

Claims

1. A liquid electrolyte composition comprising:
 - i) a magnesium salt comprising a trifluoromethane sulfonate anion;
 - ii) an additive comprising an organic halide salt, an inorganic halide salt or a mixture thereof; and
 - iii) a solvent comprising one or more ethers,wherein the organic halide salt comprises a halide anion and a cation selected from an optionally substituted quaternary ammonium or a three to nine membered N-heterocyclic cation, and the cation comprises at least one protonated nitrogen capable of dissociating the trifluoromethane sulfonate anion from the magnesium salt, and wherein the total concentration of cations of the inorganic halide salt and magnesium ions of the magnesium salt divided by the concentration of anions of the inorganic halide salt is greater than 1 in the electrolyte composition.
2. The electrolyte composition of claim 1, wherein the additive is an organic halide salt.
3. The electrolyte composition of claim 1 or 2, wherein the concentration of the magnesium salt is from 0.01 M to 2.5 M.
4. The electrolyte composition of any one of the preceding claims, wherein the molar ratio of the magnesium salt to the organic halide salt is from 10:1 to 1:10.
5. The electrolyte composition of any one of the preceding claims, wherein the molar ratio of the magnesium salt to the organic halide salt is 1:0.3 to 1:1.2.
6. The electrolyte composition of any one of the preceding claims, wherein the N-heterocyclic cation is selected from the group consisting of: an optionally substituted three-membered heterocyclic structure, an optionally substituted four-membered heterocyclic structure, an optionally substituted five-membered heterocyclic structure, an optionally substituted six-membered heterocyclic structure, an optionally substituted seven-membered heterocyclic structure, an optionally substituted eight-membered heterocyclic structure, and an optionally substituted nine-membered heterocyclic structure.
7. The electrolyte composition of claim 6, wherein the heterocyclic structure comprises 1, 2, 3, 4, 5, 6, 7, 8, or 9 heteroatoms.
8. The electrolyte composition of claim 7, wherein the heteroatoms are independently selected from the group consisting of nitrogen, oxygen, and sulfur.
9. The electrolyte composition of any one of the preceding claims, wherein the organic halide salt is selected from the group consisting of fluoride, chloride, bromide and iodide.
10. The electrolyte composition of any one of the preceding claims, comprising a mixture of at least two or more of said organic halide salts, said organic halide salts being distinct from each other.

11. The electrolyte composition of any one of the preceding claims, wherein the organic halide salt is 1-ethyl-3-methylimidazolium chloride.
12. The electrolyte composition of any one of claims 1 to 10, wherein the organic halide salt comprises a quaternary ammonium cation, said cation comprising a structure of $N^+R^1R^2R^3R^4$, wherein each of R^1 , R^2 , R^3 , and R^4 may be the same or different and wherein each of R^1 , R^2 , R^3 , and R^4 is independently an optionally substituted alkyl group.
13. The electrolyte composition of claim 12, wherein the organic halide salt is tetrabutylammonium chloride.
14. The electrolyte composition of any one of the preceding claims, wherein the concentration of the organic halide salt is from 0.01 M to 10 M.
15. 15. The electrolyte composition of any one of claims 1 and 3 to 14, wherein the additive is an inorganic halide salt.
16. The electrolyte composition of any one of claims 1 and 3 to 15, wherein the cations of the inorganic halide salt are lithium ions, sodium ions, cesium ions, magnesium ions, barium ions or aluminum ions.
17. The electrolyte composition of any one of claims 1 and 3 to 16, wherein the inorganic halide salt is a fluoride salt, a chloride salt, a bromide salt or an iodide salt.
18. The electrolyte composition of any one of claims 1 and 3 to 17, wherein the inorganic halide salt is selected from the group consisting of lithium chloride (LiCl), sodium chloride (NaCl), cesium chloride (CsCl), magnesium chloride ($MgCl_2$), barium chloride ($BaCl_2$) and aluminum chloride ($AlCl_3$).
19. The electrolyte composition of any one of claims 1 and 3 to 18, wherein the inorganic halide salt is magnesium chloride ($MgCl_2$).
20. The electrolyte composition of any one of claims 1 and 3 to 19, wherein the total concentration of the cations of the inorganic halide salt and magnesium ions of the magnesium salt divided by the concentration of anions of the inorganic halide salt in the electrolyte composition is in the range of greater than 1 to 5.
21. The electrolyte composition of any one of claims 1 and 3 to 20, wherein the concentration of the inorganic halide salt is from about 0.01 M to 10 M.
22. The electrolyte composition of any one of claims 1 and 3 to 21, where the concentration of the inorganic halide salt is about 0.2 M.
23. The electrolyte composition of any one of claims 1 and 3 to 22, wherein the concentration of the magnesium trifluoromethanesulfonate is from 0.01 M to 1.5 M.
24. A liquid electrolyte composition consisting essentially of:
i) a magnesium trifluoromethanesulfonate;

- ii) 1-ethyl-3-methylimidazolium chloride, tetrabutylammonium chloride, or a mixture thereof; and
 - iii) a solvent comprising 1,2-dimethoxyethane.
- 5 25. The electrolyte composition of claim 24, wherein the concentration of the magnesium trifluoromethanesulfonate salt is 2.5 M.
26. A liquid electrolyte composition consisting essentially of:
- 10 i) magnesium trifluoromethanesulfonate;
 - ii) magnesium chloride; and
 - iii) a solvent comprising 1,2-dimethoxyethane,
- wherein the magnesium ions and the halide ions are present in the electrolyte composition in a $[\text{Mg}^{2+}]:[\text{Cl}^-]$ ratio of from >1:1 to about 5:1.
- 15 27. The electrolyte composition of claim 26, wherein the concentration of the magnesium trifluoromethanesulfonate salt is 1.5 M.
28. The electrolyte composition of any one of the preceding claims, wherein the solvent does not comprise water.
- 20 29. An electrochemical cell comprising:
- a) a positive electrode;
 - b) a magnesium negative electrode; and
 - c) the electrolyte composition of any one of claims 1 to 28,
- 25 wherein the positive electrode and the magnesium negative electrode are in fluid communication with the electrolyte.