CLAIMS

1. A method of producing a bioactive polymer filament, the method comprising:

providing a base polymer powder and a bioactive copolymer;

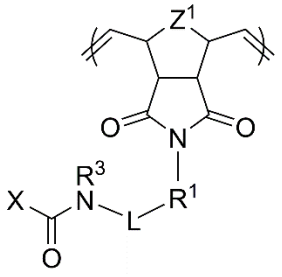
mixing the base polymer powder with the bioactive copolymer to obtain a mixture; and

extruding a bioactive polymer filament from the mixture at an extrusion temperature profile that is based on a predetermined melt/softening temperature and a predetermined onset degradation temperature of the bioactive polymer; and

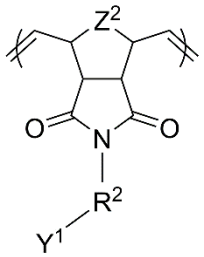
performing a post-extrusion thermal analysis on the extruded bioactive polymer filament to assess onset degradation of the bioactive polymer in the filament,

wherein the base polymer powder has an average particle size of no more than 1 mm, and

wherein the bioactive copolymer is a bioactive synthetic 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 heteroalkylene;

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

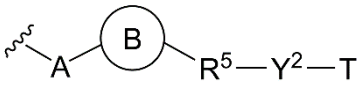
Y^1 comprises a synthetic polymer or parts thereof; and

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.

2. The method of claim 1, wherein the bioactive copolymer is acellular.

3. The method of claim 1 or 2, wherein the bioactive copolymer is obtained by ring-opening metathesis polymerisation (ROMP).

4. The method of claim 1, wherein Y^1 is represented by general formula (III):



(III)

wherein

A is selected from a single bond, oxy, carbonyl, oxycarbonyl, carboxyl, optionally substituted alkoxy, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl, optionally substituted alkylcarbonylalkyl, optionally substituted carboxyalkyl, optionally substituted oxycarbonylalkyl, optionally substituted alkylcarboxylalkyl,

optionally substituted alkoxycarbonylalkyl, N or NR^c wherein R^c is independently selected from H, optionally substituted alkyl, optionally substituted alkenyl or optionally substituted alkynyl;

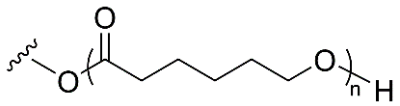
B is optionally present as a ring selected from 1,2,3-triazole or succinimide;

R^5 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;

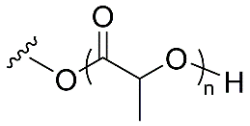
Y^2 is selected from the group consisting of polypropylene (PP), polyesters, poly(lactic acid) (PLA), poly(lactic-co-glycolic acid) (PLGA), poly(caprolactone) (PCL), polystyrene (PS), polyacrylates, poly(meth)acrylates, polyamides (PA), polyurethane (PU), and parts thereof; and

T is a terminal group selected from the group consisting of hydrogen, halogen, hydroxyl, amino, acyl, thiol, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxy, optionally substituted alkoxyalkyl, optionally substituted alkylcarbonyl, optionally substituted alkylcarbonylalkyl, optionally substituted carboxyalkyl, optionally substituted oxycarbonylalkyl, optionally substituted alkylcarboxylalkyl or optionally substituted alkoxycarbonylalkyl.

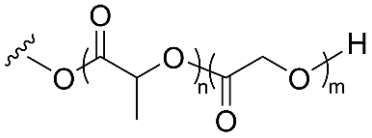
5. The method of claim 4, wherein Y^1 is selected from the following general formulae (IIIa), (IIIb), (IIIc), (IIId), (IIIe), (IIIf), or (IIIg):



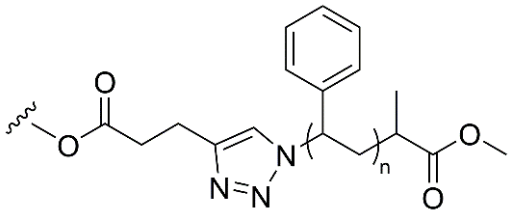
(IIIa)



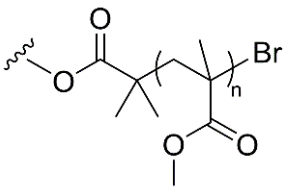
(IIIb)



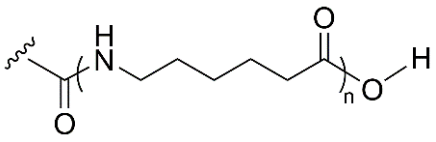
(IIIc)



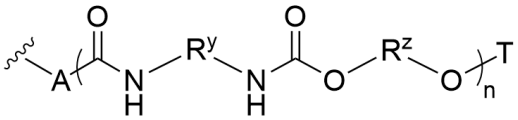
(IIId)



(IIIe)



(IIIf)



(IIIg)

wherein

R^y is selected from an alkyl, aryl or biaryl;

R^z is alkyl;

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

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

$n \geq 1$; and

$m \geq 1$.

6. The method of any one of the preceding claims, wherein the base polymer powder is obtained from cryogenic milling of base polymer pellets.

7. The method of any one of the preceding claims, wherein the post-extrusion thermal analysis comprises application of thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC).

8. The method of any one of the preceding claims, wherein the extruding is performed using an extruder having one or more rotating screws.

9. The method of any one of the preceding claims, wherein the extruded bioactive polymer filament has a filament diameter falling in the range of from 1.5 mm to 4.0 mm.

10. The method of any one of the preceding claims, further comprising performing a pre-extrusion thermal analysis on the base polymer and/or bioactive copolymer to determine the melt temperature and the onset degradation temperature of the bioactive polymer.

11. The method of any one of the preceding claims, wherein the base polymer and bioactive copolymer have been vacuum dried prior to mixing.

12. The method of any one of the preceding claims, wherein the mixture of base polymer and bioactive copolymer comprises 60.0 wt% to 99.9 wt% of the base polymer and 0.1 wt% to 40.0 wt% of the bioactive copolymer.

13. The method of any one of the preceding claims, wherein the base polymer is selected from the group consisting of polypropylene (PP), polyesters, poly(lactic acid) (PLA), poly(lactic-co-glycolic acid) (PLGA), poly(caprolactone) (PCL), polystyrene (PS), polyacrylates, poly(meth)acrylates, polyamides (PA), polyurethane (PU) and combinations thereof.

14. A bioactive polymer filament obtained from the method of any one of claims 1 to 13.

15. A fused filament fabrication (FFF) or fused deposition modelling (FDM) based three-dimensional printing method, the method comprising:

feeding a bioactive polymer filament of claim 14 into a FFF or FDM based three-dimensional printing apparatus;

applying heat to bioactive polymer filament to obtain a molten form of the bioactive polymer; and

depositing the molten bioactive polymer on a print bed to form a printed three-dimensional part or structure.

16. The method of claim 15, further comprising performing one or more of post-printing analysis of the printed three-dimensional part or structure, the post-printing analysis selected from the group consisting of:

i. a mechanical analysis of the printed three-dimensional part or structure to assess its mechanical properties;

ii. a biocompatibility analysis of the printed three-dimensional part or structure to assess its biocompatibility with living cells;

iii. a thermal analysis on the printed three-dimensional part or structure to assess onset degradation of the bioactive polymer in the printed three-dimensional part or structure; and

iv. a spectrometric analysis of the printed three-dimensional part or structure to assess the presence of bioactive copolymer in the printed three-dimensional part or structure.

17. The method of claim 15 or claim 16, wherein the step of applying heat is at a temperature that is based on a predetermined melt/softening temperature and a predetermined onset degradation temperature of the bioactive polymer.

18. The method of any one of claims 15-17, wherein the FFF or FDM based three-dimensional printing apparatus is configured for filament feedstock having filament diameters falling in the range of from 1.5 mm to 4.0 mm.

19. A method of producing a bioactive polymer filament, the method comprising:

providing a base polymer powder and a bioactive copolymer;

mixing the base polymer powder with the bioactive copolymer to obtain a mixture; and

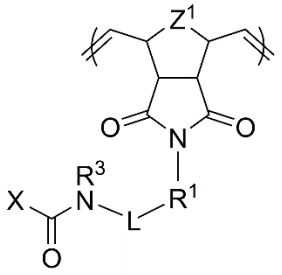
extruding a bioactive polymer filament from the mixture at an extrusion temperature profile that is based on a predetermined melt/softening temperature and a predetermined onset degradation temperature of the bioactive polymer; and

performing a post-extrusion thermal analysis on the extruded bioactive polymer filament to assess onset degradation of the bioactive polymer in the filament,

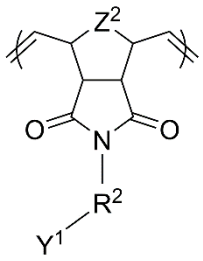
wherein the extruded bioactive polymer filament has a filament diameter falling in the range of from 1.6 mm to 3.1 mm,

wherein the mixture of base polymer and bioactive copolymer comprises 10.0 wt% of the bioactive copolymer, and

wherein the bioactive copolymer is a bioactive synthetic 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 alkyl;

R^2 is alkyl;

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

L is heteroalkylene;

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

Y^1 comprises a synthetic polymer or parts thereof; and

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.