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(54) **A MEMBRANE-FREE SUPERCAPACITOR/LITHIUM BATTERY AND ITS PREPARATION METHOD.**

(57) The invention discloses a membrane-free supercapacitor/lithium battery and its preparation method, which includes: a current collector, a positive electrode, an electrolyte, and a negative electrode. The positive and negative electrodes are coated on the current collector, with the electrolyte located between the positive and negative electrodes, separating them. A sealing material is used, and through a pressurization and heating method, the sealing material melts and seals the two poles of the supercapacitor/lithium battery. The electrolyte is injected through small holes reserved in the current collector. This separator-free supercapacitor/lithium battery saves on separator materials and battery housing, eliminating the impact of the separator on ion transport and internal stability within the supercapacitor/lithium battery. The method is simple and easy to industrialize. The supercapacitor/lithium battery sealed by this method exhibits excellent performance and long-term stability.

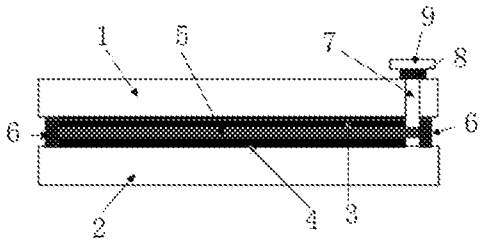

Figure 1

DESCRIPTION

A MEMBRANE-FREE SUPERCAPACITOR/LITHIUM BATTERY AND ITS PREPARATION METHOD

TECHNICAL FIELD

This invention relates to the field of electrochemical energy storage, specifically to a membrane-free supercapacitor/lithium battery and its preparation method.

BACKGROUND

As a new type of electrochemical energy storage device, the supercapacitor/lithium battery has characteristics such as high energy density, high power density, high charge/discharge efficiency, and long lifespan. It is an innovative, efficient, and practical energy storage device that can be widely used in wind power generation, solar power generation, electronics, automotive, medical, healthcare, power electronics, communications, energy, military, and other fields. A complete supercapacitor/lithium battery typically consists of five parts: the casing, current collector, electrode, separator, and electrolyte. The separator, as an important component of supercapacitors/lithium batteries, plays a critical role in their performance. However, to restrict the flow of electrons within the supercapacitor/lithium battery, the separator increases the internal resistance of the device. Moreover, as the separator ages, the internal leakage current of the supercapacitor/lithium battery significantly increases, leading to a reduction in its cycle life.

SUMMARY

This invention addresses the issue described above by designing a membrane-free supercapacitor/lithium battery and its preparation method. The electrolyte is positioned between the positive and negative electrodes, separating the two without the use of a membrane material. Additionally, sealing materials are applied, and the supercapacitor/lithium battery is sealed at both poles through a pressurization and

heating method. The structure of this invention is simple, with good sealing and long-term stability, eliminating the adverse effects of the membrane on the supercapacitor/lithium battery and improving its long-term stability.

The technical solution proposed in this invention is as follows:

A membrane-free supercapacitor/lithium battery and its preparation method characterized by the inclusion of an upper current collector, a lower current collector, a positive electrode, a negative electrode, and an electrolyte. The positive and negative electrodes are respectively applied to the upper and lower current collectors, with the electrolyte positioned between the positive and negative electrodes to separate them. The periphery of the upper and lower current collectors is sealed using a sealing material. A small hole is reserved in either the upper or lower current collector for injecting the electrolyte between the positive and negative electrodes, and after injection, the hole is sealed with a sealing material.

The membrane-free supercapacitor/lithium battery and its preparation method is further characterized by the current collector being made of conductive glass, metal, or polymer materials.

The membrane-free supercapacitor/lithium battery and its preparation method is also characterized by the positive and negative electrode materials being carbon-based materials, metal oxides, polymers, or a composite of any two of these materials.

The electrolyte in the membrane-free supercapacitor/lithium battery and its preparation method can be aqueous, organic, ionic, quasi-solid-state, or gel-based electrolytes.

In this design, the area of the positive and negative electrodes is smaller than that of the upper and lower current collectors. The ends of the upper and lower current collectors are sealed around the electrodes by melting the sealing material through a pressurization and heating process.

The sealing material used in the invention is a polymer, sealant, or a glass powder-containing mixed adhesive that is resistant to oxidation, water, heat, cold, and UV radiation, does not react with the electrolyte, and provides excellent sealing

performance. The distance between the positive and negative electrodes can also be flexibly controlled by adjusting the amount or thickness of the sealing material.

The electrolyte injection method can be either direct pouring or vacuum filling.

The small hole used for electrolyte injection is sealed with a polymer film, sealant, glass powder-containing adhesive, or solder, and the hole is sealed through mechanical pressurization and heating or by a coating method.

A sealing sheet is applied over the small hole, which can be one or two in number.

The manufacturing method for a membrane-free supercapacitor/lithium battery and its preparation method includes the following steps:

1. A small hole for electrolyte injection is set on one of the current collectors, or one hole is set on each current collector.

2. A layer of positive and negative electrode materials is prepared on the current collectors using methods such as printing, coating, spin-coating, spraying, growing, or pressing, with the electrode materials slightly smaller in area than the current collectors.

3. The electrode materials are firmly adhered to the current collectors through sintering or drying, with optional pre-pressing to flatten the electrode surface.

4. The prepared sealing material is placed between the two current collectors, covering the areas without electrode materials, and the sealing material is melted and bonded through a heating and pressurization process to seal the two current collectors together.

5. The electrolyte is injected into the supercapacitor/lithium battery through the pre-set holes, which are then sealed.

Principle of the invention:

A complete supercapacitor/lithium battery typically consists of five parts: casing, current collectors, electrodes, a separator, and electrolyte. The separator plays a crucial role in the performance of supercapacitors/lithium batteries. However, the separator increases the internal resistance to electron flow, and as it ages, internal leakage current rises significantly, limiting the cycle life of the supercapacitor/lithium battery. This invention aims to solve the issues caused by membrane materials by providing a membrane-free supercapacitor/lithium battery and its preparation method.

Advantages of the invention:

This invention eliminates the need for membrane materials and casings in supercapacitors/lithium batteries, removing the ion and electron transport resistance caused by the separator and casing. This results in improved long-term stability of the supercapacitor/lithium battery.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 Schematic diagram of the supercapacitor/lithium battery structure of the present invention (single electrolyte injection hole).

Figure 2 Schematic diagram of the supercapacitor/lithium battery structure of the present invention (double electrolyte injection hole).

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figure 1, a diaphragm-free supercapacitor/lithium battery includes an upper current collector (1), a lower current collector (2), a positive electrode (3), a negative electrode (4), and an electrolyte (5). The positive and negative electrodes (3, 4) are respectively applied to the upper and lower current collectors (1, 2), and the electrolyte (5) is positioned between the positive electrode (3) and the negative electrode (4), separating them. The upper and lower current collectors (1, 2) are sealed around the edges with a sealing membrane (6). A small hole (7) is reserved in the upper or lower current collector (1 or 2) for injecting the electrolyte (5) between the positive and negative electrodes (3, 4). After the electrolyte (5) is injected, the small hole (7) is sealed with a sealing material (8), and a sealing sheet (9) is applied on top of the sealing material (8).

Methods for sealing the electrolyte injection hole:

Method 1: (Sealing material 8 uses a polymer film) After injecting the electrolyte (5) through the small hole (7), a polymer film and a sealing sheet (9) are sequentially placed on the surface of the small hole (7). By applying heat and pressure, the polymer film melts completely, and after removing the heat source and allowing it to cool, the seal is completed.

Method 2: (Sealing material 8 uses sealant) A layer of sealant is directly applied over the electrolyte injection hole (7) that needs to be sealed. A sealing sheet may or may not be added. Once the sealant cures, the seal is completed.

Method 3: (Sealing material 8 uses mixed adhesive or solder) A layer of mixed adhesive or solder is applied directly over the electrolyte injection hole (7) that needs sealing. By heating the material to melt it, and then removing the heat source and allowing it to cool after it melts completely, the seal is completed.

Example 1

As shown in Figure 1, a diaphragm-free supercapacitor/lithium battery is prepared by readying two current collectors (1, 2) that are covered with positive and negative electrodes (3, 4). The positive and negative electrodes (3, 4) are slightly smaller in size than the current collectors (1, 2). First, a layer of polymer film is applied around the edges of one current collector (1), ensuring that the electrode portion on the current collector (1) is not covered. Then, the other current collector (2) is placed on top, and a certain amount of pressure and heat is applied to melt the polymer film. Once the polymer film has completely melted, the heat source is removed, and after cooling, the sealing membrane (6) around the current collectors is completed. Afterward, the electrolyte (5) is injected through the reserved small hole (7) using direct injection or vacuum injection. Once fully filled, the small hole (7) is sealed. There is one small hole (7) in this example.

Example 2

As shown in Figure 1, a diaphragm-free supercapacitor/lithium battery is prepared by readying two current collectors (1, 2) that are covered with positive and negative electrodes (3, 4). The positive and negative electrodes (3, 4) are slightly smaller in size than the current collectors (1, 2). First, a layer of sealant is applied around the edges of one current collector (1), ensuring that the electrode material on the current collector is not covered. Then, the other current collector (2) is placed on top, and a certain amount of pressure and heat is applied. After the sealant has dried and cured, the electrolyte is injected, and the small holes (7) are sealed. There are two small holes (7) in this example.

CLAIMS

1. A membrane-free supercapacitor/lithium battery and its preparation method, characterized in that it includes an upper current collector, a lower current collector, a positive electrode, a negative electrode, and an electrolyte; the positive and negative electrodes are respectively applied to the upper and lower current collectors, and the electrolyte is positioned between the positive and negative electrodes, separating them; the upper and lower current collectors are sealed around their edges with a sealing material, and a small hole is reserved in either the upper or lower current collector for injecting the electrolyte between the positive and negative electrodes; after injecting the electrolyte, the small hole is sealed with a small hole sealing material.

2. The dmembrane-free supercapacitor/lithium battery and its preparation method according to claim 1, characterized in that the current collector material is conductive glass, metal material, or polymer material.

3. The membrane-free supercapacitor/lithium battery and its preparation method according to claim 1, characterized in that the positive and negative electrode materials are carbon materials, metal oxides, polymers, or composites of any two of these materials.

4. The dimembrane-free supercapacitor/lithium battery and its preparation method according to claim 1, characterized in that the electrolyte is an aqueous electrolyte, organic electrolyte, ionic electrolyte, quasi-solid electrolyte, or gel electrolyte.

5. The membrane-free supercapacitor/lithium battery and its preparation method according to claim 1, characterized in that the area of the positive and negative electrodes is smaller than the area of the upper and lower current collectors, and the ends of the upper and lower current collectors are sealed by melting the sealing material through a pressurized heating method.

6. The membrane-free supercapacitor/lithium battery and its preparation method according to claim 5, characterized in that the sealing material is a polymer material, sealant, or mixed adhesive containing glass powder.

7. The membrane-free supercapacitor/lithium battery and its preparation method according to claim 1, characterized in that the electrolyte injection method is direct pouring or vacuum pouring.

8. The membrane-free supercapacitor/lithium battery and its preparation method according to claim 1, characterized in that the small hole sealing material is a polymer film, sealant, mixed adhesive containing glass powder, or solder, and is sealed by mechanical pressing and heating or coating methods.

9. The membrane-free supercapacitor/lithium battery and its preparation method according to claim 8, characterized in that the small hole sealing material is covered with a sealing sheet.

10. The diamembrane-free supercapacitor/lithium battery and its preparation method according to claim 1, characterized in that the number of small holes is one or two.

REVENDICATIONS

1. Batterie au lithium/supercondensateur sans membrane et son procédé de préparation, caractérisée en ce qu'elle comprend un collecteur de courant supérieur, un collecteur de courant inférieur, une électrode positive, une électrode négative et un électrolyte; les électrodes positive et négative sont respectivement appliquées sur les collecteurs de courant supérieur et inférieur, et l'électrolyte est positionné entre les électrodes positive et négative, les séparant; les collecteurs de courant supérieur et inférieur sont scellés sur leurs bords avec un matériau de scellement, et un petit trou est réservé dans le collecteur de courant supérieur ou inférieur pour injecter l'électrolyte entre les électrodes positive et négative; après injection de l'électrolyte, le petit trou est scellé avec un matériau de scellement pour petit trou.

2. Batterie au lithium/supercondensateur sans membrane et son procédé de préparation selon la revendication 1, caractérisée en ce que le matériau du collecteur de courant est du verre conducteur, un matériau métallique ou un matériau polymère.

3. Supercondensateur/batterie au lithium sans membrane et son procédé de préparation selon la revendication 1, caractérisé en ce que les matériaux d'électrode positive et négative sont des matériaux carbonés, des oxydes métalliques, des polymères ou des composites de deux quelconques de ces matériaux.

4. Supercondensateur/batterie au lithium sans membrane et son procédé de préparation selon la revendication 1, caractérisé en ce que l'électrolyte est un électrolyte aqueux, un électrolyte organique, un électrolyte ionique, un électrolyte quasi solide ou un électrolyte en gel.

5. Batterie au lithium/supercondensateur sans membrane et son procédé de préparation selon la revendication 1, caractérisée en ce que la surface des électrodes positives et négatives est inférieure à la surface des collecteurs de courant supérieur et inférieur, et les extrémités des collecteurs de courant supérieur et inférieur sont scellées par fusion du matériau de scellement par un procédé de chauffage sous pression.

6. Batterie au lithium/supercondensateur sans membrane et son procédé de préparation selon la revendication 5, caractérisée en ce que le matériau de scellement est un matériau polymère, un produit de scellement ou un adhésif mixte contenant de la poudre de verre.

7. Batterie au lithium/supercondensateur sans membrane et son procédé de préparation selon la revendication 1, caractérisée en ce que le procédé d'injection d'électrolyte est le coulage direct ou le coulage sous vide.

8. Batterie au lithium/supercondensateur sans membrane et son procédé de préparation selon la revendication 1, caractérisée en ce que le matériau de scellement des petits trous est un film polymère, un produit de scellement, un adhésif mixte contenant de la poudre de verre ou de la brasure, et est scellé par des procédés de pressage mécanique et de chauffage ou de revêtement.

9. Supercondensateur/batterie au lithium sans membrane et son procédé de préparation selon la revendication 8, caractérisé en ce que le matériau de scellement des petits trous est recouvert d'une feuille de scellement.

10. Supercondensateur/batterie au lithium sans membrane et son procédé de préparation selon la revendication 1, caractérisé en ce que le nombre de petits trous est de un ou deux.

FIGURES

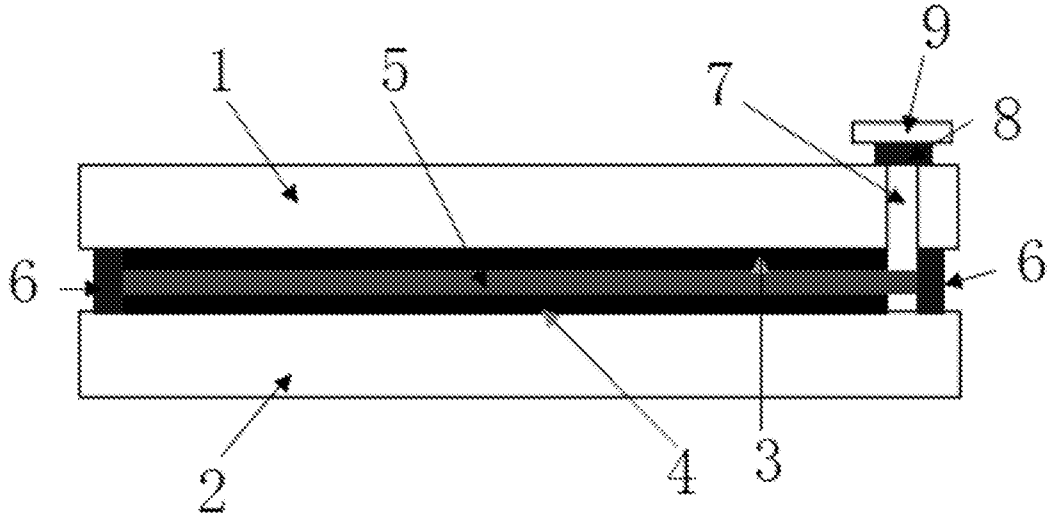

Figure 1

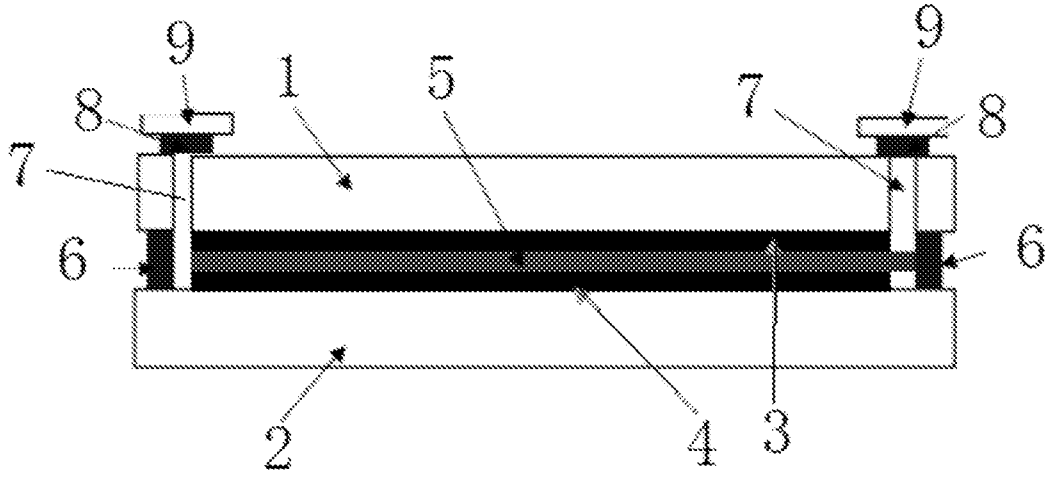

Figure 2