Claims

1. An electrolyte for use in a bipolar, static, secondary zinc bromine electrochemical cell comprising:
from 25 wt% to 70 wt% of $ZnBr_2$;
from 5 wt% to 50 wt% of water;
from 0.5 wt% to 5 wt% of a C_{1-10} glycol; and
one or more quaternary ammonium agents,
wherein the electrolyte comprises from 0.05 wt% to 10 wt% of the one or more quaternary ammonium agents, and wherein each wt% is given by weight of the electrolyte.

2. The electrolyte according to claim 1, further comprising:
from 1 wt% to 15 wt% of KBr; and
from 5 wt% to 20 wt% of KCl.

3. The electrolyte according to claim 1 or claim 2, comprising from 27 wt% to 40 wt% of $ZnBr_2$.

4. The electrolyte according to any one of claims 1-3, comprising from 1.5 wt% to 7.5 wt% of $ZnCl_2$.

5. The electrolyte according to any one of claims 1-4, comprising from 30 wt% to 45 wt% of water.

6. The electrolyte according to any one of claims 1-5, comprising from 2 wt% to 10 wt% of KBr.

7. The electrolyte according to any one of claims 1-6, comprising from 7 wt% to 17 wt% of KCl.

8. The electrolyte according to any one of claims 1-7, further comprising from 0.5 wt% to 10 wt% of a glyme.

9. The electrolyte according to claim 8, wherein the glyme comprises monoglyme, diglyme, triglyme, tetraglyme, pentaglyme, hexaglyme, or any combination thereof.

10. The electrolyte according to claim 8 or claim 9, wherein the glyme comprises tetraglyme.

11. The electrolyte according to any one of claims 8-10, comprising from 2 wt% to 4 wt% of tetraglyme.

12. The electrolyte according to any one of claims 1-11, comprising from 0.5 wt% to 2.5 wt% of an ether selected from DME-PEG, dimethyl ether, or any combination thereof.

13. The electrolyte according to claim 12, wherein the electrolyte comprises DME-PEG, and the DME-PEG has an average molecular weight of from 350 amu to 3000 amu.

14. The electrolyte according to any one of claims 12 or claim 13, wherein the DME-PEG is DME-PEG 2000, DME-PEG 1000, or a combination thereof.

15. The electrolyte according to any one of claims 12-14, comprising from 1 wt% to 2 wt% DME-PEG 2000.

16. The electrolyte according to any one of claims 12-15, comprising from 0.25 wt% to 0.75 wt% DME-PEG 1000.

17. The electrolyte according to any one of claims 1-16, further comprising from 0.1 wt% to 1.0 wt% of an alcohol, wherein the alcohol is substantially miscible in water.

18. The electrolyte according to claim 17, wherein the alcohol comprises a C_{1-4} alcohol.

19. The electrolyte according to claim 17 or claim 18, wherein the alcohol comprises methanol, ethanol, 1-propanol, iso-propanol, 1-butanol, sec-butanol, iso-butanol, tert-butanol, or any combination thereof.

20. The electrolyte according to any one of claims 17-19, comprising from 0.25 wt% to 0.75 wt% of tert-butanol.

21. The electrolyte according to any one of claims 1-20, wherein the C_{1-10} glycol comprises ethylene glycol, propylene glycol, 1,3-butylene glycol, 1,4-butylene glycol, neopentyl glycol, hexalene glycol, or any combination thereof.

22. The electrolyte according to any one of claims 1-21, comprising from 0.25 wt% to 2.5 wt% of neopentyl glycol.

23. The electrolyte according to any one of claims 1-22, wherein the one or more quaternary ammonium agents comprises a quaternary ammonium agent selected from the group consisting of tetraethylammonium bromide, trimethylpropylammonium bromide, N-methyl-N-ethylmorpholinium bromide, N-methyl-N-ethylmorpholinium bromide (MEMBr), 1-ethyl-1-methylmorpholinium bromide, N-methyl-N-butylmorpholinium bromide, N-methyl-N-ethylpyrrolidinium bromide, N,N,N-triethyl-N-propylammonium bromide, N-ethyl-N-propylpyrrolidinium bromide, N-propyl-N-butylpyrrolidinium bromide, N-methyl-N-butylpyrrolidinium bromide, 1-methyl-1-butylpyrrolidinium bromide, N-ethyl-N-(2-chloroethyl)pyrrolidinium bromide, N-methyl-N-hexylpyrrolidinium bromide, N-methyl-N-pentylpyrrolidinium bromide, N-ethyl-N-pentylpyrrolidinium bromide, N-ethyl-N-butylpyrrolidinium bromide, trimethylene-bis(N-methylpyrrolidinium) dibromide, N-butyl-N-pentylpyrrolidinium bromide, N-methyl-N-propylpyrrolidinium bromide, N-propyl-N-pentylpyrrolidinium bromide, 1-ethyl-4-methylpyridinium bromide, 1-ethyl-2-methylpyridinium bromide, 1-butyl-3-methylpyridinium bromide, cetyltrimethylammonium bromide, and any combination thereof.

24. The electrolyte according to claim 23, wherein the one or more quaternary ammonium agents comprises 3.5 wt% to 4.5 wt% 1-ethyl-4-methylpyridinium bromide.

25. The electrolyte according to claim 23 or claim 24, wherein the one or more quaternary ammonium agents comprises 1 wt% to 7 wt% 1-ethyl-2-methylpyridinium bromide.

26. The electrolyte according to any one of claims 23-25, wherein the one or more quaternary ammonium agents comprises 1.5 wt% to 2.5 wt% 1-methyl-1-butylpyrrolidinium bromide.

27. The electrolyte according to any one of claims 23-26, wherein the one or more quaternary ammonium agents comprises 1.5 wt% to 2.5 wt% 1-butyl-3-methylpyridinium bromide.

28. The electrolyte according to any one of claims 23-27, wherein the one or more quaternary ammonium agents comprises 0.5 wt% to 1.5 wt% N-methyl-N-ethylmorpholinium bromide (MEMBr).

29. The electrolyte according to any one of claims 23-28, wherein the one or more quaternary ammonium agents comprises 2 wt% to 3 wt% trimethylpropylammonium bromide.

30. The electrolyte according to any one of claims 23-29, wherein the one or more quaternary ammonium agents comprises 2 wt% to 8 wt% tetraethylammonium bromide.

31. The electrolyte according to any one of claims 23-30, wherein the one or more quaternary ammonium agents comprises 0.05 wt% to 0.2 wt% cetyltrimethylammonium bromide.

32. The electrolyte according to any one of claims 1-31, further comprising less than 1 wt% of one or more additives selected from Sn, In, Ga, Al, Tl, Bi, Pb, Sb, Ag, Mn, or Fe.

33. The electrolyte according to claim 32, wherein the one or more additives are selected from 0.0008 wt% to 0.0012 wt% of $SnCl_2 \bullet H_2O$, from 0.0008 wt% to 0.0012 wt% of In, and combinations thereof.

34. The electrolyte according to any one of claims 1-33, further comprising an acid, or the conjugate base of an acid, selected from acetic acid, nitric acid, and citric acid.

35. The electrolyte according to claim 34, comprising from 0.3 wt% to 0.6 wt% acetic acid.

36. The electrolyte according to claim 34 or claim 35, comprising from 0.12 wt% to 0.08 wt% nitric acid.

37. The electrolyte according to any one of claims 34-36, comprising from 3.5 wt% to 4.5 wt% citric acid.

38. The electrolyte according to any one of claims 34-37, comprising from 3.5 wt% to 4.5 wt% potassium dihydrogen citrate.

39. The electrolyte according to any one of claims 1-38, comprising from 0.05 wt% to 0.75 wt% of a crown ether.

40. The electrolyte according to claim 39, comprising from 0.15 wt% to 0.5 wt% of 18-crown-6 or from 0.05 wt% to 0.2 wt% of 15-crown-5.

41. An electrolyte for use in a bipolar, static, secondary zinc halide electrochemical cell comprising:
from 27 wt% to 40 wt% of $ZnBr_2$;
from 35 wt% to 41 wt% of water;
from 7.3 wt% to 9.2 wt% of KBr;
from 7 wt% to 17 wt% of KCl;
from 0.3 wt% to 0.6 wt% acetic acid; and
from 2 wt% to 8 wt% tetraethylammonium bromide,
wherein each wt% is given by weight of the electrolyte.

42. The electrolyte according to claim 41, further comprising from 0.05 wt% to 0.2 wt% of cetyltriethylammonium bromide (CTAB).

43. The electrolyte according to claim 41 or claim 42, further comprising from 3.5 wt% to 4.5 wt% of citric acid monohydrate.

44. The electrolyte according to any one of claims 41-43, further comprising from 3.5 wt% to 4.5 wt% of potassium dihydrogen citrate monohydrate.

45. An electrolyte for use in a secondary zinc halide electrochemical cell comprising:
from 27 wt% to 40 wt% of $ZnBr_2$;
from 35 wt% to 41 wt% of water;
from 7.3 wt% to 9.2 wt% of KBr;
from 7 wt% to 17 wt% of KCl;
from 0.15 wt% to 0.5 wt% of 18-crown-6; and
from 0.05 wt% to 0.2 wt% cetyltrimethylammonium bromide,
wherein each wt% is given by weight of the electrolyte.

46. The electrolyte according to claim 45, further comprising from 2 wt% to 8 wt% tetraethylammonium bromide.

47. The electrolyte according to claim 45 or claim 46, further comprising from 0.3 wt% to 0.6 wt% acetic acid.

48. The electrolyte according to any one of claims 45-47, comprising from 1 wt% to 2 wt% DME-PEG 2000.

49. The electrolyte according to any one of claims 45-48, comprising from about 0.25 wt% to about 0.75 wt% DME-PEG 1000.

50. The electrolyte according to any one of claims 45-49, comprising from about 1 wt% to about 2 wt% DME-PEG 2000 and from about 0.25 wt% to about 0.75 wt% DME-PEG 1000.