ISSN: 2472-3703 DOI: 10.6911/WSRJ.202611_12(11).0002

Effect of Different Voltages on Electrochemical Properties of Aluminum Alloy for Lithium Battery

Zhisheng Wang[1, *]

[1]College of transportation Engineering, Xinjiang Vocational University of Technology, Kashgar, Xinjiang, China

[*]Corresponding author: Zhisheng Wang (Email: wzs1985@126.com)

Abstract

In this paper, aluminum alloy as the research object, using SEM, electrochemical and XRD methods to study the effect of different voltage on the electrochemical properties of aluminum alloy for Lithium Battery. It can be observed that as the voltage increases or decreases, the surface morphology of the aluminum alloy will undergo certain changes. For instance, an excessively high voltage will lead to the occurrence of surface damage, while a too low voltage will also exhibit corresponding change characteristics. Voltages outside the reasonable range are prone to cause negative effects on the electrochemical performance. After undergoing reasonable voltage treatment, the surface morphology and electrochemical performance of the aluminum alloy will exhibit relatively positive effects, thereby enhancing its electrochemical performance as an electrode for lithium-ion batteries.

Keywords

Electrochemical performance, lithium battery, oxidation treatment.

1. INTRODUCTION

By focusing on and studying new materials and new technologies, the aim of exploring and developing batteries with better performance can be achieved[1,2]. Due to their excellent mechanical properties, aluminum alloys have been widely applied in transportation and other industrial fields[3,4]. The aluminum alloy materials prepared by the oxidation process exhibit excellent wear resistance and corrosion resistance, and are widely used in the industrial field [5, 6, 7]. To further improve the surface performance of aluminum alloys used in lithium electrodes, numerous researchers have conducted in-depth studies on surface treatment processes in recent years. This chapter focuses on aluminum alloys used for lithium electrodes, investigating the effects of different voltage treatments on their electrochemical properties using scanning electron microscopy (SEM), X-ray diffraction (XRD), and electrochemical methods. The study discusses changes in the electrochemical performance of aluminum alloys after appropriate voltage treatment, as well as their electrochemical behavior trends across various voltage ranges.

2. PROPERTIES

The performance of batteries used in drones and new energy vehicles directly affects their range of travel. The aluminum alloy materials used in batteries play a crucial role in determining the performance of the batteries.Aluminum materials are used in battery casings and aluminum-plastic films, and they can also be applied to Al collectors.Aluminum material is used on the aluminum collector. Figure1.1 shows the multiphase structure of a lithium-ion

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battery[8,9]. Experimental materials can be mainly used in the following experiments: concentrated sulfuric acid, sodium chloride, potassium hydroxide, boric acid, potassium permanganate, etc.Chemical compositions of Al alloys is as shown in the table below. During the experiment, prepare the solution and wash the sample with distilled water. The specific process flow of anodizing and polishing is as follows: 240, 600, 1000# sandpaper grinding, polishing, acid pickling, deionized water cleaning, acid pickling, oil dirt removal on the anodized surface polishing, passivation, acid pickling, cold air rapid drying.

Table 2-1. Composition analysis of Al alloys(%)

element	Cu	Mn	Mg	Ti	Zr	Zn	Si	Fe	Cr	Al
content	0.20	0.11	0.99	0.015	0.05	0.008	0.51	0.32	0.21	allowance

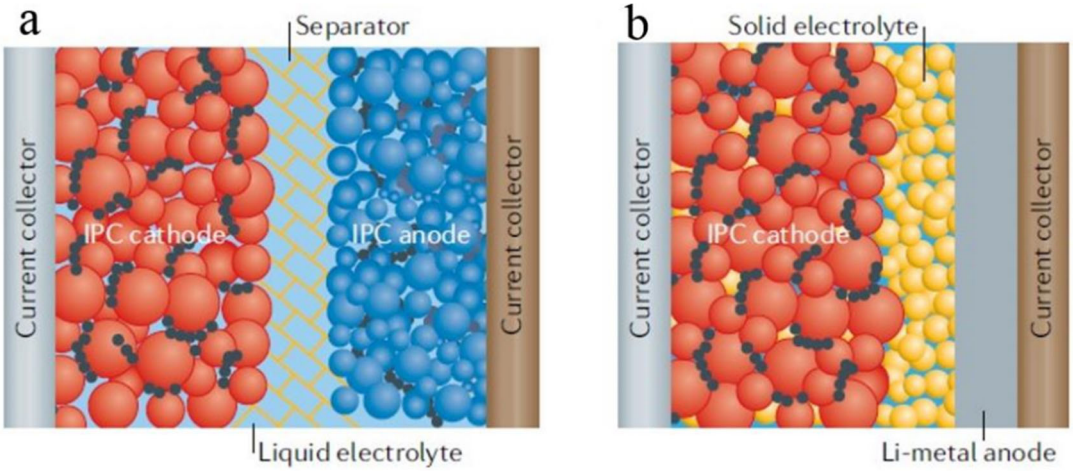


Figure 1.1 shows the multiphase structure of a lithium-ion battery [8, 9].

3. ANODIZING TEST

3.1. Anodic oxidation

The aluminum alloy test piece is used as the oxidation working anode, and the graphite sheet is used as the cathode. In these two experiments, a certain factor is selected as the final parameter for oxidation discharge test; Other additives: lactic acid, glycerol, malic acid, aluminum sulfate. Carry out mechanical stirring to ensure that the heat emitted during the anodic oxidation decomposition reaction can be evenly and timely released or dispersed. At the same time, place the oxidation-reduction reaction tank of the whole anode in the water bath, and keep the temperature at about 0oC.

3.2. Characteristic test

The microstructure of aluminum alloy for Lithium Battery Electrodes sample was observed by SEM. The phase composition was analyzed by rotating anode X-ray diffractometer (XRD). The pipeline pressure and pipeline flow are 40kV and 100mA respectively. The scanning range is 20o~80o, and the scanning speed is 10o/min. The electrochemical properties of the samples were characterized on the electrochemical workstation.

3.3. Morphology observation

By observing the surface morphology of aluminum alloy for Lithium Battery Electrodes, it can be found that different oxidation voltages have different effects on the material. As the oxidation voltage increases, the product is obvious, but the surface is not uniform. When the oxidation voltage rises to a certain level, the surface of the sample is covered with a film of oxidation

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products, but several pits on the surface can be observed. When the oxidation voltage is too high, large-scale cracks will appear on the oxidation layer of the anode oxidation section, and the surface is covered with a sparse layer of products. Under appropriate voltage conditions, the surface is relatively smooth and uniform, and is covered with a dense layer of products.From the picture we can see roughly, when the cathode oxidation voltage gradually increases to a certain level, part of the crack will appear, and the anode oxidation membrane surface color will gradually have obvious changes, when the cathode oxidation voltage gradually increases, then the color is not easy to evenly, serious when the surface occur obvious powder falls off phenomenon. As the cathode oxidation reaction voltage continues to rise, the current density decreases and the energy concentration is too high, leading to the energy can not be fully and timely oxidized out, the temperature in the film hole increases faster, and the oxidation solubility of the oxide film improves. The more intense the anodic oxide film reaction can even occur. When the oxidation voltage reaches a certain level, serious cracks appear on the surface.

By observing the surface morphology of the aluminum alloy used in Lithium battery materials, one can understand the effects of different voltages on the aluminum alloy material. The trend of electrochemical performance can be discovered through the surface morphology diagram, as it changes with the increase or decrease of voltage. The trend of the surface morphology of the aluminum alloy used in lithium electrodes; how does the development trend of the surface morphology and thickness change when the voltage exceeds a certain value. At the same time, the influence of voltage on current density and resistance can be found out, thereby knowing the electrochemical performance of the aluminum alloy used in lithium electrodes. When the voltage exceeds a certain critical value, excessive heat accumulation occurs and energy cannot be dissipated in time, resulting in a decline in electrochemical performance.

The anodic oxidation process obeys Faraday's law, that is, a certain amount of electricity is applied to the electrode, which will be strictly and quantitatively converted into metal oxides. However, the anodic oxidation process is accompanied by the production and dissolution of metal oxides. The anodic oxidation process of metallic aluminum is divided into the oxidation process of A1, the dissolution process of A1 and the dissolution process of A12O3. The oxide film formed on the surface of the sample after anodic oxidation has a two-layer structure. The micropores formed by the local dissolution of the film make the electrolyte enter the oxide film, so that the oxide film grows continuously on the aluminum substrate, and the oxide film dissolves continuously at the same time. The factors that affect anodic oxidation include oxidation voltage, time, temperature, agitation and the type of electrolyte. Therefore, in order to obtain an ideal film, various parameters of the anodic oxidation process must be optimized.

3.4. Effect of different voltages treatment on phase composition of oxide film

The composition of the oxide film can be clearly identified from the diffraction peaks in the XRD patterns after different oxidation voltages. As the operating voltage increases, the discharge energy density exhibits a certain trend. When the voltage reaches a certain level, molten material is ejected from the discharge holes during coating formation, followed by changes in surface phases and the formation of new phases.

3.5. Eiectrochemical measurements

In order to study the influence of working voltage on the performance of aluminum alloys used in lithium electrodes, we conducted tests on the electrochemical properties. From the electrochemical performance curves of the aluminum oxide film on the anode of lithium battery electrodes, it can be seen that within a certain voltage range, as the oxidation voltage increases or decreases, the changes in the electrochemical performance and interface state of the lithium battery aluminum electrode used can be observed. When within a certain working voltage

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range, as the voltage increases, the interface performance of the lithium battery shows a deteriorating trend or an improving trend. The trend of current density and resistance changes can reflect the electrochemical characteristics of the material. If the current density is too high, the energy cannot be released in time, and even partial breakdown may occur, which is likely to damage the formed oxide protective film on the surface, and the electrochemical performance will subsequently weaken. With the increase or decrease of the oxidation voltage, the current density and resistance will also change accordingly. This fully indicates that with the change of voltage, the electrochemical performance of the aluminum alloy used for lithium battery electrodes also changes. It also shows that within a reasonable voltage range, the electrochemical performance of the aluminum alloy used for lithium battery electrodes has a positive effect; but when the voltage exceeds a certain range, it will have a negative impact.

As the voltage increases, a certain trend will emerge under specific voltage conditions. However, when the voltage exceeds a certain threshold, the aluminum alloy resistance used for the lithium electrode will exhibit an opposite trend. This is because once the voltage reaches a certain level, the current density begins to rise. As the current density increases, the energy gradually concentrates and intensifies to a degree that cannot be dissipated in time, thereby causing local surface damage and subsequently reducing the resistance of the aluminum alloy used in the lithium electrode.

3.6. Auminum alloy electrodes peeling

The macroscopic and microscopic morphologies of the sample surface after different oxidation treatments can reveal the color and texture of the surface. By magnifying the image, cracks on the surface can be observed. After a certain voltage treatment, it can be found out which areas of the aluminum alloy surface are covered by the oxide film. As the oxidation voltage increases, the color of the surface area and the morphology of the film can be observed, indicating the influence of the increase in voltage on the film. By observing the film cracks in the local area of the sample surface, the influence of the voltage on the electrochemical properties of the material can be discovered. Through electron energy spectrum (EDX) analysis, it can be known whether the surface products are aluminum oxide and whether the crack area is aluminum. Through EDX microscopic analysis, the electrochemical properties of aluminum alloy electrodes for lithium batteriesthe can also be reflected.

When the voltage reaches a certain level, the cracking and peeling degree of the oxide film is observed through scanning electron microscopy. Through EDX micro-area analysis, it is determined whether the main product of the surface area is Al_2O_3, from which the influence of high oxidation voltage on the peeling of the aluminum layer can be inferred. In addition, oxygen is also detected at the crack sites.

The morphology of the crack area on the rear surface of the sample and the electron energy spectrum (EDX) scan results of the entire area show the main composition of the crack area of the oxide film; which elements mainly constitute the edges of the crack area; and which elements are dominant in the components of the surrounding area of the crack area. From this, it can be inferred that the aluminum substrate at the crack area has undergone an oxidation reaction in the local environment.

4. CONCLUSION

This chapter mainly explores the influence of different voltages on the electrochemical performance of aluminum alloy electrodes in lithium-ion batteries. The main conclusions are as follows:

(1) As the voltage increases, when reaching a certain level, it is observed whether cracks and damages will appear on the surface of the aluminum alloy electrode. An appropriate voltage has

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a positive effect on the electrochemical performance of the aluminum alloy electrode surface; while voltages exceeding or falling below a specific value may have adverse effects on the aluminum alloy electrode. An increase in voltage will change the color of the surface of the lithium electrode using aluminum alloy and cause certain changes in the surface layer, which will also affect the corrosion resistance of the aluminum material used in lithium-ion batteries.

(2) By conducting tests on the treated samples using electrochemical methods, the trends of current density and resistance can be observed, which leads to the influence of the electrochemical performance of the aluminum alloy used as the electrode of lithium-ion batteries after being treated at certain voltages. As the voltage increases and decreases, the direction of current density can be determined, and at the same time, the corrosion resistance of the sample can be reflected. When the voltage reaches a certain value, it will also have an impact on the surface morphology of the aluminum alloy material. The surface morphology of the aluminum alloy will have an effect on the electrochemical performance of the sample. Under appropriate voltages, a dense protective oxide film forms on the surface of the aluminum alloy used as the electrode of the lithium-ion battery, effectively inhibiting the diffusion of the matrix components to the outside. When the voltage exceeds the reasonable range, the surface of the sample may exhibit morphology features that do not have protective effects, and even begin to show more severe damage phenomena.

By studying the influence of voltage on the electrochemical performance of the aluminum alloy used as the electrode of lithium-ion batteries, a better process can be obtained.

ACKNOWLEDGEMENTS

This paper was supported by members of the professional team and some teachers from the School of Transportation Engineering.

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