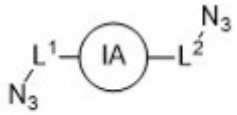
Claims

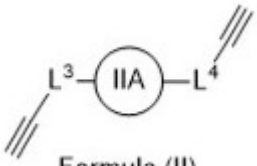
1. A solid polymer electrolyte comprising a plurality of metal cations M interspersed within a polymer comprising:
at least one monomer of Formula (I)



Formula (I)

,

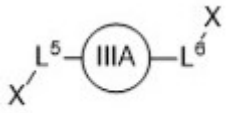
at least one monomer of Formula (II)



Formula (II)

, and

at least one monomer of Formula (III)



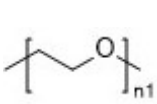
Formula (III)

,

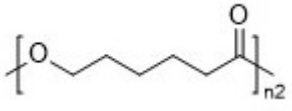
wherein
each of group IA, IIA and IIIA is independently a bivalent moiety derived from or polymerized from an ion-conducting oligomer or an ion-conducting polymer;
each X is independently a leaving group; and
each of L^1, L^2, L^3, L^4, L^5 and L^6 is independently absent or a C_1-C_6 alkylene.

2. The solid polymer electrolyte of claim 1, further comprising a quarternising agent of Formula R-Y, wherein
R is a C_1-C_{10} alkyl, a C_1-C_{10} heteroalkyl, a C_6-C_{10} aryl or a C_5-C_{10} heteroaryl, and
Y is a second leaving group, preferably a halide or a weakly coordinating anion.

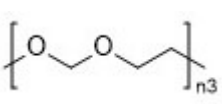
3. The solid polymer electrolyte of claim 1 or 2, wherein M is selected from the group consisting of lithium, sodium, potassium, magnesium, calcium, aluminum, vanadium, zinc and combinations thereof, and/or
each of the leaving group of X is independently a halide or a weakly coordinating anion, and/or
each of group IA, IIA and IIIA is independently selected from the group consisting of



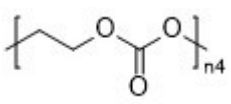
,



,

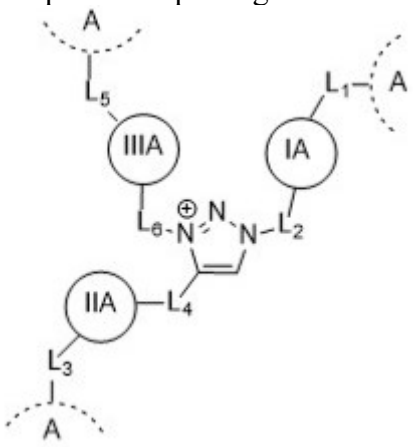


,

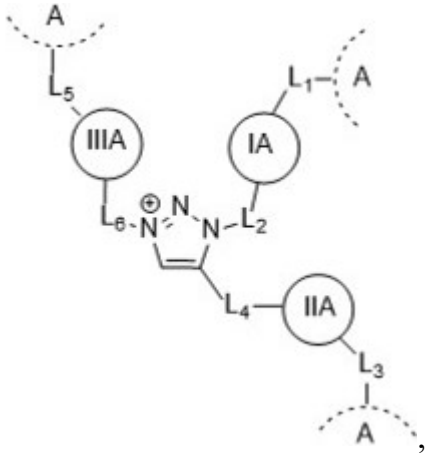


and combinations thereof,
wherein each of n1, n2, n3 and n4 is independently a number in the range of 2 to 50.

4. The solid polymer electrolyte of any one of claims 1 to 3, wherein the polymer comprises a repeating unit of the formula:



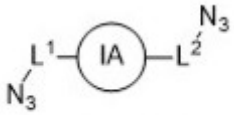
or



,

wherein when two or three repeating units are joined at A, A independently forms a triazole or a triazolium optionally quarternised with a R group, wherein R is a C_1-C_{10} alkyl, a C_1-C_{10} heteroalkyl, a C_6-C_{10} aryl or a C_5-C_{10} heteroaryl,
or a regioisomer thereof.

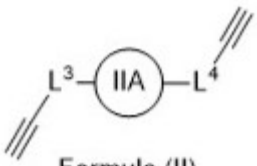
5. A method of preparing a solid polymer electrolyte comprising the step of:
reacting a metal salt MZ_n with a polymer derived from or polymerized from at least one monomer of Formula (I)



Formula (I)

,

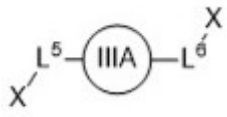
at least one monomer of Formula (II)



Formula (II)

, and

at least one monomer of Formula (III)



Formula (III)

,

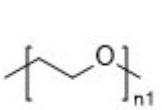
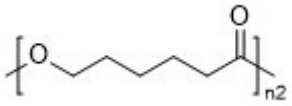
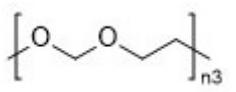
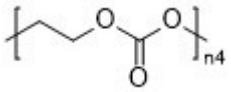
at an elevated temperature,
wherein
M is a metal cation;
Z is a weakly coordinating anion;
n is suitably selected such that MZ_n is electrically neutral;
each of group IA, IIA and IIIA is independently a bivalent moiety derived from or polymerized from an ion-conducting oligomer or an ion-conducting polymer;

each X is independently a leaving group; and
each of L^1, L^2, L^3, L^4, L^5 and L^6 is independently absent or a C_1-C_6 alkylene.

6. The method of claim 5, wherein each leaving group of X is independently a halide or a weakly coordinating anion,
optionally when each leaving group of X is the halide, the method further comprises, before the reacting step, the step of forming the polymer by heating a mixture comprising the at least one monomer of Formula (I), the at least one monomer of Formula (II) and the at least one monomer of Formula (III) at the elevated temperature, or
optionally when each leaving group of X is the weakly coordinating anion, in the reacting step, the polymer is formed in situ by heating a mixture comprising the at least one monomer of Formula (I), the at least one monomer of Formula (II) and the at least one monomer of Formula (III) at the elevated temperature.

7. The method of claim 5 or 6, wherein the polymer is further derived from or polymerized from a quarternising agent of Formula R-Y, wherein
R is a C_1-C_{10} alkyl, a C_1-C_{10} heteroalkyl, a C_6-C_{10} aryl or a C_5-C_{10} heteroaryl, and
Y is a second leaving group, preferably a halide or a weakly coordinating anion,
and/or the monomer of Formula (I) and the quarternising agent have a molar ratio in the range of about 1:0.1 to about 1:2.

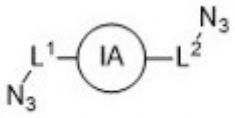
8. The method of any one of claims 5 to 7, wherein the monomer of Formula (I) and the monomer of Formula (II) have a molar ratio in the range of about 1:0.8 to about 1:1.2, and/or the monomer of Formula (I) and the monomer of Formula (III) have a molar ratio in the range of about 1:0.1 to about 1:1.

9. The method of any one of claims 5 to 8, wherein M is selected from the group consisting of lithium, sodium, potassium, magnesium, calcium, aluminum, vanadium, zinc and combinations thereof and/or each of group IA, IIA and IIIA is independently selected from the group consisting of , , ,  and combinations thereof,
wherein each of n1, n2, n3 and n4 is independently a number in the range of 2 to 50.

10. The method of any one of claims 5 to 9, wherein the reacting step is undertaken in an inert atmosphere and/or the reacting step is undertaken for a duration in the range of 0.5 days to 10 days and/or the elevated temperature is a temperature between about 50 °C to about 200 °C.

11. The method of any one of claims 5 to 10, further comprising (i) a step of hot pressing the solid polymer electrolyte, optionally the hot pressing step is undertaken at a temperature in the range of 100 to 250 °C and/or at a nominal pressure in the range of 0.5 to 20 bar, and/or
(ii) a step of drying the solid polymer electrolyte.

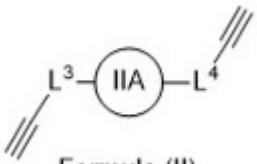
12. A solid polymer electrolyte obtainable by or obtained by reacting a metal salt MZ_n with a polymer derived from or polymerized from at least one monomer of Formula (I)



Formula (I)

,

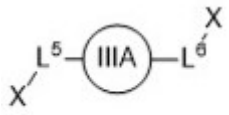
at least one monomer of Formula (II)



Formula (II)

, and

at least one monomer of Formula (III)



Formula (III)

,

at an elevated temperature,
wherein
M is a metal cation;
Z is a weakly coordinating anion;
n is suitably selected such that MZ_n is electrically neutral;
each of group IA, IIA and IIIA is independently a bivalent moiety derived from or polymerized from an ion-conducting oligomer or an ion-conducting polymer;
each X is independently a leaving group; and
each of L^1, L^2, L^3, L^4, L^5 and L^6 is independently absent or a C_1-C_6 alkylene, wherein the solid polymer electrolyte comprises a cationic covalent adaptable network.

13. The solid polymer electrolyte of claim 12, wherein the solid polymer electrolyte is free-standing or exist as part of a composite.

14. A battery comprising the solid polymer electrolyte of any one of claims 1 to 4, 12 and 13, a cathode and/or an anode.

15. The battery of claim 14, wherein the solid polymer electrolyte acts as a separator, or as an ion-conducting phase in a cathode and/or anode or a combination thereof and/or the solid polymer electrolyte is in a form of metal-ion, metal polymer, solid-state, metal-sulfide, or metal-air electrolyte.