(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 July 2006 (06.07.2006)

PCT

(10) International Publication Number
WO 2006/069544 A1

(51) International Patent Classification:
H01M 10/40 (2006.01)

(21) International Application Number:
PCT/CN2005/002389

(22) International Filing Date:
30 December 2005 (30.12.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2004101040322
31 December 2004 (31.12.2004) CN

(71) Applicant *(for all designated States except US)*: **BYD COMPANY LIMITED** [CN/CN]; Yan An Road, Kuichong, Longgang, Shenzhen, Guangdong 518119 (CN).

(72) Inventors: **XIAO, Feng**; Yan An Road, Kuichong, Longgang, Shenzhen, Guangdong 518119 (CN). **WANG, Mingxia**; Yan An Road, Kuichong, Longgang, Shenzhen, Guangdong 518119 (CN).

(74) Agent: **RUNPING & PARTNERS**; Suite 509, Yingu Mansion, N0. 9 Beisihuanxilu, Haidian District, Beijing 100080 (CN).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2006/069544 A1

(54) Title: ELECTROLYTES FOR LITHIUM ION SECONDARY BATTERIES

(57) Abstract: The present invention relates to additives for electrolytes of lithium ion secondary batteries that include one or more of the following: 1,3-propane sultone, succinic anhydride; ethenyl sulfonyl benzene, and halobenzene. It can also include biphenyl, cyclohexylbenzene; and vinylene carbonate. The weight of said 1,3-propane sultone is between 0.5 wt.% and 96.4 wt.%, said succinic anhydride is between 0.5 wt.% and 96.4 wt.%; said ethenyl sulfonyl benzene is between 0.5 wt.% and 95.2wt.%; and said halobenzene is between 0.5 wt.% and 95.2 wt.% of the weight of the additive. Batteries with electrolytes containing said additives have improved over-charge characteristics and low temperature properties, and reduced gas generation during charging and discharging.

Electrolytes for Lithium Ion Secondary Batteries

Cross Reference

[1] This application claims priority from a Chinese patent application entitled "Mixed Additives, Electrolytes and Lithium-Ion Secondary Batteries with said Additives" filed on December 31, 2004 and having a Chinese Application No. 2004101040322. Said application is incorporated herein by reference.

Field of Invention

[2] This invention relates to electrolytes for lithium ion secondary batteries. Particularly, it relates to additives for electrolytes in lithium ion secondary batteries.

Background

[3] Since their commercial introduction more than a decade ago, lithium ion secondary batteries has rapidly gained in their market share, a rate of adoption by consumers that is unseen in Cd-Ni, MH-Ni, and lead-acid batteries. This rapid development is a result of their exceptional characteristics that include: a high operating voltage, a high relative energy, wide operation temperature range, low self-discharge rate, long cycling life, low energy loss, zero memory effect, pollution-free operation, and improved safety. Lithium-ion batteries are widely used as the power source in small and expensive electronic devices such as cellular phones, laptop computers, medical devices, video cameras, and digital cameras. They have also gradually replaced traditional batteries in aerospace, aviation, naval, satellite, telecommunication, and military applications.

[4] Most newer lithium-ion batteries use carbon material for their negative electrodes. They use materials that can embed and detach lithium such as $LiCoO_2$, $LiNiO_2$, and $LiMn_2O4$ as materials for positive electrodes. The electrolyte of lithium-ion batteries generally comprises of organic solvents, electrolyte solids that are lithium salts, and additives. Organic solvents are the main constituent of electrolytes and they significantly affect the property of the electrolyte. Although there are many organic solvents and lithium salts, only a limited few can be used in lithium-ion batteries. Generally the electrolyte comprises a mixture of high dielectric constant solvents, low-viscosity solvents, and solvents that are electrochemically stabile, with wide electrical potential, wide

operation temperature ranges, good heat stability, and low toxicity, are chemically stable, safe, and do not chemically react with the current collector and the active ingredients in the batteries.

[5] The electrolyte is an important component of a battery, greatly affecting its properties. In traditional batteries, the electrolyte has an aqueous solution as the solvent. There are many choices for the aqueous solution as many chemicals dissolves well in water and the chemical and physical characteristics of many aqueous solutions are well understood. However, since the theoretical decomposition voltage of water is only 1.23V. Therefore, even when the overpotential of oxygen or hydrogen is taken into account, the maximum voltage is only about 2V for a battery with an electrolyte that comprises of aqueous solutions such as those in lead-acid secondary batteries. Traditional aqueous solutions cannot be used in lithium ion batteries as their voltage can reach as high as 3V to 4V. Therefore, the key to further development of lithium-ion batteries lies in the research of electrolyte solids and organic solvents that do not decompose at high voltage.

[6] A number of problems exist in present lithium ion batteries. A common problem is that the gas generated during charging and discharging from the decomposition of the electrolyte on the surface of the negative electrode increases the thickness of the battery. The electrical conductivity rate of organic electrolytes is also low. In addition, the solvent is flammable and easily evaporates. When the battery is over-charged or short-circuited due to misuse, dangerous conditions such as an explosion can occur. The heat stability of lithium ion batteries poses another safety issue. When the heat generated by the reactions in the battery exceeds its ability to dissipate heat, the temperature of a battery can reach its ignition point, resulting in a fire or an explosion.

[7] In recent years, adding additives is an important research approach to improve the properties of lithium ion batteries. Adding small amounts of certain chemicals, i.e., additives, to the electrolyte of a lithium ion secondary battery, can markedly improve certain properties such as the electrolyte's electrical conductivity rate and the battery's cycling efficiency and reversible capacity. These additives do not significantly increase the production costs of a battery but have the effect of substantially improving its performance.

[8] Many patents have discussed the addition of additives to the electrolyte. Sanyo Company's Japanese Patent 2000-58112, Sony Company's Japanese Patent 2000-156243, and GS Company's Japanese Patent 2001-126765 disclosed that the addition of biphenyl

could markedly improve a battery's ability to withstand over-charge. Mitsubishi Company's Japanese patent 2003-77478 disclosed that, by adding 0.02% to 0.1% of biphenyl in the positive electrode, over-charge could be effectively prevented after multiple cycles. Japanese Patent 2001-15155, jointly held by Sanyo Company and UBE, disclosed that, aromatic hydrocarbons such as cyclohexylbenzene are electrochemically active and can effectively prevent over-charge. When a battery is over-charged, excessive amounts of lithium ions escape from the positive electrode and embed in or accumulate on the negative electrode. As a result, the heat stability of the two electrodes is impaired such that the positive electrode becomes prone towards decomposition. The positive electrode would then release oxygen that can catalyze the decomposition of the electrolyte, creating large amounts of heat. The active lithium accumulated on the negative electrode can easily react with the solvent, releasing heat and converting chemical energy into heat energy. The temperature of the battery rises rapidly. As the temperature rises, the electrolyte participates in almost all the reactions within the battery. These reactions include the electrolyte's reactions with the material for the positive electrode, the lithium embedded in the carbon, lithium metal, and the self-decomposition reaction of the electrolyte.

[9] Adding biphenyl, cyclohexylbenzene, or a mixture of both to the electrolyte can prevent over-charge to a certain degree. However, by doing so, the properties of the battery at low temperatures are affected negatively. In addition, the thickness of the battery increases as a result of the large quantity of gas that is generated during the charge and discharge. Even when the additives generate only a small amount of gas, the over-charge and low-temperature properties of the battery may not be good. However, when the additives results in good over-charge properties, the battery may produce large quantities of gas and also may not have good discharge properties at low temperatures.

[10] Due to the limitations of the prior art, it is therefore desirable to have novel additives for electrolytes that can be used in lithium ion batteries and produce batteries with good low temperature properties, over-charge properties, and batteries that generate less gas during charge and discharge.

Summary of Invention

[11] An object of this invention is to provide additives for lithium ion secondary batteries that can effectively improve a battery's over-charge properties, reduce the amount

of gas generated during charging and discharging, and improve the low-temperature properties of a battery.

[12] The present invention relates to additives for electrolytes of lithium ion secondary batteries that include one or more of the following: 1, 3-propane sultone, succinic anhydride; ethenyl sulfonyl benzene, and halobenzene. It can also include biphenyl, cyclohexylbenzene; and vinylene carbonate. The weight of said 1,3-propane sultone can be between 0.5 wt.% and 96.4 wt.%, said succinic anhydride can between 0.5 wt.% and 96.4 wt.%; said ethenyl sulfonyl benzene can be between 0.5 wt.% and 95.2wt.%; and said halobenzene can be between 0.5 wt.% and 95.2 wt.% of said additive.

[13] An advantage of this invention is the additives for lithium ion secondary batteries of this invention that can effectively improve a battery's over-charge properties such that under over-charge conditions, a battery with said additives is reliable, safe, and not prone to fire or explosion.

[14] Another advantage of this invention is that the additives for electrolytes of lithium ion secondary batteries of this invention can effectively reduce the amount of gas generated during charging and discharging thus reducing the thickness of the battery.

[15] Another advantage of this invention is that the additives for electrolytes of lithium ion secondary batteries of this invention can effectively improve the low-temperature properties of a battery such that when the battery is discharged at low temperatures, it has a high capacity, a high medium voltage, and a low internal resistance.

[16] Another advantage of this invention is that the additives for electrolytes of lithium ion secondary batteries of this invention it can improve the high temperature properties of a battery such that the battery can be stored at high temperatures and has a small recovery thickness.

Detailed Description of the Preferred Embodiments

[17] The presently preferred embodiments of the present invention are electrolytes with additives that comprising of one or more of the following: 1,3-propane sultone, succinic anhydride, ethenyl sulfonyl benzene, and halobenzene. Preferably, it should also contain biphenyl; cyclohexylbenzene; and vinylene carbonate. The preferred weight of the said 1,3-propane sultone is between 0.5 wt.% and 96.4 wt.%, said succinic anhydride is between 0.5 wt.% and 96.4 wt.%, said ethenyl sulfonyl benzene is between 0.5 wt.% and 95.2wt.%; and said halobenzene is between 0.5 wt.% and 95.2 wt.%; said biphenyl is 0.5

wt.% and 95.2 wt.%; said cyclohexylbenzene is between 1.0 wt.% and 93.7 wt.%; and, said vinylene carbonate is between 0.5 wt.% and 93.0 wt.% of the weight of said additive.

[18] Moreover, the weight of said additive can be between 2 wt.% and 20 wt.% of the weight of the electrolyte.

[19] In other embodiments, the weight of said 1,3-propane sultone can be between 0.1 wt. % and 8.0 wt.%; the weight of said succinic anhydride can be between 0.1 wt.% and 8.0 wt.%; said ethenyl sulfonyl benzene can be less or equal to 6.0 wt.%; said halobenzene can be less than or equal to 6.0wt.%; said biphenyl can be between 0.1 wt.% and 6.0 wt.% biphenyl; said cyclohexylbenzene can be between 0.1 wt.% and 6.0 wt.%; and said vinylene carbonate can be between 0.1 wt.% and 4.0 wt.% of the weight of said electrolyte.

[20] Said halobenzene can be a halobenzene of one or more of its substitute. It can also be a haloalkylbenzene. The preferred selection is fluorobenzene, chlorobenzene, bromobenzene, or iobenzene. Optimally, the halobenzene should be fluorobenzene, chlorobenzene, and bromobenzene.

[21] When the additive of an electrolyte that is an embodiment is dissolved in the electrolyte of a lithium ion secondary battery, it can suppress the decomposition of solvents such as dimethyl carbonate, diethyl carbonate, ethylene carbonate, propylene carbonate, ethyl methyl carbonate, butylene carbonate, methyl ethylene carbonate, and diethyl carbonate in the electrolyte. By doing so, the additive reduces greatly or even stops the generation of gas by the decomposition of the solvents, thereby eliminating the danger of explosion from gas accumulation, improving the heat stability of the electrolyte, and enhancing the efficient use of the electrolyte. The additive also suppresses the polarization of the lithium ion in the solid particles in the materials for the positive and negative electrodes. The electrochemical properties of the carbon negative electrode is improved by the additives as these additives can reduce the irreversible capacity of the lithiumized graphite negative electrode, and the transmission impedance of the lithium ion in the positive and the negative electrodes.

[22] Electrolytes that are embodiments can also improve a battery' low temperature properties as the additives in said electrolytes can stop the battery from prematurely reaching the terminal voltage of discharge at low temperatures. More importantly, the additive in said electrolytes that are embodiments can easily polyreact to form a thin layer of electrically insulating superpolymer, covering the surface of the positive electrode, or further blocking the separator. By doing so, the additive increases the reliability and safety

of the battery and reduces the danger of the explosion or fire when the battery is overcharged.

[23] Lithium ion secondary batteries with electrolytes that are embodiments of this invention have the following advantages: (a) good low-temperature discharge properties. When discharged at low temperatures, batteries have a high capacity, high medium voltage, and low ending inner-resistance; (b) good over-charge properties. When overcharged, batteries are reliable and safe from explosion or fire; (c) low generation of gas during charge and discharge. With less gas generation, the increase in the thickness of the battery is reduced; and (d) good high temperature properties. Batteries can be stored at high-temperatures and have a small recovery thickness.

[24] The embodiments of said electrolyte can also contain one or more organic solvents. These organic solvents can be any of those being used in current technology for in lithium ion batteries. These solvents include, but are not limited to, one or more of the following: dimethyl carbonate (DMC), diethyl carbonate (DEC), ethylene carbonate (EC), propylene carbonate (PC), ethyl methyl carbonate (EMC), butylene carbonate (BC), and methyl ethylene carbonate (MEC). The quantity of said organic solvent or solvents can be any of the customary quantities of organic solvents currently being used in lithium ion batteries. For example, the amount of organic solvent can be between 70 wt.% and 95 wt. % of the weight of the electrolyte.

[25] The embodiments of said electrolyte can also contain electrolyte solids that are lithium salts that are currently used in lithium ion secondary batteries. These lithium salts include, but are not limited to, one or more of the following: lithium perchlorate, lithium hexafluoride phospho, lithium hexafluoride arsenate, and lithium perfluoride boric acid. The concentration of said lithium salt can be the commonly used concentrations of lithium salts in current lithium ion secondary batteries. For example, the concentration of lithium salts can be between 0.6mol/L and1.4mol/L.

[26] A method for fabricating electrolytes that are embodiments of this invention include the following steps:

adding said additive that are embodiments to an organic solvent. The individual ingredients in said additive can be added and mixed together before being added to the organic solvent. In the alternative, the ingredients in said additive can be added individually to the organic solvent in any order with being mixed together beforehand;

dissolving the lithium salt or salts in the organic solvent with said additive;

sealing the organic solvent with said additive and dissolved lithium salt;

heating the sealed organic solvent with said additive and dissolved lithium salt at a temperature between 50°C and 70°C for 20 to 30 minutes to rapidly dissolve any precipitate or any material causing turbidity to obtain the electrolyte that is an embodiment.

[27] Another method for fabricating electrolytes that are embodiments of this invention include the following steps:

dissolving the lithium salt or salts in the organic solvent;

[28] adding the additive to said organic solvent with said dissolved lithium salt or salts. The individual ingredients in said additive can be added and mixed together before being added to the organic solvent. In the alternative, the ingredients in said additive can be added individually to the organic solvent in any order with being mixed together beforehand;

sealing the organic solvent with said additive and dissolved lithium salt;

heating the sealed organic solvent with said additive and dissolved lithium salt at a temperature between 50°C and 70°C for 20 to 30 minutes to rapidly dissolve any precipitate or any material causing turbidity to obtain the electrolyte embodiment.

[29] The electrolytes that are embodiments of this invention can be used as the electrolyte when fabricating lithium ion batteries. The positive electrode, negative electrode, separator to be used in said batteries can be any positive electrode, negative electrode, or separators currently being used in lithium ion batteries.

[30] The following embodiments further describe this invention.

Embodiment 1

[31] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate, ethyl methyl carbonate, and dimethyl carbonate at a ratio of 1:1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 1mol/L;

adding the additive to said solution; and

heating said solution with said additive at 50°C to dissolve said additive to form the electrolyte of this embodiment.

[32] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (0.5 wt. %), biphenyl (0.5 wt. %),

cyclohexylbenzene (1.0 wt. %), 1, 3-propane sultone (0.5 wt. %), and ethenyl sulfonyl benzene (0.5 wt. %). The additive is 3 wt. % of the total weight of the electrolyte.

[33] The fabrication of the positive electrode include the following steps:

dissolving 90 grams of poly (vinylidene finoride) (ATOFINA, 761 # PVDF) in 1350 grams of N-methyl-2-pyrrolidone (NMP) solution to form a binding solution;

adding 2895 grams of $LiCoO_2$ (FMC company product) to said binding solution;

mixing well to form the positive electrode slurry;

evenly spreading the positive electrode slurry on an aluminum foil at a thickness of 20μm;

drying the positive electrode slurry on the aluminum foil at 125°C for one hour; and

pressing it to form the positive electrode plate with a thickness of 125μm.

[34] The fabrication of the negative electrode includes the following steps:

dissolving 30 grams of carboxymethyl cellulose (CMC) (Jiangmen Quantum Hi-tech Biological Engineering Co., Ltd., model CMC1500) and 75 grams of butylbenzene rubber (SBR) latex (Nangtong Shen Hua Chemical Industrial Company Limited product, model TAIPOL1500E) in 1875 grams of water to form a binding solution;

adding 1395 grams of graphite (SODIFF company product, model DAG84) to said binding solution;

mixing the graphite well in said solution to form the graphite negative electrode slurry; evenly spreading the negative electrode slurry on a copper foil to a thickness of 12μm; drying the negative electrode slurry on the copper foil at 125°C for one hour; and

pressing it to form a negative electrode plate with a thickness of 125μm.

[35] The fabrication of the battery include the following steps:

folding and winding said positive electrode plate, negative electrode plate and a polypropylene separator with a thickness of 20μm to form the core of a square lithium-ion battery;

placing the battery core in a battery shell;

welding;

injecting the electrolyte fabricated above into the battery shell; and

sealing the shell to make the Model 453450A lithium ion secondary battery.

Embodiment 2

[36] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate, ethyl methyl carbonate and dimethyl carbonate at a ratio of 1:1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 1mol/L;

adding the additive to said solution; and

heating said additive in said solution at 60°C to dissolve the additive to form the electrolyte of this embodiment.

[37] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (1.0 wt. %), biphenyl (3 wt. %), cyclohexylbenzene (0.5 wt. %), 1, 3-propane sultone (2.0 wt. %), and ethenyl sulfonyl benzene (2.0 wt. %). The additive is 8.5% of the total weight of the electrolyte.

[38] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 3

[39] The fabrication of the electrolyte include the following steps:

mixing ethylene carbonate, ethyl methyl carbonate, and dimethyl carbonate at a ratio of 1:1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 1mol/L;

adding the additive to said solution; and

heating said solution with said additive at 70°C to dissolve the additive to form the electrolyte of this embodiment.

[40] The weight of the ingredients in the additive as a weight percentage of the electrolyte is: vinylene carbonate (2.0 wt. %), biphenyl (2.0 wt. %), cyclohexylbenzene (3.0 wt. %), succinic anhydride (3.0 wt. %), and ethenyl sulfonyl benzene (2.0 wt. %). The additive is 12 wt.% of the total weight of the electrolyte.

[41] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 4

[42] The fabrication of the electrolyte include the following steps:

mixing ethylene carbonate and diethyl carbonate at a ratio of 1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 0.9mol/L;

adding the additive to said solution; and

heating said solution with said additive at 70°C to dissolve the additive to form the electrolyte of this embodiment.

[43] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (1.5 wt. %), biphenyl (1 wt. %), cyclohexylbenzene (4 wt. %), 1, 3-propane sultone (3 wt. %), and ethenyl sulfonyl benzene (4 wt. %). The additive is 13.5% of the total weight of the electrolyte.

[44] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 5

[45] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate and diethyl carbonate at a ratio of 1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 0.9mol/L;

adding the additive to said solution;

heating said solution with said additive at 70°C to dissolve said additive to form the electrolyte of this embodiment.

[46] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (3 wt. %), biphenyl (5 wt. %), cyclohexylbenzene (1 wt. %), 1,3-propane sultone (5 wt. %), and ethenyl sulfonyl benzene (3 wt. %). The additive is 17 wt. % of the total weight of the electrolyte.

[47] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 6

[48] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate and diethyl carbonate at a ratio of 1:1;

adding $LiPF_6$ solid as the electrolyte solid to form an electrolyte solution with a concentration of 0.9mol/L;

adding the additive to the solution;

heating said solution with said additive at 70°C to dissolve said additive to form the electrolyte of this embodiment.

[49] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (2 wt. %), biphenyl (1.5 wt. %), cyclohexylbenzene (6.5 wt. %), 1, 3-propane sultone (4 wt. %), and ethenyl sulfonyl benzene (5 wt. %). The additive is 19 wt. % of the total weight of the electrolyte.

[50] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 7

[51] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate, ethyl methyl carbonate, and dimethyl carbonate at a ratio of 1:1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 1mol/L;

adding the additive to said solution; and

heating said solution with said additive at 50°C to dissolve said additive to form the electrolyte of this embodiment.

[52] The weight of the ingredients in said additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (0.5 wt. %), biphenyl (0.5 wt. %), cyclohexylbenzene (1.5 wt. %), and 1,3-propane sultone (1 wt. %), and fluorobenzene (0.5 wt. %). The additive is 4 wt. % of the total weight of the electrolyte.

[53] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 8

[54] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate, ethyl methyl carbonate, and dimethyl carbonate at a ratio of 1:1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 1mol/L;

adding the additive to said solution; and

heating said solution with said additive at 70°C to dissolve said additive to form the electrolyte of this embodiment.

[55] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (1 wt. %), biphenyl (4 wt. %), cyclohexylbenzene (1 wt. %), succinic anhydride (2 wt. %), and chlorobenzene (2 wt. %). The additive is 10% of the total weight of the electrolyte.

[56] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 9

[57] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate, ethyl methyl carbonate, and dimethyl carbonate at a ratio of 1:1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 1mol/L;

adding the additive to said solution;

heating said solution with said additive at 50°C to dissolve said additive to form the electrolyte of this embodiment.

[58] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (2 wt. %), biphenyl (3 wt. %), cyclohexylbenzene (3 wt. %), and 1, 3-propane sultone (2 wt. %). The additive is 10% of the total weight of the electrolyte.

[59] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Embodiment 10

[60] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate and diethyl carbonate at a ratio of 1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution with a concentration of 0.9mol/L;

adding the additive to said solution;

heating said solution with said additive at 70°C to dissolve said additive to form the electrolyte of this embodiment.

[61] The weight of the ingredients in the additive as a weight percentage of the weight of the electrolyte is: vinylene carbonate (5 wt. %), biphenyl (1 wt. %), cyclohexylbenzene (2 wt. %), and 1, 3-propane sultone (0.5 wt. %). The additive is 8.5% of the total weight of the electrolyte.

[62] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Comparison Example 1

[63] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate, ethyl methyl carbonate, and dimethyl carbonate are at a ratio of 1:1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution of this comparison example with a concentration of 1mol/L.

[64] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Comparison Example 2

[65] The fabrication of the electrolyte includes the following steps:

mixing ethylene carbonate and diethyl carbonate at a ratio of 1:1;

adding $LiPF_6$ as the electrolyte solid to form an electrolyte solution of this comparison example with a concentration of 0/9mol/L.

[66] The lithium-ion battery in this embodiment is fabricated with the same method as that in Embodiment 1 using the electrolyte fabricated in this embodiment.

Testing of Batteries' Properties

[67] The lithium-ion secondary batteries of Embodiments 1through10 and Comparison Examples 1 and 2 are tested as follows:

[68] First, the increases in battery thickness after its initial charge and discharge are measured. Each battery is charged for the first time and the increase in battery thickness after its initial charging is measured. This increase in battery thickness is defined as the

difference between the thickness of a battery charged for the first time to a voltage of 3.9V and that of the battery before its initial charging. Each battery is then discharged for the first time. The increase in battery thickness after its initial discharging is measured. The increase in thickness after its initial charge is defined as the difference between the thickness of a battery charged for the first time to a voltage of 4.12V and that of the battery after being discharged to a voltage of 3.0V. The results of this testing are shown in Table 1.

[69] The standard capacity of lithium ion secondary batteries of Embodiments 1 through10 and Comparison Examples 1 and 2 are obtained and the results are shown in Table 1. The method for obtaining the standard capacity for a battery is as follows: A battery is charged with 1CmA at constant current and constant voltage to 4.12V. The battery is then discharged with 1CmA to 3.0V. The capacity released by the battery after charging, i.e., discharging current (MA) * discharge time (h) is the standard capacity.

Table 1

	In crease in Thickness after Initial Charge (mm)	In crease in Thickness After Initial Discharge (mm)	Standard Capacity (mAh)
Embodiment 1	0.752	0.178	815
Embodiment 2	0.766	0.179	819
Embodiment 3	0.755	0.182	811
Embodiment 4	0.762	0.184	812
Embodiment 5	0.778	0.182	815
Embodiment 6	0.796	0.198	814
Embodiment 7	0.753	0.182	810
Embodiment 8	0.742	0.178	811
Embodiment 9	0.715	0.178	810
Embodiment 10	0.716	0.181	810
Comparison Example 1	0.912	0.218	813
Comparison Example 2	0.920	0.223	812

[70] The results in Table 1 show that the capacities of batteries with electrolytes that are embodiments of this invention and the capacities of those batteries with electrolytes fabricated in the Comparison Examples are basically the same. However, the increase in thickness after the charging or discharging of the batteries with electrolytes that are embodiments is distinctly smaller than that of the batteries with electrolytes that are fabricated in the Comparison Examples. The results show that batteries with electrolytes that are embodiments generate less gas during the charging or discharging than batteries with electrolytes that are fabricated in the Comparison Examples.

[71] The overcharge properties of the lithium ion secondary batteries of embodiments 1 through 10 and Comparison Examples 1 and 2 are tested and the results are shown in Table 2. The testing method for each battery includes the following steps:

discharging with 1C at constant current to 3.0V;

adjusting the value of the output current of a constant current and constant voltage electrical to that required by the over-charge test by using a universal meter;

adjusting the output voltage to about 1V higher than the required over-charge voltage limit;

attaching the temperature sensor of a thermocouple sensor to the middle of the battery's side with heat-resistant tapes;

covering the surface of the battery with a layer of asbestos having a thickness of 12mm when the asbestos is loose;

adjusting the speed of the moving paper to 6cm/h or 20cm/h and setting a suitable magnification rate for a three-pen note apparatus;

turning on the constant current and voltage electrical source to over-charge said battery;

recording the change in the battery's temperature, voltage, electrical current; and observing and noting any leakage, breach, fume, explosion, or ignition;

recording the battery's charging time at constant current, the battery's highest temperature, and the time it reaches the highest temperature.

[72] This test is terminated when any of the following conditions occur: the battery's surface temperature rises above 200°C; the battery explodes; the battery is on fire; the over-charge electrical current drops below 50mA; the battery's voltage reaches the specified voltage and its surface temperature drops below 35°C.

Table 2

	1C, 12V Over-charge			1C, 18.5V Over-charge		
	Phenomenon	Longest Time (min)	Highest Temperature (°C)	Phenomenon	Longest time (min)	Highest Temperature (°C)
Embodiment 1	No explosion or ignition	120	158	No explosion or ignition	100	160
Embodiment 2	No explosion or ignition	150	148	No explosion or ignition	120	139
Embodiment 3	No explosion or ignition	150	119	No explosion or ignition	150	130
Embodiment 4	No explosion or ignition	150	118	No explosion or ignition	150	128
Embodiment 5	No explosion or ignition	150	112	No explosion or ignition	150	127
Embodiment 6	No explosion or ignition	150	109	No explosion or ignition	150	122
Embodiment 7	No explosion or ignition	120	154	No explosion or ignition	100	158
Embodiment 8	No explosion or ignition	150	118	No explosion or ignition	150	128
Embodiment 9	No explosion or ignition	150	116	No explosion or ignition	150	117
Embodiment 10	No explosion or ignition	150	132	No explosion or ignition	120	132
Comparison Example 1	Explosion	90	329	Explosion	98	333
Comparison Example 2	Explosion	91	338	Explosion	93	340

[73] Table 2 shows that batteries with electrolytes that are embodiments have good over-charge properties that are distinctly better that the over-charge properties of batteries with electrolytes fabricated in Comparison Examples.

[74] The high temperature properties of the lithium ion secondary batteries of Embodiments 7 through 10 and Comparison Examples 1 and 2 are tested. The results are shown in Table 3. The method for the testing of each battery includes the following steps:

charging a battery to 4.2V with 1CmA (1C) at constant current and voltage;

measuring the open circuit voltage and the internal resistance (i.e., the initial voltage, initial internal resistance and initial thickness);

storing the battery for 48 hours at a temperature of 85°C ± 2°C;

measuring the thickness of the battery after storing at 85°C;

measuring the open circuit voltage and the internal resistance after the battery is placed at a temperature of 23°C ±7°C for one hour;

discharging the battery to 3.0V with 1CmA;

recording the discharge capacity (residual capacity);

fully charging the battery;

restoring the battery for five minutes after being fully charged;

discharging the battery to 3.0V with 1CmA electrical current;

repeating above-described cycle three times;

recording the capacity (recovery capacity) of each cycle;

recording the internal resistance (recovery internal resistance) and the thickness (recovery thickness) when the battery is fully charged during the third cycle; and

calculating the battery's capacity recovery rate, internal resistance recovery rate and the capacity residue rate with the following formulae:

capacity recovery rate (%) = recovery capacity of the third cycle / initial capacity ×100%;internal resistance recovery rate (%) = recovery internal resistance / initial internal resistance ×100%;

self discharge rate (%) = (initial capacity -residual capacity)/initial capacity; and

residual capacity rate (%) = residual capacity/initial capacity.

Table 3

	85°C High-temperature storage property						
	Storage Internal Resist-ance Increase (mΩ)	Recovery Internal Resist-ance Increase (mΩ)	Storage Thickness Increase (mm)	Recovery Thickness Increase (mm)	Self-Discharge Rate (%)	Capacity Recovery Rate (%)	Internal Resistance Recovery Rate (%)
Embo-diment 7	15.8	14	1.62	1.06	27.3	80.9	39.5
Embo-diment 8	15.9	15	1.81	0.99	27.0	81.0	37.1
Embo-diment 9	15.5	14	1.91	1.01	27.40	81.9	36.8
Embo-diment 10	15.2	15	1.63	1.06	28.2	79.3	42.5
Compa-rison Example 1	22.4	26	2.19	1.18	33.3	71.5	69.0
Compa-rison Example 2	21.9	25	2.22	1.17	31.4	72.5	71.1

[75] Table 3 shows that batteries with electrolytes that are embodiments of this invention has distinctly improved high temperature storage properties at 85°C over batteries with electrolytes fabricated in the Comparison Examples. The improvements include increased storage and recovery internal resistance, increased storage and recovery thickness, and improvements in self-discharge rate, capacity recovery rate and inner resistance recovery rate.

[76] The low temperature properties of lithium ion secondary batteries of Embodiments 1 through 8 and Comparison Examples 1 and 2 are tested. The results are shown in Table 4. Each battery is tested as follows:

charging a battery to 4.2V with 1CmA at constant current and voltage;

discharging to 3.0V with 1CmA where the initial capacity of the voltage is the discharge capacity;

charging the battery to 4.2V with 1CmA at constant current and voltage;

discharging the battery is with 1CmA at a temperature of -10°C; and

recording the capacity and the ending internal resistance when the battery is discharged to 3.1V, 3.0V, and 2.75V.

[77] In Table 4, the medium voltage = (the open circuit voltage after the battery has been placed at -10°C; for 1.5 hours +discharge terminal voltage)/2.

Table 4

	-10°C, 1C Discharge				
	3.1V/Initial Capacity (%)	3.0V/Initial Capacity (%)	2.75V/Initial Capacity (%)	Medium Voltage (V)	Ending Internal Resistance (mΩ)
Embodiment 1	38.6	40.7	45.2	3.311	52.1
Embodiment 2	47.9	49.8	53.8	3.317	41.9
Embodiment 3	43.9	47.7	49.9	3.315	47.5
Embodiment 4	42.8	47.3	48.5	3.315	49.5
Embodiment 5	39.9	44.1	46.8	3.313	50.9
Embodiment 6	39.2	42.3	44.9	3.312	51.9
Embodiment 7	38.9	41.2	45.6	3.312	52.8
Embodiment 8	44.2	48.2	50.3	3.316	48.2
Comparison Example 1	33.8	38.2	43.9	3.309	53.1
Comparison Example 2	33.7	37	43.6	3.308	53.5

[78] The low temperature properties of lithium ion secondary batteries of Embodiments 1 through 8 and Comparison Examples 1 and 2 are tested. The results are listed in Table 5. Each battery is tested as follows:

charging a battery with 1CmA at constant current and voltage;

discharging to 3.0V with 1CmA where the discharge capacity is the initial capacity;

charged the battery to 4.2V with 1CmA at constant current and voltage;

discharging the battery with 1CmA at a temperature of -20°C; and

recording the capacity and the ending internal resistance when the battery is discharged to 3.1V, 3.0V, and 2.75V.

[79] In Table 5, the medium voltage = (the open circuit voltage after the battery has been placed at -20°C; for 1.5 hours +discharge terminal voltage)/2.

Table 5

	-20°C, 1C Discharge				
	3.1V/Initial Capacity (%)	3.0V/Initial Capacity (%)	2.75V/Initial Capacity (%)	Medium Voltage (V)	Ending Internal Resistance (mΩ)
Embodiment 1	27.6	28.6	40.8	3.103	56.1
Embodiment 2	32.3	35.7	42.9	3.112	54.6
Embodiment 3	31.9	36.3	43.6	3.112	54.9
Embodiment4	30.7	33.7	41.6	3.108	53.5
Embodiment 5	28.7	31.6	40.9	3.107	53.9
Embodiment 6	27.7	29.7	3.65	3.104	56.9
Embodiment 7	27.9	29.1	41.2	3.104	56.8
Embodiment 8	32.2	36.8	44.0	3.113	55.6
Comparison Example 1	22.6	28.4	39	3.1	57.7
Comparison Example 2	20	23.7	34.9	3.099	58.7

[80] Tables 4 and 5 show that a battery with an electrolyte that is an embodiment has distinctly improved low temperature properties over batteries with electrolytes that are fabricated in the Comparison Examples. A battery with an electrolyte that is an embodiment of this invention has a high capacity when discharged at temperatures of -

10°C and -20°C. This battery also has a high medium voltage when and a low ending internal resistance when discharged at low temperatures. Tables 3 and 4 also show that when there is a larger amount of the additive in the electrolyte, the over-charge properties of the battery are better, but its low-temperature properties declines slightly.

[81] While the present invention has been described with reference to certain preferred embodiments, it is to be understood that the present invention is not limited to such specific embodiments. Rather, it is the contention of the inventor that the invention be understood and construed in its broadest meaning as reflected by the following claims. Thus, these claims are to be understood as incorporating not only the preferred embodiments described herein but all those other and further alterations and modifications as would be apparent to those of ordinary skilled in the art.

Claims

We Claim:

1. An electrolyte having an additive wherein said additive comprising at least one chemical selected from the group consisting of 1, 3-propane sultone, succinic anhydride, ethenyl sulfonyl benzene, and halobenzene.

2. The electrolyte of claim 1 wherein

the weight of said 1, 3-propane sultone is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;

the weight of said succinic anhydride is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;

the weight of said ethenyl sulfonyl benzene is between 0.5 wt.% and 95.2wt.% of the weight of said additive; and

the weight of said halobenzene is between 0.5 wt.% and 95.2 wt.% of the weight of said additive.

3. The electrolyte of claim 1 wherein said halobenzene is fluorobenzene, chlorobenzene, bromobenzene, or iobenzene.

4. The electrolyte of claim 1 wherein said the weight of said additive is between 2 wt.% and 20 wt.% of the weight of said electrolyte.

5. The electrolyte of claim 1 wherein said additive also comprising biphenyl.

6. The electrolyte of claim 5 wherein the weight of said biphenyl is between 0.5 wt.% and 95.2 wt.% of the weight of said additive.

7. The electrolyte of claim 1, 5, or 6 wherein said additive also comprising cyclohexylbenzene.

8. The electrolyte of claim 7 wherein the weight of said cyclohexylbenzene is between 1.0 wt.% and 93.7 wt.% of the weight of said additive.

9. The electrolyte of claim 1, 5, 6, 7 or 8 wherein said additive also comprising vinylene carbonate.

10. The electrolyte of claim 9 wherein the weight of said vinylene carbonate is between 0.5 wt.% and 93.0 wt.% of the weight of said additive.

11. An electrolyte having an additive wherein said additive comprising:
biphenyl;
cyclohexylbenzene;
vinylene carbonate;
1, 3-propane sultone or succinic anhydride; and
ethenyl sulfonyl benzene or halobenzene.

12. The electrolyte of claim 11 wherein
the weight of said 1, 3-propane sultone is between 0.1 wt. % and 8.0 wt. % of the weight of said electrolyte;
the weight of said succinic anhydride is between 0.1 wt.% and 8.0 wt.%of the weight of said electrolyte;
the weight of said ethenyl sulfonyl benzene is less than or equal to 6.0 wt.% of the weight of said electrolyte;
the weight of said halobenzene is less than or equal to 6.0 wt.% of the weight of said electrolyte;
the weight of said biphenyl is between 0.1 wt.% and 6.0 wt.% biphenyl of the weight of said electrolyte;
the weight of said cyclohexylbenzene is between 0.1 wt.% and 6.0 wt.% of the weight of said electrolyte;
the weight of said vinylene carbonate is between 0.1 wt.% and 4.0 wt.% of the weight of said electrolyte; and
the weight of said additive is between 2 wt.% and 20 wt.% of the weight of said electrolyte.

13. An electrolyte having an additive wherein said additive comprising:
biphenyl;

cyclohexylbenzene;

vinylene carbonate;

1, 3-propane sultone or succinic anhydride; and

ethenyl sulfonyl benzene or halobenzene; and wherein

the weight of said 1, 3-propane sultone is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;

the weight of said succinic anhydride is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;

the weight of said ethenyl sulfonyl benzene is between 0.5 wt.% and 95.2wt.% of the weight of said additive;

the weight of said halobenzene is between 0.5 wt.% and 95.2 wt.% of the weight of said additive;

the weight of said biphenyl is between 0.5 wt.% and 95.2 wt.% of the weight of said additive;

the weight of said cyclohexylbenzene is between 1.0 wt.% and 93.7 wt.% of the weight of said additive;

the weight of said vinylene carbonate is between 0.5 wt.% and 93.0 wt.% of the weight of said additive;

the weight of said additive is between 2 wt.% and 20 wt.% of the weight of said electrolyte; and

said halobenzene is fluorobenzene, chlorobenzene, bromobenzene, or iobenzene.

AMENDED CLAIMS

**[received by the International Bureau on 31 March 2006 (31.03.06);
original claims 1, 5, 7, 9, 11, and 13 amended;
remaining claims unchanged (3 pages)]**

Claims

We Claim:

1. (Amended) An electrolyte having an additive, wherein said additive comprises:
1, 3-propane sultone or succinic anhydride, and
ethenyl sulfonyl benzene or halobenzene.

2. The electrolyte of claim 1 wherein
the weight of said 1, 3-propane sultone is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;
the weight of said succinic anhydride is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;
the weight of said ethenyl sulfonyl benzene is between 0.5 wt.% and 95.2wt.% of the weight of said additive; and
the weight of said halobenzene is between 0.5 wt.% and 95.2 wt.% of the weight of said additive.

3. The electrolyte of claim 1 wherein said halobenzene is fluorobenzene, chlorobenzene, bromobenzene, or iobenzene.

4. The electrolyte of claim 1 wherein said the weight of said additive is between 2 wt.% and 20 wt.% of the weight of said electrolyte.

5. (Amended) The electrolyte of claim 1 wherein said additive also comprises biphenyl.

6. The electrolyte of claim 5 wherein the weight of said biphenyl is between 0.5 wt.% and 95.2 wt.% of the weight of said additive.

7. (Amended) The electrolyte of claim 1, 5, or 6 wherein said additive also comprises cyclohexylbenzene.

8. The electrolyte of claim 7 wherein the weight of said cyclohexylbenzene is between 1.0 wt.% and 93.7 wt.% of the weight of said additive.

9. (Amended) The electrolyte of claim 1, 5, 6, 7 or 8 wherein said additive also comprises vinylene carbonate.

10. The electrolyte of claim 9 wherein the weight of said vinylene carbonate is between 0.5 wt.% and 93.0 wt.% of the weight of said additive.

11. (Amended) An electrolyte having an additive wherein said additive comprises:
biphenyl;
cyclohexylbenzene;
vinylene carbonate;
1, 3-propane sultone or succinic anhydride; and
ethenyl sulfonyl benzene or halobenzene.

12. The electrolyte of claim 11 wherein
the weight of said 1, 3-propane sultone is between 0.1 wt. % and 8.0 wt. % of the weight of said electrolyte;
the weight of said succinic anhydride is between 0.1 wt.% and 8.0 wt.% of the weight of said electrolyte;
the weight of said ethenyl sulfonyl benzene is less than or equal to 6.0 wt.% of the weight of said electrolyte;
the weight of said halobenzene is less than or equal to 6.0 wt.% of the weight of said electrolyte;
the weight of said biphenyl is between 0.1 wt.% and 6.0 wt.% biphenyl of the weight of said electrolyte;
the weight of said cyclohexylbenzene is between 0.1 wt.% and 6.0 wt.% of the weight of said electrolyte;
the weight of said vinylene carbonate is between 0.1 wt.% and 4.0 wt.% of the weight of said electrolyte; and

the weight of said additive is between 2 wt.% and 20 wt.% of the weight of said electrolyte.

13. (Amended) An electrolyte having an additive wherein said additive comprises:

biphenyl;

cyclohexylbenzene;

vinylene carbonate;

1, 3-propane sultone or succinic anhydride; and

ethenyl sulfonyl benzene or halobenzene; and wherein

the weight of said 1, 3-propane sultone is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;

the weight of said succinic anhydride is between 0.5 wt.% and 96.4 wt.% of the weight of said additive;

the weight of said ethenyl sulfonyl benzene is between 0.5 wt.% and 95.2wt.% of the weight of said additive;

the weight of said halobenzene is between 0.5 wt.% and 95.2 wt.% of the weight of said additive;

the weight of said biphenyl is between 0.5 wt.% and 95.2 wt.% of the weight of said additive;

the weight of said cyclohexylbenzene is between 1.0 wt.% and 93.7 wt.% of the weight of said additive;

the weight of said vinylene carbonate is between 0.5 wt.% and 93.0 wt.% of the weight of said additive;

the weight of said additive is between 2 wt.% and 20 wt.% of the weight of said electrolyte; and

said halobenzene is fluorobenzene, chlorobenzene, bromobenzene, or iobenzene.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2005/002389

A. CLASSIFICATION OF SUBJECT MATTER

H01M10/40 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M10/40, H01M6/16 (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

CNPAT

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI、EPODOC、PAJ、CNPAT：PROPANE SULTONE, SUCCINIC ANHYDRIDE, ETHENYL SULFONYL BENZENE, HALOBENZENE, BIPHENYL, FLUOROBENZENE, CHLOROBENZENE, BROMOBENZENE, IOBENZENE, CYCLOHEXYLBENZENE, VINYLENE CARBONATE, ELECTROLYTE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP2003-243031A, 29. Aug. 2003 (29.08.2003), claims 1 & 2	1,4-10
X	JP11-97059A, 09.Apr. 1999 (09.04.1999), claim 1	1,3-10
X	CN1532986A, 29. Sep. 2004 (29.09.2004), claims 1 & 16	1,3-10
X	CN1479400A, 03. Mar. 2004 (03.03.2004), claims 1 & 9	1,3-10
X	JP2003-17119A, 17. Jan. 2003 (17.01.2003), claims 1-3	1,4-10
X	JP2000-3724A, 07. Jan. 2000 (07.01.2000), claims 1-12	1,4-10
X	CN1439179A, 27. Aug. 2003 (27.08.2003), claims 1-22	1,4-10
X	US5296319A, 22. Mar. 1994 (22.03.1994), abstract	1,4-10
PX,E	CN1610179A, 27. Apr. 2005 (27.04.2005), claims 1-22	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 Feb. 2006 (19.02.2006)	09 · MAR 2006 (09 · 03 · 2006)

Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China
100088
Facsimile No. 86-10-62019451

Authorized officer
WANG, Fang
Telephone No. (86-10) 62085032

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2005/002389

Patent document Cited in search report	Publication date	Patent family member(s)	Publication date
JP2003-243031A	29.08.2003	NONE	
JP11-97059A	09.04.1999	NONE	
CN1532986A	29.09.2004	JP2005108440 A	21. 04.2005
		EP1463143 A2	29.09.2004
		US2004197667 A1	07. 10.2004
		KR2004083670 A	06. 10.2004
CN1479400A	03.03.2004	JP3675460B2 B2	27. 07.2005
		JP2004095556 A	25. 03.2004
		KR2004020640 A	09. 03.2004
		US2004146778 A1	29. 07.2004
		KR467696 B	24. 01.2005
JP2003-17119A	17.01.2003	NONE	
JP2000-3724A	07.01.2000	JP2000-3725A	07. 01.2000
		US6033809 A	07. 03.2000
		CA2245354 A	22. 02.1999
CN1439179A	27.08.2003	CN1591961 A	09.03.2005
		WO0201665 A1	03. 01.2002
		JP2002083632 A	22. 03.2002
		EP1304758 A1	23. 04.2003
		TW506156 A	11. 10.2002
		KR2003019457 A	06. 03.2003
		US2004091786 A1	13. 05.2004
US5296319A	22.03.1994	JP4355065 A	09.12.1992
		JP2697365B2 B2	14. 01.1998
CN1610179A	27.04.2005	JP2005129540 A	19. 05.2005
		EP1526600 A1	27. 04.2005
		US2005106471 A1	19. 05.2005