode materials.

Lithium ion batteries and sodium ion batteries for new energy vehicles have the same storage mechanism, and compared with lithium ion batteries, sodium ion batteries have the advantages of low cost and rich sodium source reserves. However, because the sodium ion radius (0.102nm) of the latter is much larger than that of lithium ion (0.076nm), In the process of practical application, finding host materials that can stably insert / remove sodium ions has become the key to the application of sodium ion batteries in new energy vehicles [8]. The performance of battery cathode material must be improved. First, in the process of increasing current density, improve the stability of battery cathode material to alleviate the decline rate of material specific capacity and slow down the decay rate as much as possible. Second, certain treatment measures should be taken to control the magnification characteristics of negative electrode materials to avoid damaging the material structure during cyclic charging and discharging [9].

As a key component of new energy vehicles, the performance of power battery system directly affects the performance of vehicle power system. In addition, consumers have higher and higher requirements for the power performance, reliability, environmental adaptability and safety performance of new energy vehicles. It is necessary to further develop the negative electrode materials of sodium ion batteries with high cycle stability and durability to buffer the volume expansion and conductivity reduction in the process of sodium. With the development of new energy and new materials, in order to realize the comprehensive application of high and new technology in the industrial operation, it is necessary to combine the industrial development of power battery materials, make rational use of mineral resources, fully show the advantages of material use, and promote the stable development of new energy power industry [10]. In recent years, the output of battery cathode materials has continued to rise, but the performance of materials needs to be improved.

2.2 Construction of power battery test and evaluation system

In the composition of the power system of new energy vehicles, the power battery system, as the energy storage system of new energy vehicles, is the most important core of new energy vehicles. The hardware design of the power battery management system has a thermometer control circuit for temperature control, an external fan control circuit and an installed voltage acquisition template. In the process of battery module design, as an important part of the battery system, the battery module is usually composed of cells, battery management units and cooling devices [11]. The use of battery system should fully meet the basic needs of safety, machinery and environment. As the core components of new energy vehicles, the development of power battery system must meet the performance requirements of the whole vehicle and the relevant national and enterprise standards. It mainly includes dynamic performance, environmental adaptability, life capacity, electromagnetic compatibility performance, structural and mechanical performance, reliability performance, safety performance, etc. The battery characteristic diagram is shown in Figure 1.

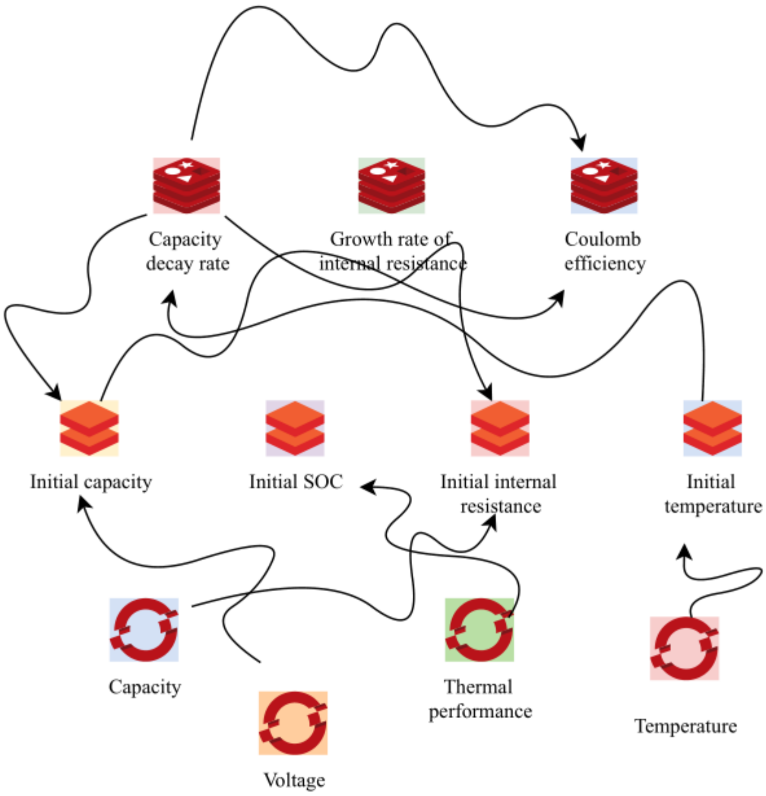

Fig.1 Battery characteristics

In battery management, detection is mainly based on information such as battery power and power supply time. The hardware design can be roughly divided into three parts. The first is to install information acquisition modules, such as temperature detector components. A fan is installed to control the temperature of the battery. When the temperature detected by the thermometer exceeds the safe usage of the battery, the control system fan will automatically start cooling the power battery. The function of hardware system is realized under the control of software. Generally, in the process of battery system testing, not only the battery management module at the battery module level will be controlled, but also the design structure of the battery itself will have certain requirements. Through the design of these requirements, the safety of the operation of the battery system can be fully guaranteed. Therefore, in the process of testing the safety performance of battery modules, we should focus on safety issues to fully ensure the effectiveness of battery system operation. Due to the complexity of the structure of the power battery system, it is very difficult to test and verify its performance. In the process of designing the test and verification method, the test and evaluation of the performance of the battery system in all aspects are considered, and for the important subsystems and parts in the battery system, their performance cannot be fully verified at the system assembly level, and they need to be verified separately. The structure diagram of power battery system assembly is shown in Figure 2.

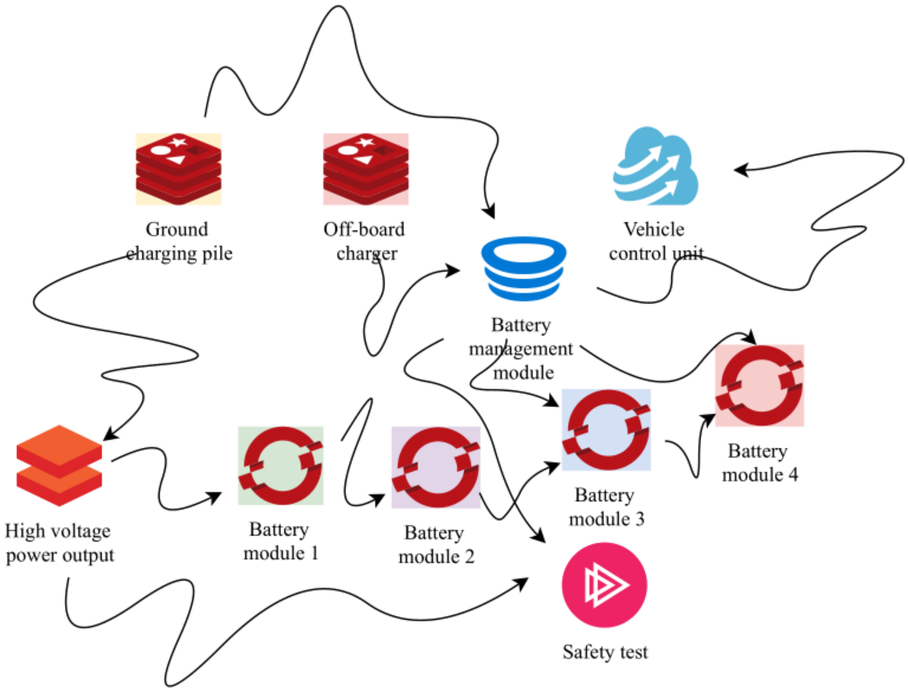

Fig.2 Structure diagram of power battery system assembly

It is assumed that the hardware design of the power battery management system considers the actual operation and use of the battery and whether the file management system is useful for retrieving information. The balanced branch switch is realized by electronic switch, which will not produce electromagnetic interference and make the work safe and reliable. Effective balance management can greatly improve the consistency of batteries in the battery pack and prolong the service life of the whole battery pack. Through the analysis of security detection performance, abuse experiments are generally used for verification. In the process of testing, battery modules will not pose a threat to people in some extreme environments. The testing content usually includes abuse tests of electrical performance, mechanical performance and thermal performance. The battery system also contains independent controllers, relays and other electronic devices, which also need to design corresponding test validation to evaluate whether their performance meets the requirements. Since these electronic devices are similar to traditional automotive electronic parts, we can use the test validation method of automotive electronic parts for reference to evaluate their performance.

3. Sample preparation and testing

3.1 Sample preparation

First, treat anhydrous copper sulfate, pour it into the prepared deionized water, stir it evenly, and make sure that all test materials are mixed into the liquid. Secondly, add ammonia and stir again. Finally, add an equal amount of sodium stannate tetrahydrate and stir it evenly with a stirring rod. Weigh the raw materials according to the mass ratio of nickel nitrate hexahydrate, ethanol and sodium chloride of 1:3:24 and mix them. Dissolve 16.4g of the mixture in 45ml of water, stir it evenly, and put it into htma6/220 oven. Set the temperature at 78 ℃ and the drying time for 24h. The dried block samples are mechanically ground into powder. After standing for 12min, the prepared materials were cleaned and centrifuged, and then freeze-dried. The powder sample was pyrolyzed at high temperature (725 ℃ /2h) in cwf11-5 atmosphere heat treatment furnace, and the protective gas was high-purity argon (purity: 99.96%). After pyrolysis, it is naturally cooled to room temperature to obtain ni/c/nacl powder. The calcined powder samples were annealed in air atmosphere (300 ℃ /4h) to obtain Ni NiO / C / NaCl powder, and then washed with deionized water and dried to obtain Ni

NiO / PCNs composites.

3.2 Test and verification of battery module

As the power battery system assembly of the energy storage device of new energy vehicles, it is also an independent working unit, with a separate control and management system and managed objects. To support the development of new energy vehicles, new battery materials are needed. After all, almost all new energy vehicles today use lithium batteries as materials. If new battery materials can be used in time, the power battery of new energy vehicles will make a leap.

As a very important part of the battery system, the battery cell is the energy storage unit. It is found that the stability of cell performance determines the dynamic performance, service life and safety ability of the battery system to some extent. To improve the consistency of power battery, we need to study the factors that affect its consistency and give corresponding control measures. At this stage, various batteries still have a certain degree of pollution, which is another important reason why they cannot be widely obtained. In addition, battery efficiency is also important. At present, most new energy vehicles cannot reach the required speed on the highway, and the battery life is insufficient. If we can start with materials and improve the efficiency of new batteries, the development of new energy vehicles will be more smooth. The thermal performance test mainly inspects whether the battery system assembly can work normally under specific temperature and humidity conditions, and also inspects whether the structure and shell material of the system can resist fatigue caused by temperature changes, and whether the thermal management ability of the battery system can ensure that the battery is within its appropriate working temperature range.

Set the reaction heat generated by electrochemical reaction as Q_R, the polarization heat generated by lithium ion polarization reaction as Q_P, the by-product heat generated by overcharge and discharge of the battery as Q_S, and the Joule heat generated by current through the internal resistance of the battery as Q_J. If the total heat in the overcharge of lithium-ion battery is expressed by Q, the total heat can be calculated by the following formula:

$$Q = Q_R + Q_P + Q_S + Q_J \tag{1}$$

Reaction heat:

$$Q_R = Q/(3600 \times F \times I) \tag{2}$$

Where Q is the total heat generated by the electrochemical reaction of lithium ion battery at the positive and negative electrodes; F is Faraday constant, generally f=96484.5c/mol; I is the charge and discharge current.

Polarization heat:

$$Q_P = I^2 r_P \tag{3}$$

Where, I is the current during charging and discharging; r_P is the polarization internal resistance.

In the process of testing, we should analyze the electrochemical performance, service life and safety performance of the experiments at the cell level, and determine the cell capacity in combination with the temperature factor of the test experiment, so as to ensure the stability of the cell test and improve the cell service life. Battery cell is the main component of new energy power battery pack, and it is also the key to affect its service life. Therefore, on the premise of ensuring the consistency of raw materials and the principle that the mechanical energy of the battery within its service life can meet the design and use requirements of the whole vehicle, it is necessary to strictly control the singleness of the battery cell variety, and carry out mass production of the battery cell raw materials of this variety, so as to meet the assembly requirements of power battery packs with batch specifications and models.

The environmental performance test mainly examines the ability of the battery system assembly to resist external environmental changes, especially the sealing performance of the shell, which is slightly different from the requirements of traditional auto parts. Mainly because the battery system belongs to high-voltage equipment, the shell design must meet a certain waterproof level, so as to prevent water from entering the battery system and causing insulation faults or even short circuits. In the process of testing the safety performance of the battery cell, the design index of the battery cell can be determined by analyzing the chemical safety coefficient of the battery and the safety problems of the battery cell design, so as to effectively avoid the impact of unreasonable battery cell testing on the operation of the battery system.

3.3 Results and analysis

Through the analysis of the testing status of the power battery system of new energy vehicles, the testing standards should be determined according to the development performance of the whole vehicle in the process of battery template and cell testing. The test and verification of battery system assembly, battery module and battery cell must be based on the performance requirements of vehicle development and relevant national and industrial access standards. Therefore, to evaluate whether the battery system assembly meets the requirements of vehicle development, we must combine the performance of the vehicle, the testing requirements of auto parts and the characteristics of the battery itself. In the development of the whole vehicle of the battery system, the testing methods should be improved in combination with the performance of the whole vehicle, the testing requirements of auto parts and the characteristics of the battery itself, so as to ensure the rationality of the testing scheme. It can be seen from table 1, table 2, figure 3 and Figure 4 that when the voltage is close to 0.8V, two oxidation peaks corresponding to the sodium removal process appear in the cyclic voltammogram, while at 0.4V, a reduction peak corresponding to the sodium insertion process appears. The research results of this paper are remarkable.

Table 1 Charge discharge curve

	0	**20**	**40**	**60**	**80**	**100**
Parameter 1	0.3	2	2.3	0.5	1.4	0.4
Parameter 2	1.1	0	2	2.5	2.4	1

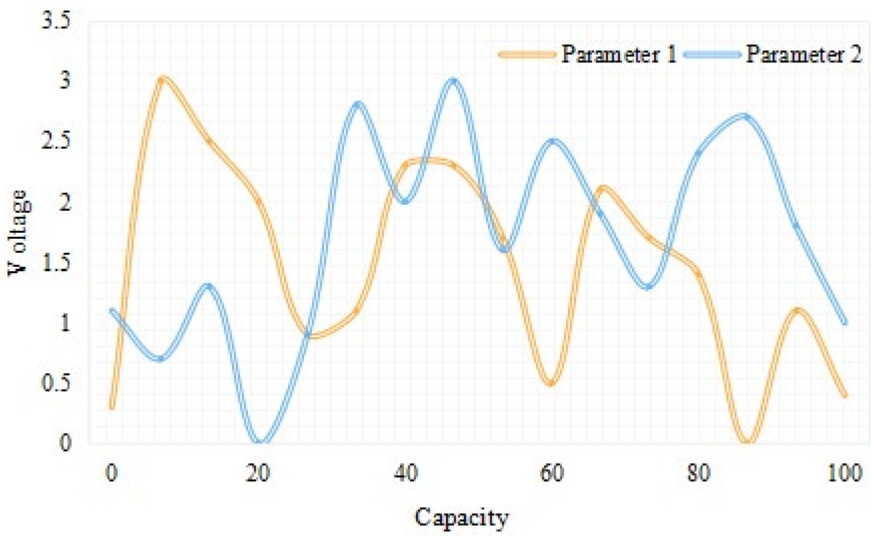

Fig.3 Charge discharge curve

Table 2 Cyclic voltammogram

	0	**0.2**	**0.4**	**0.6**	**0.8**	**1**
Parameter 1	0.7	0.1	0.7	0.2	0.7	0.4
Parameter 2	1	0.7	0.4	0.2	0.3	0.4

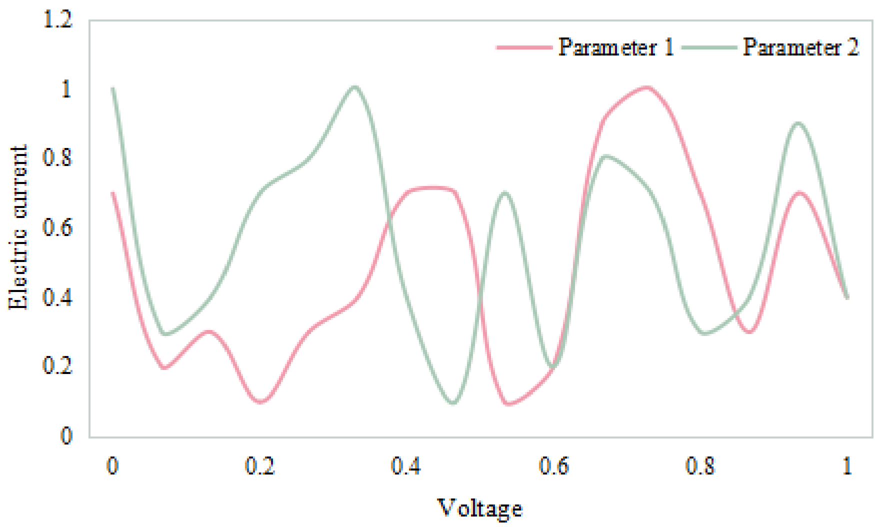

Fig.4 Cyclic voltammogram

The test verification of safety performance is generally completed under extreme test conditions. The safety of battery system assembly, battery module and battery cell under extreme environment is assessed, and the function is no longer the focus of assessment. In the safety performance testing, the testing process should be completed in extreme environments, that is, through the safety monitoring of battery system assembly, battery module and battery cell, build a safety evaluation scheme to improve the effectiveness of the testing work.

For the test and evaluation of non safety performance (mechanical, electrochemical, environmental climate, electromagnetic compatibility, etc.), on the one hand, it must meet the needs of vehicle development, which have specific quantitative standards; On the other hand, for mechanical performance, environmental climate and other tests, refer to the test requirements of iso16750-1 standard for the level of auto parts, divide the test process and the state of the battery after the test into five levels a, B, C, D and E, and compare and evaluate. It is necessary to test the mechanical performance, environment and climate, so as to fully ensure the rationality of auto parts testing and improve the stability of battery system operation, so as to make the battery system design of new energy vehicle power develop stably.

4. Conclusions

In a word, in the process of testing the power battery system of new energy vehicles, the testing scheme should be improved in combination with the service condition of the vehicle battery system. As a key component of new energy vehicles, the performance of power battery system directly affects the performance of vehicle power system. Therefore, it is particularly important to comprehensively test and evaluate the ability of power battery system and provide safe and reliable power battery system in the process of new energy vehicle development. By improving the detection methods of battery template detection, cell detection and test experiment, we can improve the overall quality of battery system detection, improve the operation effect of new energy vehicle power battery system, and promote the green development of the automotive industry. At present, there are still some deficiencies in the control and research of pack consistency of power battery. Relevant designers and process technicians need to strengthen the research of pack consistency to ensure the performance balance of single cell of power battery pack in the process of use.

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