Claims

1. A method of partially depolymerising a depolymerisable condensation polymer, the method comprising the steps of:
(a) forming a mixture comprising a depolymerisable condensation polymer, a polar aprotic solvent, a catalyst and a cleaving agent;
(b) heating the mixture to a temperature from greater than 150 °C to less than 200 °C and allowing the depolymerisation reaction to take place for a period of time to provide oligomers derived from the depolymerisable condensation polymer,
wherein the cleaving agent is a polyol compound; and
wherein the catalyst is selected from one or more of the group consisting of an ionic liquid, a secondary amine, a tertiary amine, and a heterocyclic amine, wherein
when the catalyst comprises an ionic liquid, the process involves a subsequent step of cooling the mixture after the period of time to provide an ionogel, suitable for use as a solid-state electrolyte.

2. The method according to Claim 1, wherein the process involves quenching the mixture into water with stirring after the period of time to precipitate out the oligomers derived from the depolymerisable condensation polymer to provide a branched oligomeric resin after collection of the precipitated oligomers derived from the depolymerisable condensation polymer.

3. The method according to any one of the preceding claims, wherein the polyol compound is selected from one or more of the group selected from glycerol, ethylene glycol, propylene glycol, tris(hydroxymethyl)aminomethane, tris(hydroxymethyl)methane, pentaerythritol, and sugar alcohols (e.g. one or more of the group consisting of erythritol, threitol, arabitol, xylitol, ribitol, mannitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, maltotriitol, maltotetraitol, polyglycitol, and sorbitol).

4. The method according to any one of the preceding claims, wherein the catalyst is an imidazolinium-based ionic liquid or hexamethylenetetramine

5. The method according to Claim 3, wherein the catalyst is a 1-alkyl-3-methylimidazolium-based ionic liquid having an alkyl chain length of from C1 to C8alkyl.

6. The method according to Claim 3, wherein the catalyst is 1-ethyl-3-methylimidazolium chloride.

7. The method according to any one of the preceding claims, wherein the depolymerisable condensation polymer is selected from one or more of the group consisting of a thermoplastic polyamide, a thermoplastic polyester, and a thermoplastic and/or crosslinked polyurethane.

8. The method according to Claim 8, wherein the depolymerisable condensation polymer is selected from one or more of the group consisting of a polyurethane, nylon 6,6, nylon 6, polyethylene terephthalate, polylactic acid, and elastane, optionally wherein the depolymerisable condensation polymer is selected from one or more of the group consisting of nylon 6,6, nylon 6, polyethylene terephthalate, and polylactic acid.

9. The method according to any one of the preceding claims, wherein the period of time is from 3 hours to 48 hours, such as from 4 hours to 24 hours, such as from 5 hours to 18 hours.

10. The method according to any one of the preceding claims, wherein the temperature is from 155 °C to 195 °C, such as from 170 °C to 190 °C, such as about 180 °C.

11. The method according to any one of the preceding claims, wherein the stoichiometric ratio of the depolymerisable condensation polymer to the cleaving agent is from 1.25:1 to 10:1, such as from 5:3 to 5:1, such as about 5:2.

12. The method according to any one of the preceding claims, wherein the ionogel is used in further processing steps to provide a reinforced composite material, which additional steps include:

(ai) providing a plurality of glass fiber meshes coated in the ionogel; and

(aii) stacking the plurality of glass fiber meshes coated in an ionogel and subjecting the resulting stack to heat and pressure to provide a reinforced composite material.

13. The method according to any one of Claims 2 to 11 as dependent upon Claim 2, wherein the branched oligomeric resin is used in further processing steps to provide a transparent film coating, which additional steps include:

(bi) melting the branched oligomeric resin; and

(bii) applying the melted brached oliogmeric resin onto a surface to provide a transparent film coating upon cooling.

14. The method according to any one of Claims 2 to 11 as dependent upon Claim 2, wherein the branched oligomeric resin is used in further processing steps to provide a blended material suitable for use in coating, which additional steps include:

(ci) forming a mixture comprising the branched oligomeric resin, an isocyanate resin and a solvent; and

(cii) removing the solvent to provide a blended material suitable for coating.

15. The method according to any one of Claims 2 to 11 as dependent upon Claim 2, wherein the branched oligomeric resin is used in further processing steps to provide a crosslinked material suitable for use in coating, which additional steps include:

(ci) forming a reaction mixture comprising the branched oligomeric resin, an triglycidyl isocyanurate epoxy crosslinker and a solvent, which is allowed to react for a period of time; and

(cii) removing the solvent to provide a crosslinked material suitable for use in coating.

16. The method according to any one of Claims 2 to 11 as dependent upon Claim 2, wherein the branched oligomeric resin is used in further processing steps to provide a vitrimer material, which additional steps include:

(di) providing a melted mixture of the branched oligomeric resin, an anhydride material (e.g. maleic anhydride) and a metal salt (e.g. zinc acetate);

(dii) subjecting the melted mixture to extrusion to provide a vitrimer material.

17. The method according to any one of Claims 2 to 11 as dependent upon Claim 2, wherein the branched oligomeric resin is used in further processing steps to provide a vitrimeric resin, which additional steps include:

(ei) forming a reaction mixture comprising the branched oligomeric resin, a dicarboxylic acid (e.g. succinic acid), a metal salt (e.g. zinc acetate) and a solvent;

(eii) quenching the reaction mixture by using a water and/or an alkyl alcohol (e.g. isopropyl alcohol) and then collecting a precipitated material, which is the vitrimeric resin.

18. The method according to Claim 18, wherein the vitrimeric resin is further melted and subjected to extrusion to provide an extruded vitrimeric material.

19. The method according to any one of Claims 2 to 11 as dependent upon Claim 2, wherein the branched oligomeric resin is used in further processing steps to provide a solid-state electrolyte, which additional steps include:

(fi) providing an ionogel slurry comprising the branched oligomeric resin, an ionic liquid (e.g. 1-ethyl-3-methylimidazolium chloride), a first solvent (e.g. propylene carbonate) and a second solvent (e.g. ethyl acetate); and

(fii) film casting the ionogel slurry onto a substrate and drying the slurry to provide a solid electrolyte.

20. The method according to any one of Claims 1 to 11 , wherein when the catalyst comprises an ionic liquid and the process provides an ionogel, then the ionogel is used in further processing steps to provide a composite product, which additional steps include:

(ai) applying the ionogel to a first substrate to form a coated surface and pressing a second substrate against the coated surface to form a pre-adhered composite material; and

(aii) heating the pre-adhered composite material to an elevated temperature for a period of time to substantially remove the solvent in the ionogel and provide the composite material.