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(54) The title of the invention

HIGH-ENERGY-DENSITY LITHIUM-ION BATTERY AND PREPARATION METHOD THEREOF

(57) Abstract

The present invention relates to the field of lithium-ion batteries, and in particular provides a high-energy-density lithium-ion battery and a preparation method thereof. A negative electrode plate on the outermost layer of a cell of the high-energy-density lithium-ion battery is a negative electrode plate provided with a negative electrode slurry on a single side, with the side without slurry facing outwards. The negative electrode plate on the outermost layer of the cell of the above high-energy-density lithium-ion battery is a negative electrode plate provided with a negative electrode slurry on a single side, while a negative electrode plate on the outermost layer of an existing cell is a negative electrode plate provided with a negative electrode slurry on double sides. Therefore, the mass of the cell is smaller than that of the existing cell, while the capacity of the battery remains unchanged. The energy density is the capacity divided by the mass, so the energy density is improved and the

cost is lower.

1. A high-energy-density lithium-ion battery, characterized in that a negative electrode plate on the outermost layer of a cell of the lithium-ion battery is a negative electrode plate provided with a negative electrode slurry on a single side, with the side without slurry facing outwards.

2. A method for preparing the high-energy-density lithium-ion battery of claim 1, comprising the following steps:

(a) applying a positive electrode slurry and a negative electrode slurry on both sides of a positive electrode current collector and a negative electrode current collector respectively, and then drying and compacting to form a double-sided positive electrode plate and a double-sided negative electrode plate;

(b) applying the negative electrode slurry on one side of the negative electrode current collector, and then drying and compacting to form a single-sided negative electrode plate;

(c) cutting the double-sided positive electrode plate, the double-sided negative electrode plate and the single-sided negative electrode plate into required sizes respectively and assembling them into a cell, wherein the single-sided negative electrode plate is provided on the outermost layer, with the side without slurry facing outwards; and

(d) placing the cell into a shell, then injecting an electrolyte into the shell, sealing the shell, and finally performing formation and grading to obtain the high-energy-density lithium-ion battery.

3. The method for preparing the high-energy-density lithium-ion battery according to claim 2, wherein in step (a), the positive electrode slurry is applied on both sides of the positive electrode current collector, and then dried at a temperature of 110-140°C, followed by rolling between rollers with a compaction density of 2.3-2.8 g/cm^3, forming the double-sided positive electrode plate.

4. The method for preparing the high-energy-density lithium-ion battery according to claim 2, wherein in step (a), the negative electrode slurry is applied on both sides of the negative electrode current collector, and then dried at a temperature of 95-110°C, followed by rolling between rollers with a compaction density of 1.5-2 g/cm^3, forming the double-sided negative electrode plate.

5. The method for preparing the high-energy-density lithium-ion battery according to claim 2, wherein in step (b), the negative electrode slurry is applied on one side of the negative electrode current collector, and then dried at a temperature of 95-110°C, followed by rolling between rollers with a compaction density of 1.5-2 g/cm^3, forming the single-sided negative electrode plate.

6. The method for preparing the high-energy-density lithium-ion battery according to any one of claims 2 to 5, wherein the positive electrode slurry comprises a positive electrode material, and the positive electrode material comprises at least one of lithium

cobalt oxide, lithium manganese oxide, nickel-cobalt-manganese ternary battery material, or lithium iron phosphate.

7. The method for preparing the high-energy-density lithium-ion battery according to claim 6, wherein the positive electrode material comprises a mixture of lithium manganese oxide and lithium iron phosphate.

8. The method for preparing the high-energy-density lithium-ion battery according to claim 7, wherein the mass ratio of lithium manganese oxide to lithium iron phosphate is 1:1 to 1:5.

9. The method for preparing the high-energy-density lithium-ion battery according to any one of claims 2 to 5, wherein the negative electrode slurry comprises a negative electrode material, and the negative electrode material comprises at least one of natural graphite, artificial graphite, carbon-silicon negative electrode material, soft carbon, or hard carbon.

10. The method for preparing the high-energy-density lithium-ion battery according to claim 9, wherein the negative electrode material comprises a mixture of artificial graphite and hard carbon.

HIGH-ENERGY-DENSITY LITHIUM-ION BATTERY AND PREPARATION METHOD THEREOF

FIELD OF THE INVENTION

[0001] The present invention relates to the field of lithium-ion batteries, and in particular to a high-energy-density lithium-ion battery and a preparation method thereof.

BACKGROUND OF THE INVENTION

[0002] With the continuous updating and development of lithium battery technology, its advantages of light weight, high capacity and long life are gradually gaining favor among consumers. The lithium battery market has expanded from mobile phones to cameras, DVDs, model airplanes, toys, and many other fields. In recent years, lithium-ion batteries have been widely used not only in portable electronic devices, but also in large and medium-sized electric equipment such as electric cars, electric bicycles and electric tools due to their advantages such as high voltage, many use cycles and long storage time.

[0003] With the popularization of mobile Internet devices such as smartphones and laptops, the promotion of electric vehicles such as electric bicycles and electric motorcycles, and the development of aerospace technologies such as drones and space probes, the performance of lithium-ion batteries is facing higher development requirements, and high energy density has become one of the research directions of high-performance lithium-ion batteries.

[0004] In view of this, the present invention is proposed.

SUMMARY OF THE INVENTION

[0005] A first object of the present invention is to provide a high-energy-density lithium-ion battery, wherein the lithium-ion battery has the advantages of high energy density and low cost.

[0006] A second object of the present invention is to provide a method for preparing a high-energy-density lithium-ion battery. The method has a scientific and simple process and strong operability. The high-energy-density lithium-ion battery prepared by the above method has the advantages of higher energy density and lower cost.

[0007] In order to achieve the above objectives of the present invention, the following technical solutions are adopted.

[0008] In a first aspect, the present invention provides a high-energy-density lithium-ion battery, wherein a negative electrode plate on the outermost layer of a cell of the lithium-ion battery is a negative electrode plate provided with a negative electrode slurry on a single side, with the side without slurry facing outwards.

[0009] In a second aspect, the present invention provides a method for preparing the above high-energy-density lithium-ion battery, comprising the following steps:

[0010] (a) applying a positive electrode slurry and a negative electrode slurry on both sides of a positive electrode current collector and a negative electrode current collector respectively, and then drying and compacting to form a double-sided positive electrode plate and a double-sided negative electrode plate;

[0011] (b) applying the negative electrode slurry on one side of the negative electrode current collector, and then drying and compacting to form a single-sided negative electrode plate;

[0012] (c) cutting the double-sided positive electrode plate, the double-sided negative electrode plate and the single-sided negative electrode plate into required sizes respectively and assembling them into a cell, wherein the single-sided negative electrode plate is provided on the outermost layer, with the side without slurry facing outwards; and

[0013] (d) placing the cell into a shell, then injecting an electrolyte into the shell, sealing the shell, and finally performing formation and grading to obtain the high-energy-density lithium-ion battery.

[0014] As a further preferred technical solution, in step (a), the positive electrode slurry is applied on both sides of the positive electrode current collector, and then dried at a temperature of 110-140°C, followed by rolling between rollers with a compaction density of 2.3-2.8 g/cm^3, forming the double-sided positive electrode plate.

[0015] As a further preferred technical solution, in step (a), the negative electrode slurry is applied on both sides of the negative electrode current collector, and then dried at a temperature of 95-110°C, followed by rolling between rollers with a compaction density of 1.5-2 g/cm^3, forming the double-sided negative electrode plate.

[0016] As a further preferred technical solution, in step (b), the negative electrode slurry is applied on one side of the negative electrode current collector, and then dried at a temperature of 95-110°C, followed by rolling between rollers with a compaction density of 1.5-2 g/cm^3, forming the single-sided negative electrode plate.

[0017] As a further preferred technical solution, the positive electrode slurry comprises a positive electrode material, and the positive electrode material comprises at least one of lithium cobalt oxide, lithium manganese oxide, nickel-cobalt-manganese ternary battery material, or lithium iron phosphate.

[0018] As a further preferred technical solution, the positive electrode material comprises a mixture of lithium manganese oxide and lithium iron phosphate.

[0019] As a further preferred technical solution, the mass ratio of lithium manganese oxide to lithium iron phosphate is 1:1 to 1:5.

[0020] As a further preferred technical solution, the negative electrode slurry comprises a negative electrode material, and the negative electrode material comprises at least one of natural graphite, artificial graphite, carbon-silicon negative electrode material, soft carbon, or hard carbon.

[0021] As a further preferred technical solution, the negative electrode material comprises a mixture of artificial graphite and hard carbon.

[0022] Compared with the prior art, the beneficial effects of the present invention are as follows:

[0023] The negative electrode plate on the outermost layer of the cell of the high-energy-density lithium-ion battery provided by the present invention is a negative electrode plate provided with a negative electrode slurry on a single side, while a negative electrode plate on the outermost layer of an existing cell is a negative electrode plate provided with a negative electrode slurry on double sides. Therefore, the mass of the cell is smaller than that of the existing cell, while the capacity of the battery remains unchanged. The energy density is the capacity divided by the mass, so the energy density is improved and the cost is lower. Herein, the reason why the capacity of the battery remains unchanged is that: the number of positive electrode plates in the lithium-ion battery is less than that of negative electrode plates, that is, the negative electrode plates are relatively abundant, so the battery capacity is mainly determined by active materials in the positive electrode plates; the content of the active materials has not changed, so the battery capacity remains unchanged.

[0024] In the method for preparing the high-energy-density lithium-ion battery provided by the present invention, two different negative electrode plates, namely a double-sided negative electrode plate and a single-sided negative electrode plate, are prepared. The process is scientific and simple, and the operability is strong. The high-energy-density lithium-ion battery prepared by the above method has the advantages of higher energy density and lower cost.

DETAILED DESCRIPTION OF THE INVENTION

[0025] The embodiments of the present invention will be described in detail below with reference to examples, but those skilled in the art will appreciate that the following examples are only used to illustrate the present invention and should not be construed as limiting the scope of the present invention. If the specific conditions are not specified in the examples, the conditions should be followed according to the conventional conditions or the conditions recommended by the manufacturers.

[0026] In a first aspect, the present invention provides a high-energy-density lithium-ion battery, wherein a negative electrode plate on the outermost layer of a cell of the lithium-ion battery is a negative electrode plate provided with a negative electrode slurry on a single side, with the side without slurry facing outwards.

[0027] The negative electrode plate on the outermost layer of the cell of the above high-energy-density lithium-ion battery is a negative electrode plate provided with a negative electrode slurry on a single side, while a negative electrode plate on the outermost layer of an existing cell is a negative electrode plate provided with a negative electrode slurry on double sides. Therefore, the mass of the cell is smaller than that of the existing cell, while the capacity of the battery remains unchanged. The energy density is the capacity divided by the mass, so the energy density is improved and the cost is lower. Herein, the reason why the capacity of the battery remains unchanged is that: the number of positive electrode plates in the lithium-ion battery is less than that of negative electrode plates, that is, the negative electrode plates are relatively abundant, so the battery capacity is mainly determined by active materials in the positive electrode plates; the content of the active materials has not changed, so the battery capacity remains unchanged.

[0028] In the present invention, "a negative electrode plate provided with a negative electrode slurry" should be understood in a broad sense: when the battery is a stacked type, the above negative electrode plate is independent of other negative electrode plates; when the battery is a wound type, the above negative electrode plate is the end of the entire negative electrode plate, and the end is provided with the negative electrode slurry only on a single side.

[0029] It should be understood that "a negative electrode plate on the outermost layer of a cell" refers to a negative electrode plate among all the negative electrode plates that is located at the outermost layer of a cell; and "the side without slurry facing outward" means that the side not provided with a negative electrode slurry is facing the outside of the cell.

[0030] In a second aspect, the present invention provides a method for preparing the above high-energy-density lithium-ion battery, comprising the following steps:

[0031] (a) applying a positive electrode slurry and a negative electrode slurry on both sides of a positive electrode current collector and a negative electrode current collector respectively, and then drying and compacting to form a double-sided positive electrode plate and a double-sided negative electrode plate;

[0032] (b) applying the negative electrode slurry on one side of the negative electrode current collector, and then drying and compacting to form a single-sided negative electrode plate;

[0033] (c) cutting the double-sided positive electrode plate, the double-sided negative electrode plate and the single-sided negative electrode plate into required sizes respectively and assembling them into a cell, wherein the single-sided negative electrode plate is provided on the outermost layer, with the side without slurry facing outwards; and

[0034] (d) placing the cell into a shell, then injecting an electrolyte into the shell, sealing the shell, and finally performing formation and grading to obtain the high-energy-density lithium-ion battery.

[0035] In the method for preparing the above high-energy-density lithium-ion battery, two different negative electrode plates, namely a double-sided negative electrode plate and a single-sided negative electrode plate, are prepared. The process is scientific and simple, and the operability is strong. The high-energy-density lithium-ion battery prepared by the above method has the advantages of higher energy density and lower cost.

[0036] What is prepared by the above method is a stacked-type lithium-ion battery, which has the advantages of low internal resistance, great high-rate discharge capacity, high discharge platform, high capacity density, high energy density, high thickness controllability, not easy to deform and flexible size compared to a wound-type lithium-ion battery, and has a wider range of applications.

[0037] The drying temperature of an electrode plate has a certain influence on the electrode plate. If the drying temperature is too low, the drying time will be increased and the production cycle will be extended. If the drying temperature is too high, cracks will easily occur, affecting product performance. The compaction density has a great influence on battery performance. The compaction density is closely related to the specific capacity of the electrode plate, efficiency, internal resistance and battery cycle performance. Within a certain range, the greater the compaction density, the higher the battery capacity. However, when the compaction density is too large or too small, it will be unfavorable for the intercalation and deintercalation of lithium ions.

[0038] Based on the above considerations, in a preferred embodiment, in step (a), the positive electrode slurry is applied on both sides of the positive electrode current collector, and then dried at a temperature of 110-140°C, followed by rolling between rollers with a compaction density of 2.3-2.8 g/cm^3, forming the double-sided positive electrode plate. The above drying temperature is typically, but not limited to, 110°C, 115°C, 120°C, 125°C, 130°C, 135°C, or 140°C; the above compaction density is typically, but not limited to, 2.3 g/cm^3, 2.4 g/cm^3, 2.5 g/cm^3, 2.6 g/cm^3, 2.7 g/cm^3, or 2.8 g/cm^3.

[0039] Based on the above considerations, in a preferred embodiment, in step (a), the negative electrode slurry is applied on both sides of the negative electrode current collector, and then dried at a temperature of 95-110°C, followed by rolling between rollers with a compaction density of 1.5-2 g/cm^3, forming the double-sided negative electrode plate. The above drying temperature is typically, but not limited to, 95°C, 96°C, 98°C, 100°C, 102°C, 104°C, 106°C, 108°C, or 110°C; the above compaction density is typically, but not limited to, 1.5 g/cm^3, 1.6 g/cm^3, 1.7 g/cm^3, 1.8 g/cm^3, 1.9 g/cm^3, or 2 g/cm^3.

[0040] Based on the above considerations, in a preferred embodiment, in step (b), the negative electrode slurry is applied on one side of the negative electrode current collector, and then dried at a temperature of 95-110°C, followed by rolling between rollers with a compaction density of 1.5-2 g/cm^3, forming the single-sided negative electrode plate. The above drying temperature is typically, but not limited to, 95°C, 96°C, 98°C, 100°C, 102°C, 104°C, 106°C, 108°C, or 110°C; the above compaction density is typically, but not limited to, 1.5 g/cm^3, 1.6 g/cm^3, 1.7 g/cm^3, 1.8 g/cm^3, 1.9 g/cm^3, or 2 g/cm^3.

[0041] In a preferred embodiment, the positive electrode slurry comprises a positive electrode material, and the positive electrode material comprises at least one of lithium cobalt oxide, lithium manganese oxide, nickel-cobalt-manganese ternary battery material, or lithium iron phosphate. Lithium cobalt oxide has a gray-black powder appearance, excellent electrochemical performance, first discharge specific capacity greater than 135 mAh/g, and high tap density, which helps to improve the volume specific capacity of the battery, and the product performance is stable and consistent. Lithium manganese oxide has the advantages of low price, high potential, environmental friendliness, and high safety performance. Nickel-cobalt-manganese ternary battery material has low cost, high gram capacity (>150 mAh/g), good matching of working voltage with existing electrolyte (4.1V), and good safety. Lithium iron phosphate has a theoretical specific capacity of as high as 170 mAh/g. It is the safest lithium-ion battery positive electrode material at present. It does not contain any heavy metal elements that are harmful to the human body, has a long life, and can be charged and discharged more than 2000 times under 100% DOD conditions.

[0042] The positive electrode material in the present invention is typically, but not limited to, lithium cobalt oxide, lithium manganese oxide, nickel-cobalt-manganese ternary battery material, lithium iron phosphate, a mixture of lithium cobalt oxide and lithium manganese oxide, a mixture of lithium manganese oxide and lithium iron phosphate, a mixture of nickel-cobalt-manganese ternary battery material and lithium iron phosphate, a mixture of lithium cobalt oxide, lithium manganese oxide and nickel-cobalt-manganese ternary battery material, a mixture of lithium manganese oxide, nickel-cobalt-manganese ternary battery material and lithium iron phosphate, etc.

[0043] In a preferred embodiment, the positive electrode material comprises a mixture of lithium manganese oxide and lithium iron phosphate. Using a mixture of lithium manganese oxide and lithium iron phosphate as the positive electrode material can not only make the battery price more moderate, but also improve the high and low temperature cycle performance.

[0044] In a preferred embodiment, the mass ratio of lithium manganese oxide to lithium iron phosphate is 1:1 to 1:5. The above mass ratio is typically, but not limited to, 1:1, 1:2, 1:3, 1:4, or 1:5. The mixture of lithium manganese oxide and lithium iron phosphate in the above mass ratio as the positive electrode material can make the performance of the battery more excellent.

[0045] In a preferred embodiment, the negative electrode slurry comprises a negative electrode material, and the negative electrode material comprises at least one of natural graphite, artificial graphite, carbon-silicon negative electrode material, soft carbon, or hard carbon. Natural graphite negative electrode material is made of natural flaky crystalline graphite through crushing, spheroidization, classification, passivation, surface treatment and other processes. Its high crystallinity is naturally formed. Artificial graphite negative electrode material is made by sintering graphitizable carbon (such as petroleum coke, needle coke, asphalt coke, etc.) at a certain temperature, and then crushing, classification, and high-temperature graphitization. Its high crystallinity is formed by high-temperature graphitization. Carbon-silicon negative electrode material is carbon-silicon composite negative electrode material, and its structure mainly includes coated type, embedded type, and doped type. Nano-scale silicon-carbon negative electrode material has high lithium storage capacity (the theoretical capacity at room temperature is as high as 3580 mAh/g), far exceeding graphite (372 mAh/g), good electron channels, small strain, and an environment that promotes the stable growth of SEI films. Soft carbon, also known as graphitizable carbon, refers to amorphous carbon that can be graphitized under high temperature conditions above 2000°C. It has low crystallinity, small grain size, large interplanar spacing, good compatibility with electrolyte, high irreversible capacity of the first charge and discharge, low output voltage, and no obvious charge and discharge platform potential. Common soft carbons include petroleum coke and needle coke. Hard carbon, also known as non-graphitizable carbon, is the pyrolytic carbon of high molecular polymers. This type of carbon is difficult to graphitize even at a high temperature of 3000°C. Hard carbon includes resin carbon, organic polymer pyrolytic carbon, carbon black, etc. Among them, polyfurfuryl alcohol resin carbon as lithium-ion negative electrode material has a specific capacity of up to 400 mAh/g and appropriate interplanar spacing, which is conducive to the intercalation of lithium without causing significant expansion of the structure, and has good charge and discharge cycle performance.

[0046] The negative electrode material in the present invention is typically, but not limited to, natural graphite, artificial graphite, carbon-silicon negative electrode material, soft carbon, hard carbon, a mixture of natural graphite and artificial graphite, a mixture of artificial graphite and hard carbon, a mixture of carbon-silicon negative electrode material and soft carbon, a mixture of soft carbon and hard carbon, a mixture of natural graphite, artificial graphite and carbon-silicon negative electrode material, a mixture of carbon-silicon negative electrode material, soft carbon and hard carbon, etc.

[0047] In a preferred embodiment, the negative electrode material comprises a mixture of artificial graphite and hard carbon. Further preferably, the mass ratio of artificial graphite to hard carbon is 4:1 to 1:2. The above mass ratio is typically, but not limited to, 4:1, 3:1, 2:1, 1:1, or 1:2. The mixture of artificial graphite and hard carbon in the above mass ratio as the negative electrode material can make the performance of the battery more excellent.

[0048] It should be understood that the preparation steps and parameters not mentioned in the present invention, such as the particle size of the positive electrode material or the negative electrode material, the selection and addition amount of a conductive agent, a binder and a solvent in the positive electrode slurry or the negative electrode slurry, etc., can be selected according to the conventional methods in the art, and the present invention does not impose any particular limitation on this.

[0049] The present invention will be further described in detail below with reference to examples and comparative examples.

[0050] Example 1

[0051] A high-energy-density lithium-ion battery, wherein a negative electrode plate on the outermost layer of a cell of the lithium-ion battery is a negative electrode plate provided with a negative electrode slurry on a single side, with the side without slurry facing outwards;

[0052] a method for preparing the above high-energy-density lithium-ion battery comprises the following steps:

[0053] (a) a positive electrode slurry and a negative electrode slurry were applied on both sides of a positive electrode current collector and a negative electrode current collector, respectively, and then dried and compacted to form a double-sided positive electrode plate and a double-sided negative electrode plate; the drying temperature of the double-sided positive electrode plate was 105°C, and the compaction density was 3.0 g/cm^3; the drying temperature of the double-sided negative electrode plate was 115°C and the compaction density was 2.5 g/cm^3;

[0054] (b) the negative electrode slurry was applied on one side of the negative electrode current collector, and then dried and compacted to form a single-sided negative electrode plate; the drying temperature of the single-sided negative electrode plate was 115°C, and the compaction density was 2.5 g/cm^3;

[0055] the positive electrode material was lithium cobalt oxide; the negative electrode material was natural graphite;

[0056] (c) the double-sided positive electrode plate, the double-sided negative electrode plate and the single-sided negative electrode plate were cut into required sizes respectively and assembled into a cell, wherein the single-sided negative electrode plate was provided on the outermost layer, with the side without slurry facing outwards; and

[0057] (d) the cell was placed into a shell, then an electrolyte was injected into the shell, the shell was sealed, and formation and grading were finally performed to obtain the high-energy-density lithium-ion battery.

[0058] After testing by a lithium battery grading system, the lithium-ion battery in Example 1 had a capacity of 30.51 Ah, an energy density of 190.35 Wh/kg, and 2267 cycles at 1C.

[0059] Example 2

[0060] A high-energy-density lithium-ion battery, different from Example 1 in that the drying temperature of the double-sided positive electrode plate was 120°C, and the compaction density was 2.5 g/cm^3; the drying temperature of the double-sided negative electrode plate was 100°C and the compaction density was 1.8 g/cm^3; the drying temperature of the single-sided negative electrode plate was 100°C and the compaction density was 1.8 g/cm^3; the remaining steps and parameters were the same as those in Example 1.

[0061] After testing by the lithium battery grading system, the lithium-ion battery in Example 2 had a capacity of 31.48 Ah, an energy density of 189.92 Wh/kg, and 2146 cycles at 1C.

[0062] Example 3

[0063] A high-energy-density lithium-ion battery, different from Example 1 in that the drying temperature of the double-sided positive electrode plate was 110°C, and the compaction density was 2.3 g/cm^3; the drying temperature of the double-sided negative electrode plate was 95°C and the compaction density was 1.5 g/cm^3; the drying temperature of the single-sided negative electrode plate was 95°C and the compaction density was 1.5 g/cm^3; the remaining steps and parameters were the same as those in Example 1.

[0064] After testing by the lithium battery grading system, the lithium-ion battery in Example 3 had a capacity of 32.44 Ah, an energy density of 191.28 Wh/kg, and 2071 cycles at 1C.

[0065] Example 4

[0066] A high-energy-density lithium-ion battery, different from Example 1 in that the drying temperature of the double-sided positive electrode plate was 140°C, and the compaction density was 2.8 g/cm^3; the drying temperature of the double-sided negative electrode plate was 110°C and the compaction density was 2 g/cm^3; the drying temperature of the single-sided negative electrode plate was 110°C and the compaction density was 2 g/cm^3; the remaining steps and parameters were the same as those in Example 1.

[0067] After testing by the lithium battery grading system, the lithium-ion battery in Example 4 had a capacity of 31.85 Ah, an energy density of 190.39 Wh/kg, and 2154 cycles at 1C.

[0068] Example 5

[0069] A high-energy-density lithium-ion battery, different from Example 1 in that the positive electrode material was a mixture of lithium manganese oxide and lithium iron phosphate, and the mass ratio of lithium manganese oxide to lithium iron phosphate was 1:3; the remaining steps and parameters were the same as those in Example 1.

[0070] After testing by the lithium battery grading system, the lithium-ion battery in Example 5 had a capacity of 30.48 Ah, an energy density of 191.72 Wh/kg, and 2089 cycles at 1C.

[0071] Example 6

[0072] A high-energy-density lithium-ion battery, different from Example 1 in that the negative electrode material was a mixture of artificial graphite and hard carbon, and the mass ratio of artificial graphite to hard carbon was 2:1; the remaining steps and parameters were the same as those in Example 1.

[0073] After testing by the lithium battery grading system, the lithium-ion battery in Example 6 had a capacity of 31.34 Ah, an energy density of 192.19 Wh/kg, and 2248 cycles at 1C.

[0074] Example 7

[0075] A high-energy-density lithium-ion battery, different from Example 1 in that the positive electrode material was a mixture of lithium manganese oxide and lithium iron phosphate, and the mass ratio of lithium manganese oxide to lithium iron phosphate was 1:3; and the negative electrode material was a mixture of artificial graphite and hard carbon, and the mass ratio of artificial graphite to hard carbon was 2:1; the remaining steps and parameters were the same as those in Example 1.

[0076] After testing by the lithium battery grading system, the lithium-ion battery in Example 7 had a capacity of 32.98 Ah, an energy density of 191.56 Wh/kg, and 2469 cycles at 1C.

[0077] Comparative Example 1

[0078] A lithium-ion battery, the preparation method of which comprises the following steps:

[0079] (a) a positive electrode slurry and a negative electrode slurry were applied on both sides of a positive electrode current collector and a negative electrode current collector, respectively, and then dried and compacted to form a double-sided positive electrode plate and a double-sided negative electrode plate; the drying temperature of the double-sided positive electrode plate was 105°C, and the compaction density was 3.0 g/cm^3; the drying temperature of the double-sided negative electrode plate was 115°C and the compaction density was 2.5 g/cm^3;

[0080] the positive electrode material was lithium cobalt oxide; the negative electrode material was natural graphite;

[0081] (c) the double-sided positive electrode plate and the double-sided negative electrode plate were cut into required sizes and assembled into a cell, wherein the single-sided negative electrode plate was provided on the outermost layer, with the side without slurry facing outwards;

[0082] (d) the cell was placed into a shell, then an electrolyte was injected into the shell, the shell was sealed, and formation and grading were finally performed to obtain the high-energy-density lithium-ion battery.

[0083] After testing by the lithium battery grading system, the lithium-ion battery in Comparative Example 1 had a capacity of 31.69 Ah, an energy density of 170.43 Wh/kg, and 2058 cycles at 1C.

[0084] Although the present invention has been illustrated and described with specific examples, it will be appreciated that many other changes and modifications can be made without departing from the spirit and scope of the present invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of the present invention.

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DECLARATION OF TRANSLATOR

I, LI XIAO YUAN, hereby declare as follows:

1. I personally performed the attached translation from Chinese into English of the patent that is entitled "高能量密度的锂离子电池及其制备方法" in Chinese and "HIGH-ENERGY-DENSITY LITHIUM-ION BATTERY AND PREPARATION METHOD THEREOF" in English

2. The attached translation is, to the best of my knowledge, a true, full and accurate translation of the attached Chinese document.

3. I am competent to perform this translation, because I have a ***Master's Degree in Materials Chemistry***.

4. I declare under the penalty of perjury under the laws of the United States that the foregoing is true and correct; and further declare that I am aware that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 1001 of Title 18 of the United States Code.

Dated: Dec. 22, 2024

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