

CLAIMS:

1. A nonaqueous electrolyte solution for a lithium battery, which solution comprises
 - i) a liquid electrolyte medium;
 - ii) a lithium-containing salt; and
 - iii) a flame retardant amount of A) tribromoethylene or tribromoneopentyl alcohol or B) a flame retardant mixture of a) 1,2-dibromoethane and tribromoethylene in a weight ratio of about 0.75:1 to about 3:1, or b) tribromoethylene and 2-phenoxy-2,4,4,6,6-pentafluoro-1,3,5,2λ5,4λ5,6λ5triazatriphosphinine in a weight ratio of 0.75:1 to about 2.25:1.
2. A solution as in Claim 1 wherein iii) is tribromoethylene, and wherein the flame retardant amount is more than 4 wt% relative to the total weight of the solution; or tribromoneopentyl alcohol, and wherein the flame retardant amount is more than 10 wt% relative to the total weight of the solution.
3. A solution as in Claim 1 wherein iii) is tribromoethylene or tribromoneopentyl alcohol, and wherein the flame retardant amount is more than 15 wt% relative to the total weight of the solution.
4. A solution as in Claim 1 wherein iii) is a flame retardant mixture, and is 1,2-dibromoethane and tribromoethylene, wherein the flame retardant amount is about 6 wt% or more relative to the total weight of the solution; or tribromoethylene and 2-phenoxy-2,4,4,6,6-pentafluoro-1,3,5,2λ5,4λ5,6λ5triazatriphosphinine, and wherein the flame retardant amount is about 4 wt% or more relative to the total weight of the solution.
5. A solution as in Claim 1 wherein the flame retardant mixture is 1,2-dibromoethane and tribromoethylene, and wherein the flame retardant amount is about 20 wt% or more relative to the total weight of the solution.
6. A solution as in Claim 1 which also comprises 2-phenoxy-2,4,4,6,6-pentafluoro-1,3,5,2λ5,4λ5,6λ5triazatriphosphinine, wherein the brominated flame retardant is tribromoethylene, wherein the weight ratio of tribromoethylene to 2-phenoxy-2,4,4,6,6-pentafluoro-1,3,5,2λ5,4λ5,6λ5triazatriphosphinine is about 0.75:1 to about 2:1, and the

flame retardant amount is about 4 wt% or more flame retardant molecules relative to the total weight of the nonaqueous electrolyte solution.

7. A solution as in any of Claims 1-6 wherein the liquid electrolyte medium is ethylene carbonate, ethyl methyl carbonate, or a mixture thereof, and/or wherein the lithium-containing salt is lithium hexafluorophosphate or lithium bis(oxalato)borate.

8. A solution as in Claim 1 wherein iii) is tribromoethylene or tribromoneopentyl alcohol, and wherein the solution also comprises

iv) at least one electrochemical additive selected from:

- a) unsaturated cyclic carbonates containing three to about six carbon atoms,
- b) fluorine-containing saturated cyclic carbonates containing three to about five carbon atoms and one to about four fluorine atoms,
- c) tris(trihydrocarbylsilyl) phosphites containing three to about nine carbon atoms,
- d) trihydrocarbyl phosphates containing three to about twelve carbon atoms,
- e) cyclic sultones containing three to about eight carbon atoms,
- f) saturated cyclic hydrocarbyl sulfites having a 5-membered or 6-membered ring and containing two to about six carbon atoms,
- g) saturated cyclic hydrocarbyl sulfates having a 5-membered or 6-membered ring and containing two to about six carbon atoms,
- h) cyclic dioxadithio polyoxide compounds having a 6-membered, 7-membered, or 8-membered ring and containing two to about six carbon atoms,
- i) another lithium-containing salt, and
- j) mixtures of any two or more of the foregoing.

9. A solution as in Claim 8 wherein the electrochemical additive is selected from:

- a) unsaturated cyclic carbonates containing three to about four carbon atoms,
- b) fluorine-containing saturated cyclic carbonates containing three to about four carbon atoms and one to about two fluorine atoms,
- c) tris(trihydrocarbylsilyl) phosphites containing three to about six carbon atoms,
- d) trihydrocarbyl phosphates containing three to about nine carbon atoms,
- e) cyclic sultones containing three to about four carbon atoms,
- f) saturated cyclic hydrocarbyl sulfites having a 5-membered ring and containing two to about four carbon atoms,

- g) saturated cyclic hydrocarbyl sulfates having a 5-membered ring and containing two to about four carbon atoms,
 - h) cyclic dioxadithio polyoxide compounds having a 6-membered or 7-membered ring and containing two to about four carbon atoms,
 - i) another lithium-containing salt, and
 - j) mixtures of any two or more of the foregoing.
10. A solution as in Claim 8 or 9 wherein the electrochemical additive is selected from:
- a) an unsaturated cyclic carbonate in an amount of about 0.5 wt% to about 12 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - b) a fluorine-containing saturated cyclic carbonate in an amount of about 0.5 wt% to about 15 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - c) a tris(trihydrocarbylsilyl) phosphite in an amount of about 0.1 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - d) a trihydrocarbyl phosphate in an amount of about 0.5 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - e) a cyclic sultone in an amount of about 0.25 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - f) a saturated cyclic hydrocarbyl sulfite in an amount of about 0.5 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - g) a saturated cyclic hydrocarbyl sulfate in an amount of about 0.25 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - h) a cyclic dioxadithio polyoxide compound in an amount of about 0.5 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution,
 - i) another lithium-containing salt in an amount of about 0.5 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution, and
 - j) mixtures of any two or more of the foregoing.
11. A solution as in any of Claims 8-10 wherein the electrochemical additive is a saturated cyclic hydrocarbyl sulfate, a cyclic sultone, a tris(trihydrocarbylsilyl) phosphite, or another lithium-containing salt.
12. A solution as in Claim 8 wherein the electrochemical additive is a saturated cyclic hydrocarbyl sulfate in an amount of about 1 wt% to about 4 wt%, a cyclic sultone in an

amount of about 0.5 wt% to about 4 wt%, a tris(trihydrocarbylsilyl) phosphite in an amount of about 0.2 wt% to about 3 wt%, or another lithium-containing salt in an amount of about 1 wt% to about 4 wt%, each relative to the total weight of the nonaqueous electrolyte solution.

13. A solution as in Claim 8 or 12 wherein the electrochemical additive is vinylene carbonate, 1,3,2-dioxathiolane 2,2-dioxide, 1,3-propene sultone, 1,3-propane sultone, tris(trimethylsilyl)phosphite, or lithium bis(oxalato)borate.

14. A solution as in Claim 12 or 13 wherein each electrochemical additive is not used with other electrochemical additives.

15. A solution as in any of Claims 8-10 wherein the electrochemical additive is selected from vinylene carbonate, 4-fluoro-ethylene carbonate, tris(trimethylsilyl)phosphite, triallyl phosphate, 1-propane-1,3-sultone, 1-propene-1,3-sultone, 1,3,2-dioxathiolane 2-oxide, 1,3,2-dioxathiolane 2,2-dioxide, 1,5,2,4-dioxadithiane 2,2,4,4-tetroxide, lithium bis(oxalato)borate, and mixtures of any two or more of these.

16. A solution as in Claim 15 wherein the electrochemical additive is selected from:
vinylene carbonate in an amount of about 0.5 wt% to about 3 wt%, relative to the total weight of the nonaqueous electrolyte solution;
vinylene carbonate in an amount of about 8 wt% to about 11 wt%, relative to the total weight of the nonaqueous electrolyte solution;
4-fluoro-ethylene carbonate in an amount of about 0.5 wt% to about 15 wt%, relative to the total weight of the nonaqueous electrolyte solution;
tris(trimethylsilyl)phosphite in an amount of about 0.2 wt% to about 3 wt%, relative to the total weight of the nonaqueous electrolyte solution;
triallyl phosphate in an amount of about 1 wt% to about 5 wt%, relative to the total weight of the nonaqueous electrolyte solution;
1,3-propane sultone or 1,3-propene sultone in an amount of about 0.5 wt% to about 4 wt%, relative to the total weight of the nonaqueous electrolyte solution;
1,3,2-dioxathiolane 2-oxide in an amount of about 1 wt% to about 4 wt%, relative to the total weight of the nonaqueous electrolyte solution;

1,3,2-dioxathiolane 2,2-dioxide in an amount of about 1 wt% to about 4 wt%, relative to the total weight of the nonaqueous electrolyte solution;

1,5,2,4-dioxadithiane 2,2,4,4-tetroxide in an amount of about 1 wt% to about 4 wt%, relative to the total weight of the nonaqueous electrolyte solution;

lithium bis(oxalato)borate in an amount of about 1 wt% to about 4 wt%, relative to the total weight of the nonaqueous electrolyte solution; and

mixtures of any two or more of these.

17. A solution as in Claim 15 or 16 wherein the electrochemical additive is selected from vinylene carbonate, 1-propane-1,3-sultone, 1-propene-1,3-sultone, 1,3,2-dioxathiolane 2,2-dioxide, tris(trimethylsilyl)phosphite, and lithium bis(oxalato)borate.

18. A solution as in Claim 15 wherein the electrochemical additive selected from 1-propane-1,3-sultone in an amount of about 0.5 wt% to about 4 wt%, 1-propene-1,3-sultone in an amount of about 0.5 wt% to about 4 wt%, 1,3,2-dioxathiolane 2,2-dioxide, in an amount of about 1 wt% to about 4 wt%, and lithium bis(oxalato)borate in an amount of about 1 wt% to about 4 wt%, each relative to the total weight of the nonaqueous electrolyte solution.

19. A solution as in Claim 17 or 18 wherein each electrochemical additive is not used with other electrochemical additives.

20. A nonaqueous lithium battery comprising a positive electrode, a negative electrode, and the nonaqueous electrolyte solution as in any of Claims 1-19.

21. A process for producing a nonaqueous electrolyte solution for a lithium battery, which process comprises combining components comprising:

- i) a liquid electrolyte medium;
- ii) a lithium-containing salt; and
- iii) a flame retardant amount of A) tribromoethylene or tribromoneopentyl alcohol or B) a flame retardant mixture of a) 1,2-dibromoethane and tribromoethylene in a weight ratio of about 0.75:1 to about 3:1, or b) tribromoethylene and 2-phenoxy-2,4,4,6,6-pentafluoro-1,3,5,2λ5,4λ5,6λ5triazatriphosphinine in a weight ratio of 0.75:1 to about 2.25:1.

22. A process as in Claim 21 wherein iii) is tribromoethylene or tribromoneopentyl alcohol, and the components also comprise

iv) at least one electrochemical additive selected from:

- a) unsaturated cyclic carbonates containing three to about six carbon atoms,
- b) fluorine-containing saturated cyclic carbonates containing three to about five carbon atoms and one to about four fluorine atoms,
- c) tris(trihydrocarbylsilyl) phosphites containing three to about nine carbon atoms,
- d) trihydrocarbyl phosphates containing three to about twelve carbon atoms,
- e) cyclic sultones containing three to about eight carbon atoms,
- f) saturated cyclic hydrocarbyl sulfites having a 5-membered or 6-membered ring and containing two to about six carbon atoms,
- g) saturated cyclic hydrocarbyl sulfates having a 5-membered or 6-membered ring and containing two to about six carbon atoms,
- h) cyclic dioxadithio polyoxide compounds having a 6-membered, 7-membered, or 8-membered ring and containing two to about six carbon atoms,
- i) another lithium-containing salt, and
- j) mixtures of any two or more of the foregoing.

23. A process as in Claim 22 wherein the electrochemical additive is selected from vinylene carbonate, 4-fluoro-ethylene carbonate, tris(trimethylsilyl)phosphite, triallyl phosphate, 1-propane-1,3-sultone, 1-propene-1,3-sultone, 1,3,2-dioxathiolane 2-oxide, 1,3,2-dioxathiolane 2,2-dioxide, 1,5,2,4-dioxadithiane 2,2,4,4-tetroxide, lithium bis(oxalato)borate, and mixtures of any two or more of these.

24. A process as in Claim 21 wherein iii) is tribromoethylene, and wherein the flame retardant amount is more than 4 wt% relative to the total weight of the solution; or tribromoneopentyl alcohol, and wherein the flame retardant amount is more than 10 wt% relative to the total weight of the solution.

25. A process as in Claim 21 wherein iii) is tribromoethylene or tribromoneopentyl alcohol, and wherein the flame retardant amount is more than 15 wt% relative to the total weight of the solution.

26. A process as in Claim 21 wherein iii) is a flame retardant mixture, and is 1,2-dibromoethane and tribromoethylene, wherein the flame retardant amount is about 6 wt% or more relative to the total weight of the solution; or tribromoethylene and 2-phenoxy-2,4,4,6,6-pentafluoro-1,3,5,2λ5,4λ5,6λ5triazatriphosphinine, and wherein the flame retardant amount is about 4 wt% or more relative to the total weight of the solution.
27. A process as in Claim 21 wherein the flame retardant mixture is 1,2-dibromoethane and tribromoethylene, and wherein the flame retardant amount is about 20 wt% or more relative to the total weight of the solution.
28. A process as in Claim 21 or 22 wherein the liquid electrolyte medium is ethylene carbonate, ethyl methyl carbonate, or a mixture thereof, and/or wherein the lithium-containing salt is lithium hexafluorophosphate or lithium bis(oxalato)borate.