Construction of high-quality lithium metal cathode protective film based on PIMs

Cheng Qian

Follow-up Water Drive Room, Geological Research Institute, Sixth Oil Production Plant, Daqing Oilfield Company Limited, Daqing, Heilongjiang 163000 China

Abstract: Lithium metal is widely concerned and valued by people because of its technical advantages such as extremely high energy density and lowest electrode potential, but the crystallization problem of lithium metal is very serious at this stage, which greatly restricts and limits the commercial development of lithium batteries. In this paper, we firstly analyze the connotation of PIMs in detail, and summarize the experimental procedure and conclusions of high-quality lithium metal anode protective film based on PIMs in combination with the current research status of high-quality lithium metal anode protective film.

Keywords: Polymers of intrinsic microporosity; lithium metal; anode protection film; current status of research

1. Introduction

PIMs as lithium metal anode protective film can greatly enhance the long cycle mode of metal production efficiency, in which polymeric substances on the one hand can provide fast channels for lithium ions to be deposited continuously, and on the other hand can also maximize the buffering of lithium metal charging and discharging process material changes. So, it is widely used in high performance lithium metal anode protective film transformation link.

2. Contents of PIMs

In the process of lithium metal anode protection material research, intrinsic microporous polymer is a new material with linked molecular micro-pores, because the material has a huge available coverage surface area, so in the lithium metal anode protection film research process in the adsorption, dispersion and catalytic and other aspects of significant material advantages. At this stage, the common PIMs used in lithium metal mainly contain: zeolite and activated carbon substances, but the organic material with similar internal structure in this material has also received the attention of researchers, so the technical staff actively introduced a new nano-organic material imitating the performance of activated carbon, this new porous material is also known as microporous polymer in the subsequent use process, mainly composed of phthalocyanine dyes, porphyrins. The material is composed of phthalocyanine dyes, porphyrins and six other substances, and the material has an open-mode microporous structure due to the rigid spiral skeleton in its own internal structure, which constantly organizes the solidified substances in close combination with each other. At the same time, the material has certain solubility in the process of use, and the technician makes a useful material by continuous dissolution processing.

3. Status of research on high - performance lithium metal cathode protection film

Lithium metal is considered to be the most promising material for the production of metal batteries in the industrial production process, and it is widely used in the battery production process because of the material's own advantages and technical characteristics such as higher energy density and lower electricity. However, lithium metal still has many problems and deficiencies in the safety of anode production, such as: the growth of lithium electron crystalline material, the formation of structural layers of dead lithium material and other related aspects. In addition, the PIMs in the high performance lithium metal electrolyte structure level is also considered as one of the key factors affecting the lithium substance deposition as well as the power chemistry performance, for this reason during the recent years of technical research, the research technicians will use different technical strategies to develop the ultimate goal of stabilizing the whole production process, achieving the link test crystal growth and improving the cycle life of lithium metal cathode.

At present, there are still deficiencies and problems in the precise control of our PIMs in the production structure of high-performance lithium metal anode protective films, which are affected by the natural formation of SEI substances, and technicians use electronic structural layer deposition as well as analysis of the mode of production, manufacturing, composition studies, and mechanical properties to produce adjustable double-layer protective films as artificial SEI substances for lithium metal anodes.

Lithium gold cathodes with a double-layer protective film exhibit excellent cycling stability and inhibited dendrite growth. Lithium metal: anode has been considered in recent years as the ultimate choice for next-generation lithium metal batteries, which has the advantages of high theoretical specific capacity, low potential and light mass.

4. Experimental procedure of high-performance lithium metal cathode protection film

4.1 Synthesis of PIMs

To further test the effect of intrinsic microporous polymers in high performance lithium metal cathode protective films, 1 g of 4,4'-diamine and 3,3'-dimethylbiphenyl were dissolved in 2.1 ml of dimethoxymethane solution and kept in an ice bath at all times to ensure that the dissolution temperature was 0 degrees C. After the reaction of the substances stabilized, 8 ml of trifluoroacetic acid was added again. After the reaction stabilizes, 8 ml of trifluoroacetic acid is added again, and the test solution is slowly heated to an ambient temperature of 25°C for 96 hours. After repeated centrifugation and precipitation, methanol and acetone are used for repeated measurements and tests, and chloroform is used for repeated precipitation to purify the structure, and the test solution is dried under vacuum for subsequent use.

4.2 Spin-coating method preparation

Spin coating technology is the simple name of equipment spin coating method. It is a common preparation technology in the production of organic light source diodes. This method mainly uses a glue dispenser, and the entire production process is divided into three operations: raw material distribution, high-speed rotation and volatilization. In the process, the film thickness is further controlled by controlling the glue uniformity time, equipment rotation speed, reagent drop volume and solution performance. For this reason, during experiments with high-performance lithium metal negative protective films, the use of this technique requires rapid rotation of the device perpendicular to its own central axis to apply the liquid covering material uniformly to the substrate structure. First the technician needs to precisely control 20 mg of pure and dried test material and dissolve it in 1 g of chloroform solution to obtain a clear bright yellow test solution. Next, 100 µl of the test solution is obtained using liquid transfer equipment and placed on the copper foil structure. Finally, a homogenizer is used for subsequent performance testing. It is also worth noting that the machine first needs to be set up to spin-coat at a low speed of 500 rpm for at least 30 seconds to obtain a thin, uniform and positionally dispersed test solution, and then to increase the base speed of the machine to 6000 rpm for at least 60 seconds to obtain a standard test substance and solution environment. With this simple spin coating, the film thickness can be adjusted by speed and time, and large area production can be achieved.

4.3 Nuclear magnetic resonance testing

The NMR test implementation process can effectively clarify the organic chemical compounds, and this technical approach can be used to further determine the PIMs surface area and the location of the pore distribution by nitrogen adsorption, so in the testing process, all test samples should ensure consistency, so this test samples are selected to carry out basic electrochemical test mode of button cells.

Battery testing process, high - performance lithium metal negative protective film copper fluid as the positive electrode, need to use lithium sheet for the electrode and the entire test process needs to ensure that the standard room temperature conditions, and the assembled button cell should be in the blue power test system internal structure for discharge performance testing, so as to effectively verify the power operation cycle efficiency and basic performance, so the entire test operation procedures focus on Material deposition performance, followed by the test solution placed on the high-performance lithium metal sheet to ensure that the test process voltage standard range of 1 volt, its battery current density of 0. 5mA/cm2.1mA/cm2.

5. Experimental conclusion of high-performance lithium metal anode protection film

5.1 Usage Properties of PIMs

The DMBP-TB intrinsically microporous polymer produced using the above test technique approach was analyzed in detail using NMR hydrogen spectroscopy to finally derive the internal structural characteristics of the substance. As shown in Figure 1, the chemical properties of the intrinsically microporous polymer are plotted.

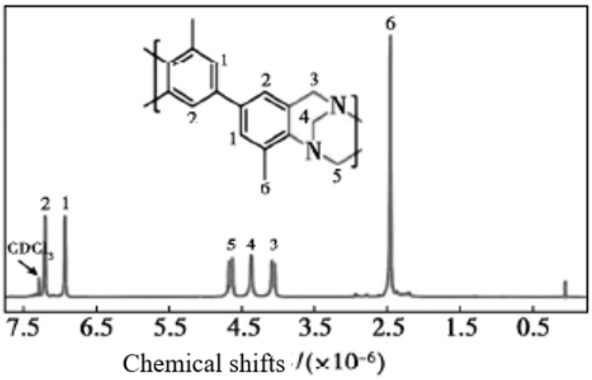

Figure 1 Chemical properties of intrinsic microporous polymers

According to Figure 1, if the deuterium with chloroform CDCl3 substance is used as the dissolution reagent during the test, subsequent performance tests need to be carried out using an RF frequency of 400 MHz to ensure the accuracy of the test results.

Meanwhile, throughout the test session, unlike common microporous skeleton materials, the intrinsic microporous polymer can effectively dissolve in a variety of test environments and solutions, so the substance itself has high self-forming film technology characteristics, providing large-area electrode protection for subsequent high-performance lithium metal cathode protective film production.

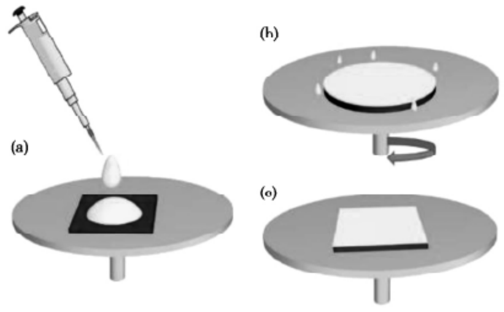

Figure 2 Schematic diagram of the spin-coating method of wrapping electrodes

As the technical approach can effectively use the equipment spin coating time, rotation speed, polymer solution base concentration and substance dosage to further regulate the film-forming effect, the final clear base optimization conditions: the equipment rotation speed is controlled at 6000 rpm, and the base rotation time is about 60 seconds. The quantity of polymeric substance base used is 100 ml, and the ratio of polymeric substance solution substance base concentration is 1 to 50. Since the base ductility of the film-forming material is high and the material flexibility is high, it can effectively relieve the base stress changes formed by the high-performance lithium metal negative electrode protective film in the long cycle after the test material covers the surface of the motor made of copper through technical operation, and prevent the destruction of the internal structure of the motor The film can be used to prevent the damage of the internal structure of the motor. As the internal structure of the film itself has porous characteristics, it can provide certain channels for lithium-ion deposition of lithium metal anode, effectively adjust the deposition of lithium metal to a certain extent, effectively prevent local polarization, effectively prevent the deposition of lithium ions in some electrodes in excessive quantities, and effectively control crystal growth.

5.2 Inhibition analysis of PIMs

In the process of PIMs suppression analysis, when using unmodified copper electrode as a concentrated fluid, lithium-ion elements will produce deposition problems on the surface structure of the copper substance, whereas the same substance surface will produce significant unevenness problems, resulting in significantly uneven lithium-ion base deposition efficiency, eventually resulting in faster deposition in some areas and relatively slow deposition in some areas. Among the faster-growing areas will produce tree-like external morphology, the tip position with higher active performance of lithium-ion distribution is very dense, the base reaction activity location point increasing, resulting in more lithium-ion material constantly deposited, ultimately resulting in uneven distribution of lithium-ion material.

Due to the relatively high reactivity of the lithium metal base in the intrinsic microporous polymer, it is very easy to generate SEI films by chemical reaction with the electrolytic solution, and during the whole reaction process, the lithium metal substance produces great material volume expansion, which eventually causes uneven stress distribution under the film position. In order to further release the relevant pressure, it is inevitable that the lithium metal will wear out from the film, at this time, if the system maintenance is not carried out in time, resulting in further fracture of the experimental material, it will certainly cause the cycle efficiency and quality reduction, resulting in system short circuit and explosion and other safety risks and problems. In addition, if the copper material surface uniformly wrapped with PIMs, will be due to the polymer itself does not have electrical conductivity, and the main structure of the material body structure produces a large number of media holes, when the lithium ion through the film material, will be in the film structure and copper material electrode deposition and thus produce sandwich material structure, further hindering the growth of the test crystal material.

6. Conclusion.

It can be seen that in order to further ensure the quality and effect of high performance lithium metal cathode protective film transformation, the technicians use the PIMs for structural wrapping to help the protective film surface current base density of 2mA/cm2 when cycling at least about 150 weeks, and at the same time, because the porous polymer itself has a high level of film formation characteristics, so the use of a simple spin coating method can complete the production and wrapping of large areas

https://doi.org/10.1051/e3sconf/202235202011

in order to complete the commerciality of the genus lithium cathode.

References

1. QI Liya, LIU Jianye, Zhang Hengyuan, et al. Construction of high-performance lithium metal anode protective film based on intrinsic microporous polymer[J]. New Chemical Materials, 2020, 48(6):5-5.
2. Luo Lianwei, Ma Wenyan, Liu Yu, et al. Performance study of anthraquinone-based conjugated microporous polymers for lithium-ion battery cathode materials[J]. China Advances in Materials, 2021, 40(9):8-8.
3. Fu Jingru, Ben Teng, Qiu Shilun. Preparation of polymer-supported metal-organic skeletal membranes and their gas separation properties[J]. Journal of Physical Chemistry, 2020(1):9-9.
4. Li Kaihua, Zhu Zhiyang, Cheng Bo Wen, Li Jianxin, Ma Xiaohua. Research progress on self-polymerized microporous polymeric gas separation membrane materials[J]. Membrane Science and Technology, 2020, 40(5):11-11.
5. Liu Lehao, Lv Jing, Mo Jinsan, et al. Flexible high-voltage composite electrolyte membrane based on three-dimensional aramid nanofiber backbone and its solid-state lithium-metal battery (in English) [J]. Science China Materials, 2020, v.63(05):45-60.