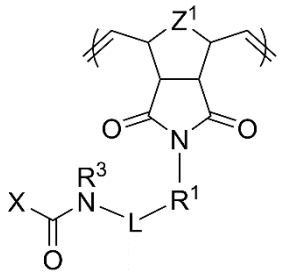
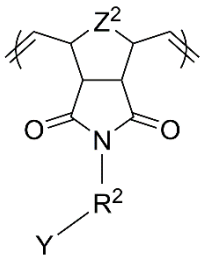
CLAIMS

1. A bioactive polyethylene copolymer with a poly(norbornene) backbone comprising one or more repeating units represented by general formula (I) and one or more repeating units represented by general formula (II):



(I)



(II)

wherein

R^1 is optionally substituted alkyl;

R^2 is selected from a single bond, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl or optionally substituted alkylcarbonylalkyl;

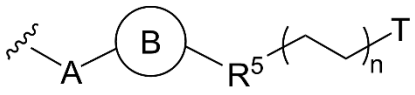
R^3 is selected from H, optionally substituted alkyl, optionally substituted alkenyl or optionally substituted alkynyl;

L is polyalkylene glycol;

X comprises a bioactive moiety selected from the group consisting of proteins, peptides, carbohydrates, therapeutic/drug molecules and derivatives thereof;

Z^1 and Z^2 are each independently selected from CR^aR^b, O, NR^c, SiR^aR^b, PR^a or S, wherein R^a, R^b, and R^c are each independently selected from the group consisting of H, optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl; and

Y is represented by general formula (III):



(III)

wherein

A is optionally present as NR^c, wherein R^c is independently selected from H, optionally substituted alkyl, optionally substituted alkenyl or optionally substituted alkynyl;

B is optionally present as a 5-membered or 6-membered heterocyclic ring having at least one N heteroatom in the ring;

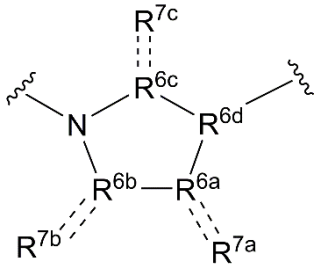
R^5 is selected from an optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl or optionally substituted alkylcarbonylalkyl;

T is a terminal group selected from the group consisting of hydrogen and methyl; and

n is from 10 to 350.

2. The copolymer of claim 1, wherein n is from 20 to 250.

3. The copolymer of claim 1 or claim 2, wherein B is present and represented by the following structure:



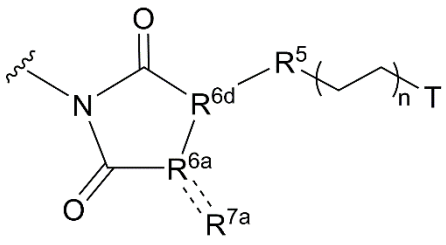
wherein

R^{6a}, R^{6b}, R^{6c} and R^{6d} are each independently selected from the group consisting of C, CR^a, CR^aR^b, N, NR^c, O or S, wherein R^a, R^b, and R^c are each independently selected from the group consisting of H,

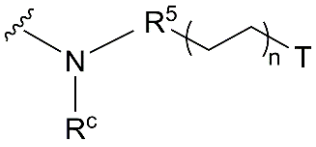
optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl; and

R^{7a}, R^{7b} and R^{7c} are optionally present as =O, =S, –F, –Cl, –Br, –I, $=CR^aR^b$, $–CR^aR^bR^c$, –OH, –SH, $–NH_2$ or $=NR^c$.

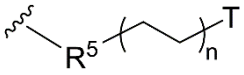
4. The copolymer of any one of the preceding claims, wherein Y is selected from the following general formulae (IIIa), (IIIb) or (IIIc):



(IIIa)



(IIIb)



(IIIc)

wherein

R^5 is selected from the group consisting of C_1-C_{20} alkyl, C_2-C_{20} alkenyl, C_2-C_{20} alkynyl, C_1-C_{20} alkoxy, C_1-C_{20} alkoxyalkyl, C_2-C_{20} alkylcarbonyl and C_3-C_{20} alkylcarbonylalkyl;

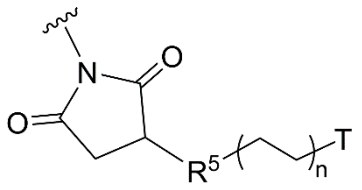
R^{6a} and R^{6d} are each independently selected from the group consisting of C, CR^a, CR^aR^b, N, NR^c, O or S, wherein R^a, R^b, and R^c are each independently selected from the group consisting of H, optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl;

R^{7a} is optionally present as =O, =S, –F, –Cl, –Br, –I, $=CR^aR^b$, $–CR^aR^bR^c$, –OH, –SH, $–NH_2$ or $=NR^c$;

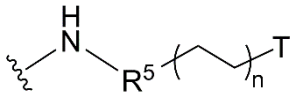
T is a terminal group selected from the group consisting of hydrogen and methyl; and

n is from 10 to 350.

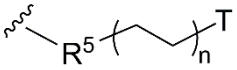
5. The copolymer of any one of the preceding claims, wherein Y is selected from the following general formulae (IIId), (IIIe) or (IIIf):



(IIId)



(IIIe)



(IIIf)

wherein

R^5 is selected from the group consisting of C_1-C_{20} alkyl, C_2-C_{20} alkenyl, C_2-C_{20} alkynyl, C_1-C_{20} alkoxy, C_1-C_{20} alkoxyalkyl, C_2-C_{20} alkylcarbonyl and C_3-C_{20} alkylcarbonylalkyl;

T is a terminal group selected from the group consisting of hydrogen and methyl; and

n is from 10 to 350.

6. The copolymer of any one of the preceding claims, wherein the repeating unit represented by general formula (I) is in an amount of from 1 to 100 molar % relative to the copolymer.

7. The copolymer of any one of the preceding claims, wherein the molecular weight of general formula (I) do not differ from the molecular weight of general formula (II) by more than 30% of the molecular weight of general formula (II).

8. The copolymer of any one of the preceding claims, wherein L is polyethylene glycol (PEG).

9. The copolymer of any one of the preceding claims, wherein L is polyethylene glycol (PEG) having a number average molecular weight of between 500 and 7,000.

10. The copolymer of any one of the preceding claims, wherein R^1 is C_1-C_4 alkyl and R^2 is selected from C_1-C_{20} alkyl, C_2-C_{20} alkenyl, C_2-C_{20} alkynyl, C_1-C_{20} alkoxy, C_1-C_{20} alkoxyalkyl, C_2-C_{20} alkylcarbonyl or C_3-C_{20} alkylcarbonylalkyl.

11. The copolymer of any one of the preceding claims, wherein R^1 is straight or branched C_1-C_4 alkyl substituents independently selected from methyl, ethyl, n-propyl, 2-propyl, isopropyl, n-butyl, isobutyl, sec-butyl or t-butyl, and R^2 is straight or branched C_1-C_{20} alkyl substituents independently selected from methyl, ethyl, n-propyl, 2-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl, hexyl, amyl, 1,2-dimethylpropyl, 1,1-dimethylpropyl, pentyl, isopentyl, hexyl, 4-methylpentyl, 1-methylpentyl, 2-methylpentyl, 3-methylpentyl, 2,2-dimethylbutyl, 3,3-dimethylbutyl, 1,2-dimethylbutyl, 1,3-dimethylbutyl, 1,2,2-trimethylpropyl, 1,1,2-trimethylpropyl, 2-ethylpentyl, 3-ethylpentyl, heptyl, 1-methylhexyl, 2,2-dimethylpentyl, 3,3-dimethylpentyl, 4,4-dimethylpentyl, 1,2-dimethylpentyl, 1,3-dimethylpentyl, 1,4-

dimethylpentyl, 1,2,3-trimethylbutyl, 1,1,2-trimethylbutyl, 1,1,3-trimethylbutyl, 5-methylheptyl, 1-methylheptyl, octyl, nonyl or decyl.

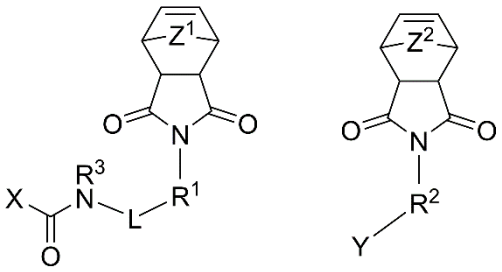
12. The copolymer of any one of the preceding claims, wherein Z^1 and Z^2 are both CR^aR^b wherein R^a and R^b are each independently selected from the group consisting of H, optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl.

13. The copolymer of any one of the preceding claims, wherein X comprises protein, peptide or carbohydrate selected from the group consisting of peptide sequence, laminin-derived peptide, integrin binding peptide, cell-penetrating peptide, collagen sequence, collagen mimics, collagen fragment, heparin sulfate, glycosaminoglycans (GAGs) and derivatives thereof.

14. The copolymer of any one of the preceding claims, wherein X is selected from the group consisting of RGD, SRGDS, RGDS, A5G81 (AGQWHRVSVRWGC), SVVYGLR, $(IRIK)_2$, $(IKKI)_3$, DGEA, $(PHypG)_n$ type sequence, $(PGHyp)_n$ type sequence, $(HypGP)_n$ type sequence, $(HypPG)_n$ type sequence, $(GHypP)_n$ type sequence, $(GPHyp)_n$ type sequence, heparin oligosaccharide DP8, DP10, DP12, DP14, DP16 and hyaluronic acid.

15. A method of preparing a bioactive polyethylene copolymer of any one of claims 1 to 14, the method comprising:

polymerising one or more bioactive macromolecules represented by general formula (IV) with one or more polyethylene macromolecules represented by general formula (V) in the presence of a catalyst to obtain the bioactive polyethylene copolymer:



(IV) (V)

wherein

R^1 is optionally substituted alkyl;

R^2 is selected from a single bond, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl or optionally substituted alkylcarbonylalkyl;

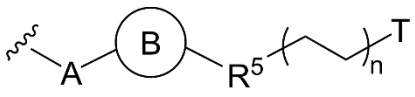
R^3 is selected from H, optionally substituted alkyl, optionally substituted alkenyl or optionally substituted alkynyl;

L is polyalkylene glycol;

X comprises a bioactive moiety selected from the group consisting of proteins, peptides, carbohydrates, therapeutic/drug molecules and derivatives thereof;

Z^1 and Z^2 are each independently selected from CR^aR^b, O, NR^c, SiR^aR^b, PR^a or S, wherein R^a, R^b, and R^c are each independently selected from the group consisting of H, optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl; and

Y is represented by general formula (III):



(III)

wherein

A is optionally present as NR^c, wherein R^c is independently selected from H, optionally substituted alkyl, optionally substituted alkenyl or optionally substituted alkynyl;

B is optionally present as a 5-membered or 6-membered heterocyclic ring having at least one N heteroatom in the ring;

R^5 is selected from an optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl or optionally substituted alkylcarbonylalkyl;

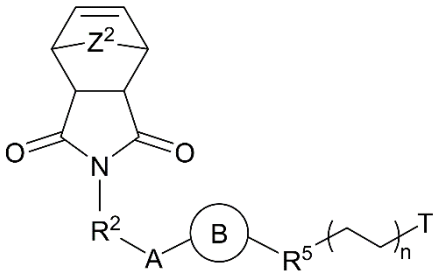
T is a terminal group selected from the group consisting of hydrogen and methyl; and

n is from 10 to 350.

16. The method according to claim 15, wherein the catalyst comprises a ruthenium complex.

17. The method according to any one of claims 15 to 16, wherein the method comprises ring opening metathesis polymerisation (ROMP).

18. A polyethylene macromolecule represented by general formula (VIII) for preparing the copolymer of any one of claims 1 to 14:



(VIII)

wherein

R^2 is selected from a single bond, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally

substituted alkoxyalkyl, optionally substituted alkylcarbonyl or optionally substituted alkylcarbonylalkyl;

Z^2 is selected from CR^aR^b, O, NR^c, SiR^aR^b, PR^a or S, wherein R^a, R^b, and R^c are each independently selected from the group consisting of H, optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl;

A is optionally present as NR^c, wherein R^c is independently selected from H, optionally substituted alkyl, optionally substituted alkenyl or optionally substituted alkynyl;

B is optionally present as a 5-membered or 6-membered heterocyclic ring having at least one N heteroatom in the ring;

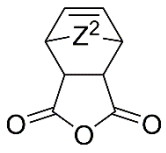
R^5 is selected from an optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl or optionally substituted alkylcarbonylalkyl;

T is a terminal group selected from the group consisting of hydrogen and methyl; and

n is from 10 to 350.

19. A method of preparing a polyethylene macromolecule of claim 18, the method comprising:

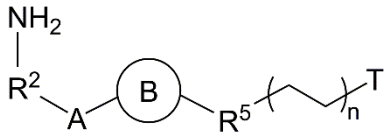
(i) providing a dicarboxylic anhydride having general formula (IX):



(IX)

wherein Z^2 is selected from CR^aR^b, O, NR^c, SiR^aR^b, PR^a or S, wherein R^a, R^b, and R^c are each independently selected from the group consisting of H, optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl; and

(ii) reacting said dicarboxylic anhydride having general formula (IX) with an amine to obtain the polyethylene macromolecule, the amine is represented by general formula (X):



(X)

wherein

R^2 is selected from a single bond, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl or optionally substituted alkylcarbonylalkyl;

A is optionally present as NR^c, wherein R^c is independently selected from H, optionally substituted alkyl, optionally substituted alkenyl or optionally substituted alkynyl;

B is optionally present as a 5-membered or 6-membered heterocyclic ring having at least one N heteroatom in the ring;

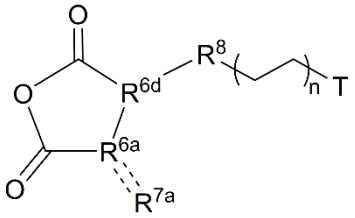
R^5 is selected from the group consisting of C_1-C_{20} alkyl, C_2-C_{20} alkenyl, C_2-C_{20} alkynyl, C_1-C_{20} alkoxy, C_1-C_{20} alkoxyalkyl, C_2-C_{20} alkylcarbonyl and C_3-C_{20} alkylcarbonylalkyl;

T is a terminal group selected from the group consisting of hydrogen and methyl;

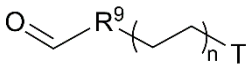
n is from 10 to 350.

20. The method according to claim 19, further comprising, prior to step (ii),

(a-i) providing a polyethylene having general formula (XIa) or (XIb):



(XIa)



(XIb)

wherein

R^{6a} and R^{6d} are each independently selected from the group consisting of C, CR^a, CR^aR^b, N, NR^c, O or S, wherein R^a, R^b, and R^c are each independently selected from the group consisting of H, optionally substituted alkyl, optionally substituted alkenyl and optionally substituted alkynyl;

R^{7a} is optionally present as =O, =S, –F, –Cl, –Br, –I, $=CR^aR^b$, $–CR^aR^bR^c$, –OH, –SH, $–NH_2$ or $=NR^c$;

R^8 and R^9 are each independently selected from the group consisting of C_1-C_{20} alkyl, C_2-C_{20} alkenyl, C_2-C_{20} alkynyl, C_1-C_{20} alkoxy, C_1-C_{20} alkoxyalkyl, C_2-C_{20} alkylcarbonyl and C_3-C_{20} alkylcarbonylalkyl;

T is a terminal group selected from the group consisting of hydrogen and methyl;

n is from 10 to 350; and

(b-i) reacting said polyethylene having general formula (XIa) or (XIb) with a diamine $H_2N–R^2–NH_2$ or ammonia NH_3 to obtain the amine having general formula (X).

21. The method according to claim 19 or 20, wherein at least one of step (ii) and step (b-i) is performed in the presence of an organic solvent and/or a base.

22. The method according to claim 21, wherein the organic solvent comprises an aromatic solvent; and the base comprises a tertiary amine.

23. A material comprising a copolymer of any one of claims 1 to 14 for use in medicine.

24. The material according to claim 23, wherein the material is part of an apparatus selected from the group consisting of consumer care products, wound dressing, skin scaffold, bone and bone marrow organoid scaffold, cartilage implant, joint implant and medical device.