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A COMPOSITE ELECTRODE MATERIAL FOR VANADIUM REDOX FLOW BATTERIES, WHICH COMBINES CORROSION RESISTANCE WITH HIGH CONDUCTIVITY, AND ITS PREPARATION METHOD.

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The present invention discloses a composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity, belonging to the field of composite electrode materials for vanadium redox flow batteries. The composite electrode material, which combines excellent sulfuric acid corrosion resistance and high conductivity, is constructed by combining fluorinated polymers with inorganic particles, and the ratio of fluorinated polymers to inorganic particles is adjustable. The fluorinated polymers exhibit excellent heat resistance, corrosion resistance, and weather resistance, while the inorganic particles have good conductivity and mechanical strength. By compounding these two types of materials and optimizing the composite ratio between them, the resulting composite electrode prepared by the present invention possesses excellent chemical stability, sulfuric acid corrosion resistance, as well as superior electrical conductivity and mechanical strength.

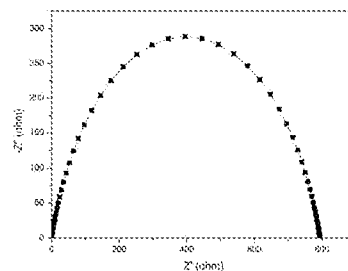


Figure 1

**A COMPOSITE ELECTRODE MATERIAL FOR VANADIUM REDOX FLOW
BATTERIES, WHICH COMBINES CORROSION RESISTANCE WITH HIGH
CONDUCTIVITY, AND ITS PREPARATION METHOD**

TECHNICAL FIELD

The present invention falls within the technical field of composite electrode material preparation for vanadium redox flow batteries. It relates to a composite electrode material for vanadium redox flow batteries, which combines corrosion resistance with high conductivity, and its preparation method.

BACKGROUND

The vanadium redox flow batteries (VRFBs), based on the oxidation/reduction mechanism of different valence states of vanadium, achieves efficient energy storage and release. It exhibits many advantages, such as large battery capacity, low cost, high power, lossless deep discharge at high currents, long lifespan, and simple operation. VRFBs have become the most promising and efficient green energy storage system, effectively addressing issues such as petroleum resource depletion and environmental pollution worldwide. The main structure of VRFB includes electrodes, electrolyte, and electrolyte membrane. The electrode provides an effective site for the electrochemical reactions of the vanadium battery, allowing electron transfer and ion conversion on its surface. It is a critical structure influencing the overall performance of the battery. In other words, the development of electrode materials has always determined the development of VRFBs.

In the early stages of VRFBs development, metal electrode materials received widespread attention from researchers due to their advantages of conductivity and good processability. Embodiments include inert metals such as platinum and gold. However, on the one hand, the reversibility of electrochemical reactions of vanadium ions on the surfaces of these inert metals is poor. On the other hand, these materials

are costly, making inert metal electrode materials impractical and of limited value. In contrast, active metals have better electrochemical properties, but it is challenging for them to meet all the essential requirements for stability, conductivity, and electrochemical activity as both positive and negative electrodes. For Embodiment, titanium used as a positive electrode tends to form a thick passivation film on its surface, affecting conductivity. As a negative electrode, the protective passivation film is easily reduced, leading to the corrosion and dissolution of the titanium base.

Later, researchers found that coating metals such as iridium and ruthenium on metal substrates like titanium and lead, or forming metal oxide coatings, can transform them into new electrodes with behaviors completely different from the original metal substrates. This greatly improves the electrochemical activity of such electrode materials. However, despite the favorable electrochemical activity and stability exhibited by titanium electrodes coated with iridium oxide, the low overpotential for hydrogen evolution results in significant hydrogen evolution side reactions when used as a negative electrode, leading to efficiency issues in the battery. Additionally, if such electrode materials are used as positive electrodes, there is a competitive oxygen evolution side reaction.

In comparison to metal materials, carbon materials possess unique characteristics. When used as electrode materials, carbon materials exhibit good conductivity, corrosion resistance, and a wide potential window in sulfuric acid solutions. Therefore, the use of carbon materials as electrode materials for VRFBs has attracted the interest of many researchers, leading to the development of a series of carbon-based electrode materials such as graphite plates, flexible graphite, graphite felts, and carbon felts. Unfortunately, when carbon-based materials are used as electrode materials, overcharging the battery can cause corrosive damage to the electrodes due to side reactions. Moreover, when oxygen evolution occurs on the electrode surface, the electrode is oxidized into carbon dioxide or carbon monoxide by oxygen radicals. This oxidation erodes the surface, potentially causing a further decrease in the overpotential. Under the influence of hydrogen evolution side

reactions, the structure of the electrode surface is damaged, significantly affecting its electrochemical performance. LU506402

Therefore, developing electrode materials for VRFBs that simultaneously exhibit good electrochemical performance and resistance to sulfuric acid corrosion is a pressing scientific challenge that needs to be addressed.

SUMMARY

The invention aims to address at least the above problems and/or deficiencies and provide advantages that will be explained later. In order to achieve these objectives and other advantages according to the invention, a composite electrode material for a vanadium redox flow battery (VRFB) that balances corrosion resistance with high conductivity is provided, along with its preparation method. This resolves the technical challenges of simultaneously achieving good electrochemical performance and stability in strong acid for existing VRFB electrode materials.

The technical solution adopted to solve the technical problems in the invention is as follows:

A composite electrode material for a vanadium redox flow battery, balancing corrosion resistance with high conductivity, characterized by being constructed by the composite of a fluororesin and inorganic particles, with the ratio between the resin and inorganic particles being arbitrarily adjustable.

Furthermore, the fluororesin is a fluorine-containing polymer with a large molecular weight, exhibiting good chemical stability, thermal stability, and resistance to sulfuric acid corrosion.

Additionally, the inorganic particles have excellent conductivity and can be zero-dimensional, one-dimensional, two-dimensional, or even three-dimensional.

Furthermore, the two components can achieve a uniform and stable composite.

A method for preparing a composite electrode material for a vanadium redox flow battery that balances corrosion resistance with high conductivity, comprising the following steps:

S1. Mix the fluororesin with inorganic particles, grind in a mortar for 60 minutes to obtain a pre-mixed composite; S2. Place the pre-mixed composite obtained in step S1 into a ball mill for cryo-milling for 1-5 hours, sieve through a 400-mesh screen to obtain fine powder; S3. Place the fine powder obtained in step S2 into a mold, press using a press machine with a pressure of 5-25 MPa, maintain the pressure for 30-60 minutes to obtain a composite material; S4. Drill fine holes in the composite material obtained in step S3, insert wires, coat the surface with insulating glue to obtain a composite electrode material.

Furthermore, the ratio between the fluororesin and inorganic particles in step S1 is 9-3:1-7.

Furthermore, the rotation speed of the ball mill in step S2 is 200-600 rpm.

Furthermore, the fluororesin is a series of fluorine-containing polymers, also known as fluororesins, including polytetrafluoroethylene, polyvinylidene fluoride, ethylene-tetrafluoroethylene copolymer, polyvinyl fluoride, fluorinated ethylene propylene copolymer, perfluoroalkoxy resin, polyvinylidene fluoride, ethylene-chlorotrifluoroethylene copolymer, polyvinylidene fluoride, polytetrafluoroethylene, polyvinylidene difluoride-hexafluoropropylene copolymer, vinylidene fluoride-hexafluoropropylene copolymer, tetrafluoroethylene-hexafluoropropylene-vinylidene fluoride terpolymer, etc.

Furthermore, the inorganic particles are inorganic particles with conductivity, including graphite, carbon black, carbon fibers, carbon nanotubes, fullerenes, tin oxide, zinc oxide, iron sulfide, etc.

The present invention has at least the following beneficial effects:

(1) The composite electrode material for a vanadium redox flow battery, which balances corrosion resistance with high conductivity, comprises a fluororesin material containing fluorine elements. The fluororesin has excellent chemical stability, resistance to strong acid corrosion, thermal stability, and good mechanical properties, providing the composite electrode material in the present invention with good stability in VRFBs' sulfuric acid electrolyte. This ensures that the electrode material prepared

in this invention has a long service life, contributing to the overall longevity of vanadium redox flow batteries. LU506402

(2) The composite electrode material in this invention, which balances corrosion resistance with high conductivity, includes inorganic particles. The excellent conductivity and high mechanical strength of the inorganic particles provide the composite electrode material in the present invention with good ionic conductivity in the sulfuric acid electrolyte of vanadium redox flow batteries. This ensures that the electrode material prepared in this invention contributes to the good electrochemical properties of the constructed vanadium redox flow batteries.

(3) The electrode material in this invention is a composite electrode material based on a polymer matrix, avoiding side reactions such as hydrogen and oxygen evolution that may affect battery performance.

(4) The electrode material in this invention exhibits excellent overall performance and has a wide range of raw material sources, presenting good prospects for practical applications.

Other advantages, objectives, and features of the present invention will be partially revealed through the following detailed description and partially understood by those skilled in the art through their study and practice of the invention.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is an AC impedance diagram of the composite electrode material CP-1 prepared in Embodiment 1;

Figure 2 is an AC impedance diagram of the composite electrode material CP-2 prepared in Embodiment 2;

Figure 3 is an AC impedance diagram of the composite electrode material CP-3 prepared in Embodiment 3;

Figure 4 is an AC impedance diagram of the composite electrode material CP-4 prepared in Embodiment 4;

Figure 5 is an AC impedance diagram of the composite electrode material CP-5 prepared in Embodiment 5;

Figure 6 is an AC impedance diagram of the composite electrode material CP-6 LU506402 prepared in Embodiment 6;

Figure 7 is an AC impedance diagram of the composite electrode material CP-7 prepared in Embodiment 7;

Figure 8 is an AC impedance diagram of the composite electrode material CP-8 prepared in Embodiment 8;

Figure 9 is an AC impedance diagram of the composite electrode material CP-9 prepared in Embodiment 9;

Figure 10 is an AC impedance diagram of the composite electrode material CP-10 prepared in Embodiment 10;

Figure 11 is a comparison chart of the infrared spectra of composite electrode materials CP-9 and CP-10 prepared in Embodiment 9 and Embodiment 10.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be further described in detail below in conjunction with the accompanying drawings, so that those skilled in the art can implement it with reference to the text of the description.

It will be understood that terms such as "having," "comprising," and "including" as used herein do not connote the presence or addition of one or more other elements or combinations thereof.

The testing method of relevant data in the embodiment of the present invention is as follows:

The testing method for relevant data in the embodiments of the present invention is as follows:

Utilize the FTIR-1500 Fourier Transform Infrared Spectrometer for Fourier Transform Infrared (FT-IR) spectroscopy detection of the sample.

Use the CHI660D Electrochemical Workstation for alternating current impedance testing of the sample. Adopt a three-electrode system with an electrode material prepared in this invention, which is a corrosion-resistant and highly conductive fluororesin/inorganic particle vanadium redox flow battery electrode material, as the

working electrode. Graphite serves as the auxiliary electrode, and a saturated calomel electrode acts as the reference electrode. The electrolyte used is a sulfuric acid vanadium oxy sulfate (VOSO_4) aqueous solution. The electrochemical performance is tested in a 100 mL electrolytic cell. LU506402

Embodiment 1:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 1 hour at a speed of 500 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold, press it using a press machine at 20 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-1.

Embodiment 2:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 3 hours at a speed of 500 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold, press it using a press machine at 20 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-2.

Embodiment 3:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 5 hours at a speed of 500 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold,

press it using a press machine at 20 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-3. LU506402

Embodiment 4:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 2 hours at a speed of 400 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold, press it using a press machine at 20 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-4.

Embodiment 5:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 2 hours at a speed of 600 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold, press it using a press machine at 20 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-5.

Embodiment 6:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 2 hours at a speed of 550 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold,

press it using a press machine at 5 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-6.

Embodiment 7:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 2 hours at a speed of 550 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold, press it using a press machine at 15 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-7.

Embodiment 8:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 4:6 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 2 hours at a speed of 550 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold, press it using a press machine at 25 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-8.

Embodiment 9:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 1:9 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 2 hours at a speed of 550 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold,

press it using a press machine at 10 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-9.

Embodiment 10:

Weigh a mixture of carbon nanofibers and polytetrafluoroethylene (PTFE) at 10 g, with a mass ratio of 5:5 for carbon nanofibers to PTFE. Grind the mixture in a mortar for 60 minutes to obtain a pre-mixed composite. Put the obtained pre-mixed composite into a ball mill for cryogenic ball milling for 2 hours at a speed of 550 r/min, pass through a 400-mesh sieve to obtain fine powder. Put the fine powder into a mold, press it using a press machine at 10 MPa, maintain the pressure for 30 minutes, and obtain a composite material. Drill pores in the obtained composite material, insert wires, coat the surface with insulating adhesive, and obtain the composite electrode material CP-10.

Figures 1, 2, and 3 are AC impedance plots of the composite electrode materials CP-1, CP-2, and CP-3 prepared in Implementation Embodiments 1, 2, and 3, respectively. These are the results of AC impedance tests of the composite electrodes under conditions where the ball milling time was varied to 1 h, 2 h, and 3 h, respectively, while keeping other conditions constant. It can be observed that the electrical conductivity of the composite electrodes prepared by the present invention changes with the variation in ball milling time. Overall, the electrical conductivity of the composite electrodes prepared by the present invention is at a relatively good level.

Figures 4 and 5 are AC impedance plots of the composite electrode materials CP-4 and CP-5 prepared in Implementation Embodiments 4 and 5, respectively. These are the results of AC impedance tests of the composite electrodes under conditions where the ball milling speed was varied to 400 r/min and 600 r/min, respectively, while keeping other conditions constant. It can be observed that the electrical conductivity of the composite electrodes prepared by the present invention changes with the variation in ball milling speed.

Figures 6, 7, and 8 show AC impedance plots of the composite electrode materials CP-6, CP-7, and CP-8 prepared in Implementation Embodiments 6, 7, and 8, respectively. These are the results of AC impedance tests of the composite electrodes under conditions where the press machine pressure was varied to 5 MPa, 15 MPa, and 25 MPa, respectively, while keeping other conditions constant. It can be observed that the electrical conductivity of the composite electrodes prepared by the present invention changes with the variation in pressure.

Figures 9 and 10 show AC impedance plots of the composite electrode materials CP-9 and CP-10 prepared in Implementation Embodiments 9 and 10, respectively. These are the results of AC impedance tests of the composite electrodes under conditions where the ratio between fluororesin and inorganic particles was varied to 1:9 and 5:5, respectively, while keeping other conditions constant. It can be observed that the electrical conductivity of the composite electrodes prepared by the present invention changes with the variation in the ratio between fluororesin and inorganic particles.

Figure 11 compares the infrared spectra of the composite electrode materials CP-9 and CP-10 prepared in Implementation Embodiments 9 and 10. The characteristic peaks of polytetrafluoroethylene (PTFE) in the infrared spectra appear at 503 cm^{-1} , 557 cm^{-1} , 639 cm^{-1} , 1153 cm^{-1} , and 1210 cm^{-1} . By comparing the highest and lowest doping ratios (CNFs:PTFE) of 5:5 and 1:9, it can be observed that an increase in CNFs doping weakens the peaks at 1600~1700 cm^{-1} , strengthens the peak at 557 cm^{-1} , and causes a blue shift in the peak at 425 cm^{-1} , shifting it to 438 cm^{-1} . This indicates a significant mutual influence between the doping ratio and the infrared spectra, suggesting the successful composite of polytetrafluoroethylene and carbon nanofibers.

Although the embodiments of the present invention have been disclosed above, they are not limited to the applications listed in the description and embodiments. They can be applied to various fields suitable for the present invention. For those familiar with the art, they can easily make additional modifications, and the invention is therefore not limited to the specific details and illustrations shown and

described herein without departing from the general concept defined by the claims LU506402 and equivalent scope.

CLAIMS

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1. A composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity, characterized by being constructed by compounding fluorinated polymers with inorganic particles, and the ratio between the polymer and inorganic particles is adjustable.

2. The composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity as claimed in claim 1, characterized in that the fluororesin is a fluorine-containing polymer with a large molecular weight, exhibiting excellent chemical stability, thermal stability, and resistance to sulfuric acid corrosion.

3. The composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity as claimed in claim 1, characterized in that the inorganic particles have excellent conductivity and can be zero-dimensional, one-dimensional, two-dimensional, or even three-dimensional.

4. The composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity as claimed in claim 1, characterized in that the two components can achieve uniform and stable compounding together.

5. A method for preparing a composite electrode for a vanadium redox flow battery that balances corrosion resistance and high conductivity, as claimed in any one of claims 1-4, comprising the following steps: S1. mix fluorinated polymers with inorganic particles, grind in a mortar for 60 minutes to obtain a pre-mixed composite; S2. place the pre-mixed composite obtained in step S1 into a ball mill for cryo-milling for 1-5 hours, pass through a 400-mesh sieve to obtain fine powder; S3. place the fine powder obtained in step S2 into a mold, press using a hydraulic press at a pressure of

5-25 MPa, maintain pressure for 30-60 minutes to obtain a composite material; S4. LU506402 take the composite material obtained in step S3, drill fine holes, insert wires, coat the surface with insulating glue to obtain a composite electrode material.

6. The method for preparing a composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity as claimed in claim 5, wherein the ratio between the fluorinated polymer and inorganic particles in step S1 is 9-3:1-7.

7. The method for preparing a composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity as claimed in claim 5, wherein the rotational speed of the ball mill in step S2 is 200-600 revolutions per minute.

8. A composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity as claimed in claim 5, wherein the fluorinated polymer is a series of fluorine-containing polymers, also known as fluororesin, including polytetrafluoroethylene, polyvinylidene fluoride, ethylene-tetrafluoroethylene copolymer, polytetrafluoroethylene, perfluoroalkoxy resin, polyvinyl chloride-trifluoroethylene copolymer, ethylene-chlorotrifluoroethylene copolymer, polyvinylidene fluoride, polyfluoroethylene, polyvinylidene fluoride-hexafluoropropylene copolymer, vinylidene fluoride-tetrafluoroethylene copolymer, vinylidene fluoride-hexafluoropropylene copolymer, tetrafluoroethylene-hexafluoropropylene-vinylidene fluoride terpolymer, and the like.

9. A composite electrode material for a vanadium redox flow battery that balances corrosion resistance and high conductivity as claimed in claim 5, wherein the inorganic particles are conductive inorganic particles, including graphite, carbon black, carbon fibers, carbon nanotubes, fullerenes, tin oxide, zinc oxide, iron sulfide, and the like.

1. Un matériau d'électrode composite pour une batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et la conductivité élevée, caractérisé en ce qu'il est construit en mélangeant des polymères fluorés avec des particules inorganiques, et le rapport entre le polymère et les particules inorganiques est réglable.
2. Matériau d'électrode composite pour batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et la conductivité élevée selon la revendication 1, caractérisé en ce que la résine fluorée est un polymère contenant du fluor avec un poids moléculaire élevé, présentant une excellente stabilité chimique, une excellente stabilité thermique, et résistance à la corrosion par l'acide sulfurique.
3. Matériau d'électrode composite pour une batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et la conductivité élevée selon la revendication 1, caractérisé en ce que les particules inorganiques ont une excellente conductivité et peuvent être zéro dimensionnelles, unidimensionnelles, bidimensionnelles ou même en trois dimensions.
4. Matériau d'électrode composite pour une batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et la conductivité élevée selon la revendication 1, caractérisé en ce que les deux composants peuvent obtenir une composition uniforme et stable ensemble.
5. Procédé de préparation d'une électrode composite pour une batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et la conductivité élevée, selon l'une quelconque des revendications 1 à 4, comprenant les étapes suivantes : S1. mélanger des polymères fluorés avec des particules inorganiques, broyer dans un mortier pendant 60 minutes pour obtenir un composite pré-mélangé ; S2. placer le composite pré-mélangé obtenu à l'étape S1 dans un broyeur à boulets pour un cryobroyage pendant 1 à 5 heures, passer à travers un tamis de 400 mesh pour

obtenir une poudre fine ; S3. placer la poudre fine obtenue à l'étape S2 dans un moule, presser à l'aide d'une presse hydraulique à une pression de 5-25 MPa, maintenir la pression pendant 30-60 minutes pour obtenir un matériau composite ; S4. prendre le matériau composite obtenu à l'étape S3, percer des trous fins, insérer des fils, enduire la surface de colle isolante pour obtenir un matériau d'électrode composite.

6. Procédé de préparation d'un matériau d'électrode composite pour une batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et la conductivité élevée selon la revendication 5, dans lequel le rapport entre le polymère fluoré et les particules inorganiques à l'étape S1 est de 9-3:1-7.

7. Procédé de préparation d'un matériau d'électrode composite pour une batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et une conductivité élevée selon la revendication 5, dans lequel la vitesse de rotation du broyeur à boulets à l'étape S2 est de 200 à 600 tours par minute.

8. Matériau d'électrode composite pour batterie à flux redox au vanadium qui équilibre la résistance à la corrosion et la conductivité élevée selon la revendication 5, dans lequel le polymère fluoré est une série de polymères contenant du fluor, également connus sous le nom de résine fluorée, comprenant le polytétrafluoroéthylène, le fluorure de polyvinylidène, l'éthylène-copolymère de tétrafluoroéthylène, polytétrafluoroéthylène, résine perfluoroalcoxy, copolymère chlorure de polyvinyle-trifluoroéthylène, copolymère éthylène-chlorotrifluoroéthylène, fluorure de polyvinylidène, polyfluoroéthylène, copolymère fluorure de polyvinylidène-hexafluoropropylène, copolymère fluorure de vinylidène-tétrafluoroéthylène, copolymère fluorure de vinylidène-hexafluoropropylène, terpolymère tétrafluoroéthylène-hexafluoropropylène-fluorure de vinylidène, etc.

9. Matériau d'électrode composite pour une batterie à flux redox au vanadium qui LU506402
équilibre la résistance à la corrosion et la conductivité élevée selon la revendication 5,
dans lequel les particules inorganiques sont des particules inorganiques
conductrices, notamment du graphite, du noir de carbone, des fibres de carbone, des
nanotubes de carbone, des fullerènes, de l'oxyde d'étain, l'oxyde de zinc, le sulfure
de fer, etc.

FIGURES

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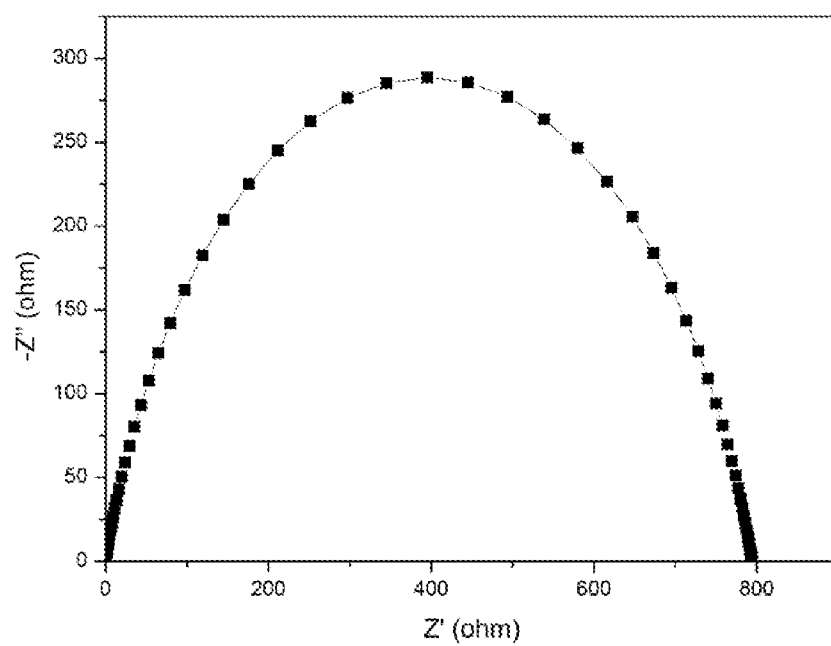


Figure1

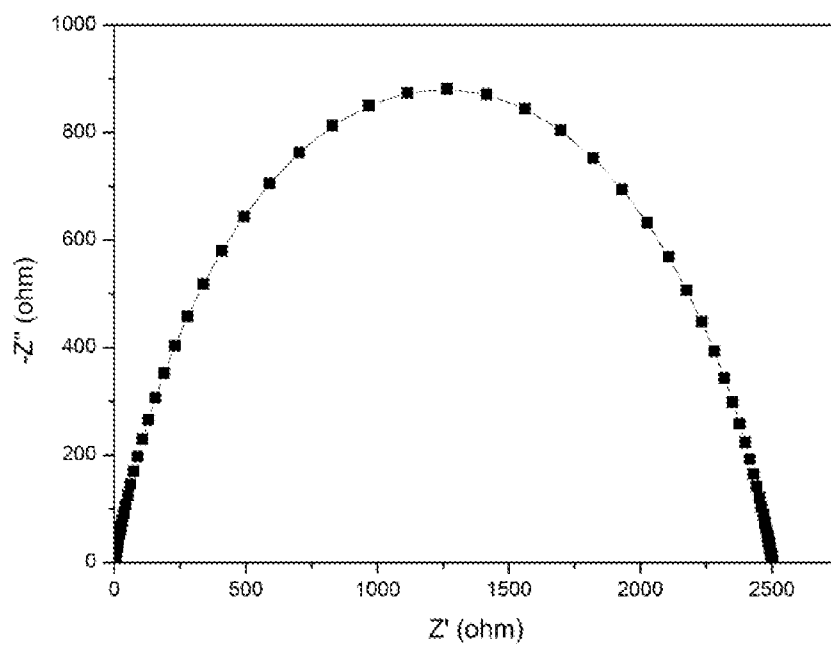


Figure2

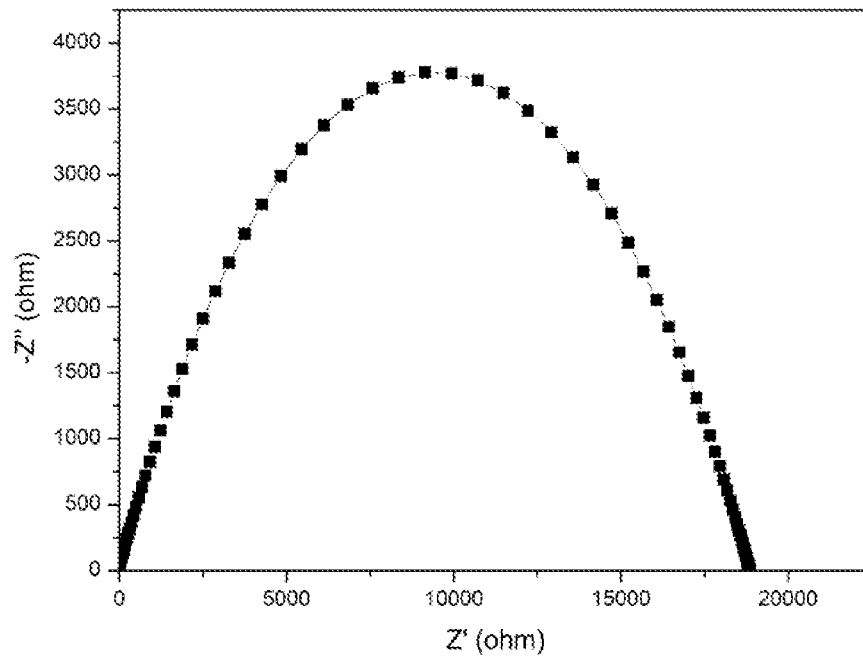


Figure3

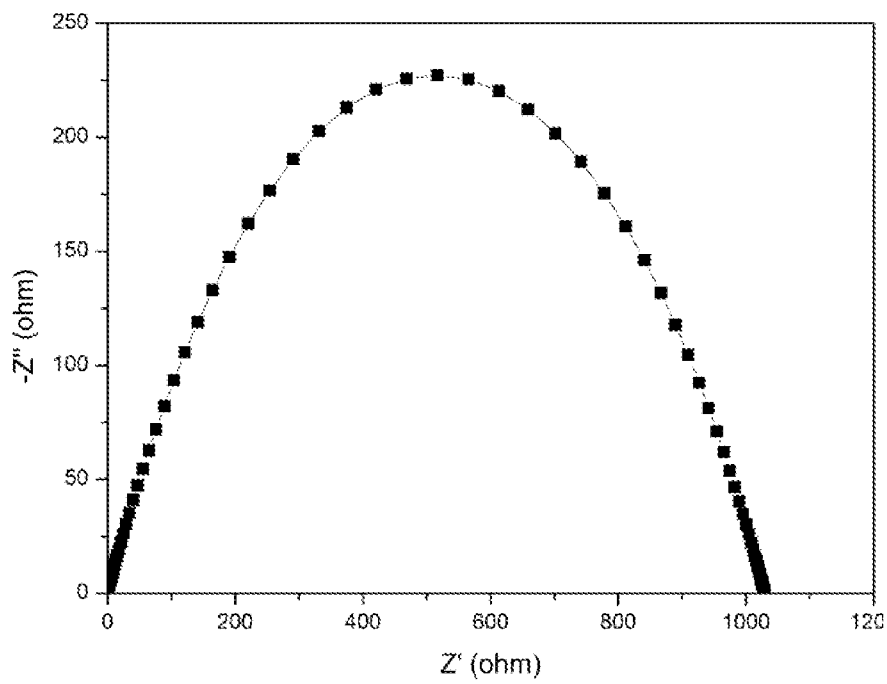


Figure4

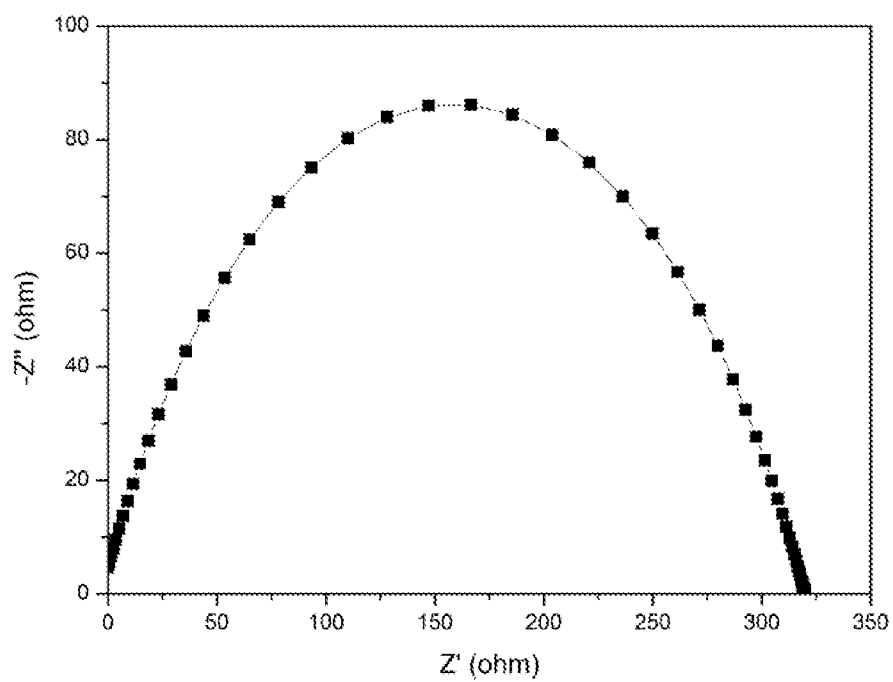


Figure5

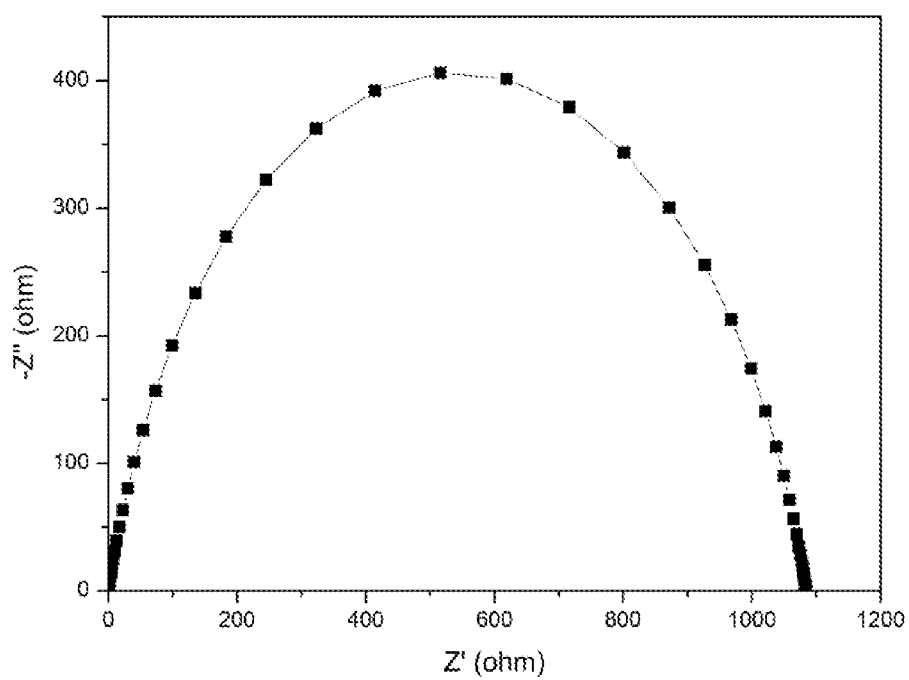


Figure6

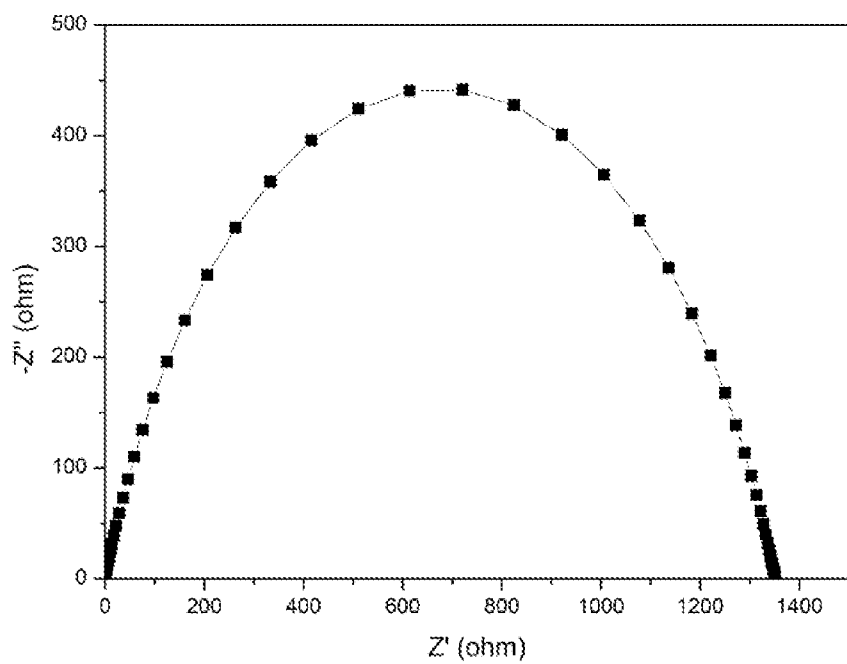


Figure7

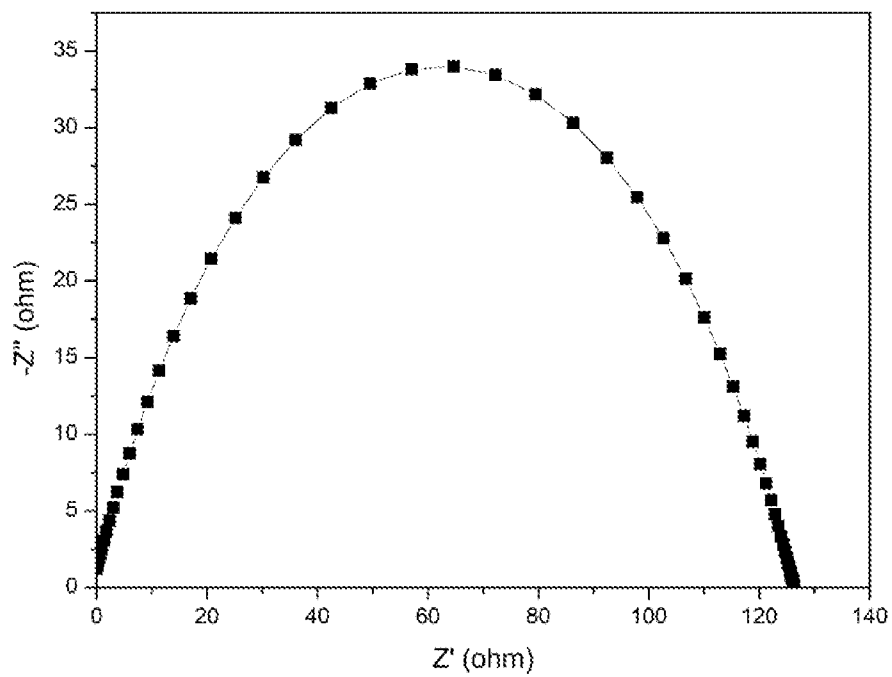


Figure8

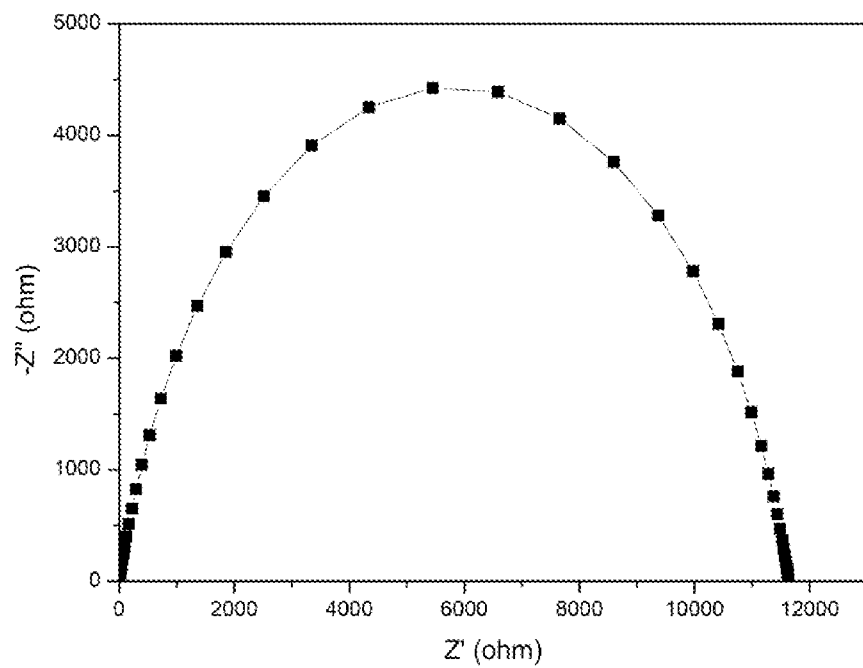


Figure9

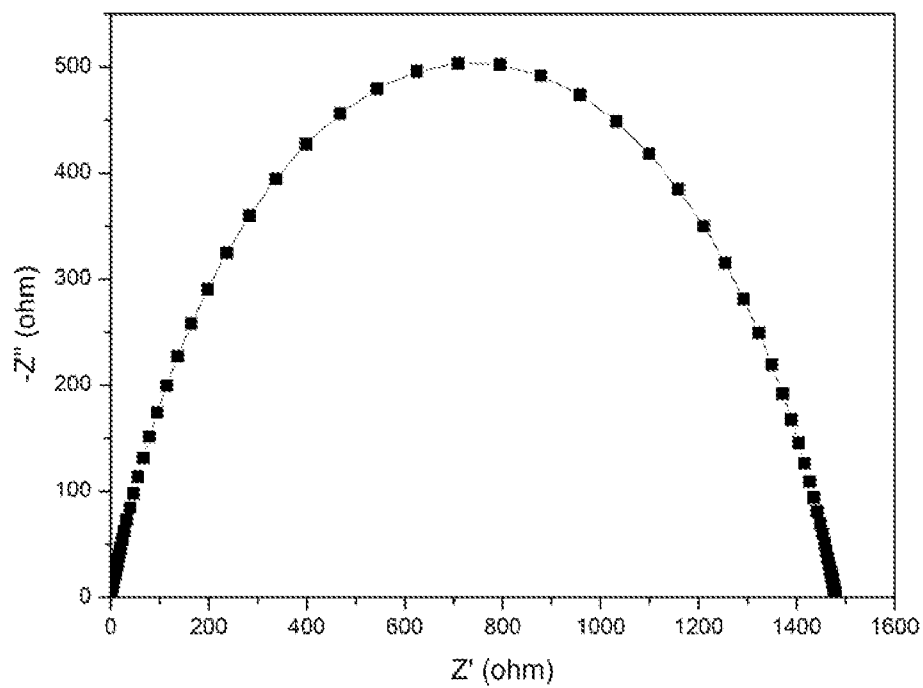


Figure10

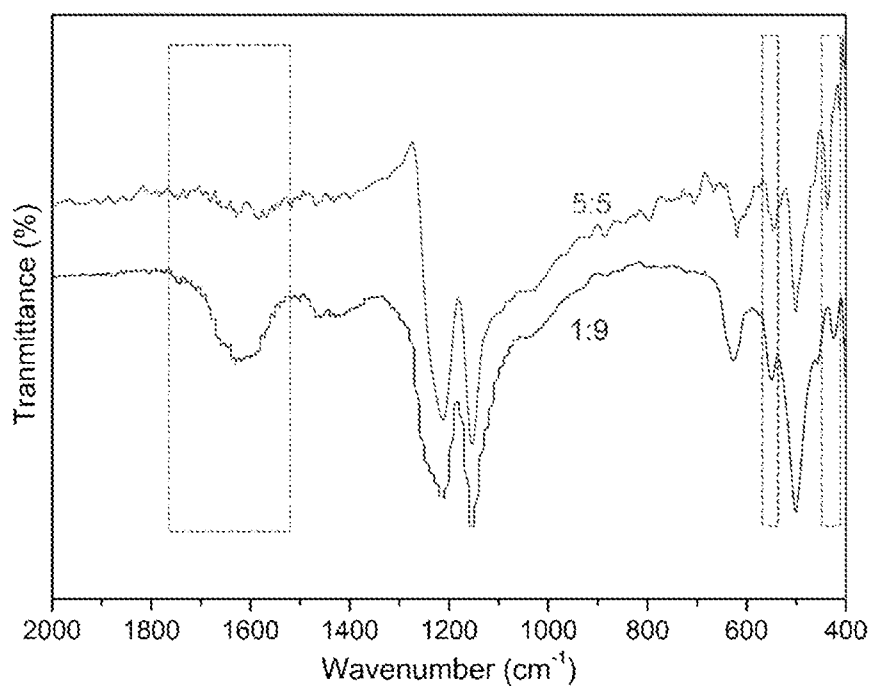


Figure11