CLAIMS

1. A process for inserting amide linkages into a polyolefin, the process comprising the steps of:

(i) providing a polyoxime derived from the oxidation of a polyolefin into a polyketone and subsequently converting the polyketone into the polyoxime; and

(ii) subjecting the polyoxime to a Beckmann rearrangement reaction in the presence of a dehydrating reagent to obtain a polyamide.

2. The process according to claim 1, wherein step (i) comprises:

(ia) oxidizing the polyolefin into the polyketone in the presence of an oxidizing agent; and

(ib) converting the polyketone into the polyoxime in the presence of hydroxylamine.

3. The process according to claim 2, wherein step (ia) comprises:

(iaa) oxidizing the polyolefin into the polyketone in the presence of oxygen and benzaldehyde; or

(iab) oxidizing the polyolefin into the polyketone in the presence of oxygen and N-hydroxytetrachlorophthalimide.

4. The process according to claim 3, wherein one or more of the following applies:

(a) benzaldehyde is provided in excess of the amount of olefin repeating units in the polyolefin, such as at least 2 molar equivalents relative to the amount of olefin repeating units in the polyolefin, such as at least 3 molar equivalents relative to the amount of olefin repeating units in the polyolefin, optionally wherein benzaldehyde is provided in an amount of about 3 molar equivalents relative to the amount of olefin repeating units in the polyolefin;

(b) N-hydroxytetrachlorophthalimide is provided in an amount of from 0.01 to 0.05 molar equivalent relative to the amount of olefin repeating units, such as from 0.015 to 0.035 molar equivalent relative to the amount of olefin repeating units, optionally wherein N-hydroxytetrachlorophthalimide is provided in an amount of about 0.025 molar equivalent relative to the amount of olefin repeating units; and/or

(c) oxygen is provided at a concentration of from 21 % vol/vol to 100 % vol/vol, optionally wherein the oxygen is provided at a concentration of about 21% vol/vol;

(d) step (iaa) comprises oxidising the polyolefin in the presence of oxygen and benzaldehyde at a temperature of from 110°C to 130°C, such as about 120°C, for a period of from 18 hours to 30 hours, such as about 24 hours;

(e) step (iab) comprises oxidising the polyolefin in the presence of oxygen and N-hydroxytetrachlorophthalimide at a temperature of from 110°C to 130°C, such as about 120°C, for a period of from 18 hours to 30 hours, such as about 24 hours;

(f) step (ia) is conducted in a suitable solvent, wherein the solvent is 1,2,4-trichlorobenzene; and

(g) the degree of ketone functionalisation in step (ia) is from 0.5% to 2.5%, such as about 1.01% or about 2.00%, based on the aliphatic backbone of the polyolefin as measured by ^{1}H nuclear magnetic resonance spectroscopy.

5. The process according to any one of claims 2 to 4, wherein step (ib) comprises converting the polyketone into a polyoxime in the presence of hydroxylamine and a base, optionally wherein the base is selected from a group consisting of sodium methoxide, potassium methoxide.

6. The process according to claim 5, wherein one or more of the following apply:

(a) each of hydroxylamine and the base is provided in an amount of at least 1 molar equivalent relative to the amount of ketone functional groups in the polyketone, such as at least 2 molar equivalents relative to the amount of ketone functional groups in the polyketone, optionally wherein each of hydroxylamine and the base is provided in an amount of about 2.45 molar equivalent relative to the amount of ketone functional groups in the polyketone;

(b) step (ib) comprises converting the polyketone into a polyoxime in the presence of hydroxylamine and the base at a temperature of from 70°C to 90°C, such as about 80°C or about 90°C, for a period of from 18 hours to 30 hours, such as about 24 hours;

(c) step (ib) is conducted in a suitable solvent, wherein the solvent comprises a mixture of

(i) toluene or 1,2,4-trichlorobenzene or *p*-cymene,

(ii) ethanol; and

(iii) water, further optionally wherein one or more of the following apply:

(aa) the mixture of toluene, ethanol and water is provided in a volume ratio of 30-50: 0.5-2: 0.5-2, optionally wherein the mixture of toluene, ethanol and water is provided in a volume ratio of about 40: 1: 1;

(ab) the mixture 1,2,4-trichlorobenzene, ethanol and water is provided in a volume ratio of 125-175: 0.5-5: 0.5-5, optionally wherein the mixture of toluene, ethanol and water is provided in a volume ratio of about 150: 4.5: 3; and

(ac) the solvent is provided in a volume of 5 mL to 20 mL per 1g of the polyketone, such as 7.5 mL to 17.5 mL per 1g of the polyketone, optionally wherein the solvent is provided in a volume of about 10.5 mL or about 17.5 mL per 1g of the polyketone; and

(d) the degree of oxime functionalisation in step (ib) is from 0.5% to 2.5%, such as about 0.95% or about 2.00%, based on the aliphatic backbone of the polyoxime as measured by ^{1}H nuclear magnetic resonance spectroscopy.

7. The process according to any of the preceding claims, wherein the dehydrating agent is selected from a group consisting of phosphorus pentoxide or phosphorus pentachloride, optionally wherein the dehydrating agent is phosphorus pentoxide.

8. The process according to any of the preceding claims, wherein one or more of the following apply:
(a) the dehydrating agent is provided in an amount of at least 2 weight equivalents relative to the amount of oxime functional groups in the polyoxime, such as at least 3 weight equivalents relative to the amount of oxime functional groups in the polyoxime, optionally wherein the dehydrating agent is provided in an amount of about 2.5 weight equivalents relative to the amount of oxime functional groups in the polyoxime;
(b) step (ii) comprises subjecting the polyoxime to a Beckmann rearrangement reaction in the presence of a dehydrating reagent at a temperature of from 55°C to 150°C, such as about 65°C or about 120°C, for a period of from 1.5 hours to 3 hours, such as about 2 hours;
(c) step (ii) is conducted in a suitable solvent, wherein the solvent is selected from a group consisting of chloroform, 1,2,4-trichlorobenzene and *p*-cymene, further optionally wherein:

(ba) chloroform is provided in a volume of 200 mL to 300 mL with respect to 10g of polyoxime, optionally wherein chloroform is provided in a volume of about 250 mL with respect to 10g of polyoxime; or

(bb) 1,2,4-trichlorobenzene is provided in a volume of 200 mL to 300 mL with respect to 10 g of polyoxime, optionally wherein chloroform is provided in a volume of about 250 mL with respect to 10g of polyoxime;
(d) the process further comprises (iia) adding excess iced water to the dehydration reaction mixture of step (ii) to quench the reaction; and
(e) the degree of amide functionalisation in step (ii) is from 0.5% to 2.5%, such as about 0.86% or about 2.00%, based on the aliphatic backbone of the polyamide as measured by ^{1}H nuclear magnetic resonance spectroscopy.

9. A process to provide a reformed polyamide, the process comprising the steps of:
(iii) subjecting a polyamide comprising a plurality of amide groups obtained from any one of Claims 1 to 8 to hydrolysis conditions to cleave at least a portion of the amide groups to provide an intermediate mixture comprising a plurality of different compounds comprising carboxylic acid groups, amine groups or both; and

(iv) generating a reformed polyamide from the intermediate mixture in the presence of a suitable catalyst.

10. The process according to claim 9, wherein the hydrolysis conditions refer to an acidic or basic environment, optionally wherein step (iii) comprises hydrolysing the polyamide in the presence of an acid, optionally wherein the acid is selected from aqueous hydrochloric acid, sulfuric acid and nitric acid, optionally wherein the acid is aqueous hydrochloric acid, further optionally wherein:
(a) the acid is provided in excess of the amount of amide functional groups in the polyamide, such as at least 2 molar equivalents relative to the amount of amide functional groups in the polyamide, such as at least 4 molar equivalents relative to the amount of amide functional groups in the polyamide, optionally wherein the acid is provided in an amount of about 5 molar equivalents relative to the amount of amide functional groups in the polyamide; and
(b) step (iii) comprises hydrolysing the polyamide in the presence of an acid at a temperature of from 90°C to 110°C, such as about 100°C, for a period of from 18 hours to 30 hours, such as about 24 hours.

11 The process according to claim 9 or claim 10, wherein the catalyst is a Lewis acid selected from a group consisting of a boronic acid and titanium isopropoxide, optionally wherein the catalyst is titanium isopropoxide.

12. The process according to any one of claims 9 to 11, wherein one or both of the following apply:
(a) the catalyst is provided in an amount of 5 mol% to 15 mol% of the amount of amide functional groups in the polyamide before step (iii), optionally wherein the catalyst is provided in an amount of about 10 mol% of the amount of amide functional groups in the polyamide before step (iii); and
(b) step (iv) comprises generating a reformed polyamide from the intermediate mixture in the presence of titanium isopropoxide at a temperature of from 150°C to 170°C, such as about 160°C, for a period of from 3 hours to 12 hours, such as about 6 hours.

13. The process according to any one of claims 9 to 12, wherein the reformed polyamide is subjected to compression molding.

14. The process according to any one of the preceding claims, wherein the polyolefin is polyethylene, optionally wherein the polyethylene is high-density polyethylene or low-density polyethylene.

15. The process according to claim 14, wherein one or both of the following apply:

(A) when the polyethylene is low-density polyethylene, one or more of the following apply:

(a) the polyamide formed at step (ii) displays an increased elongation at break of more than 200% compared to the low-density polyethylene;

(b) the polyamide formed at step (ii) displays an increased tensile strength compared to the low-density polyethylene;

(c) the reformed polyamide subjected to compression molding displays an increased elongation at break of more than 100% compared to the polyamide formed at step (ii);

(d) the reformed polyamide subjected to compression molding displays an increased elongation at break of more than 600% compared to the low-density polyethylene;

(e) the reformed polyamide subjected to compression molding displays an increased tensile strength compared to the low-density polyethylene;

(f) the polyamide formed at step (ii) displays an increased water contact angle compared to the low-density polyethylene; and

(g) the polyamide formed at step (ii) displays an aggregated induced emission (AIE) effect-like fluorescence behavior when irradiated at 390 nm; and

(B) when the polyethylene is high-density polyethylene, one or more of the following apply:

(a) the polyamide formed at step (ii) displays an increased elongation at break of compared to the high-density polyethylene;

(b) the polyamide formed at step (ii) displays an increased tensile strength compared to the high-density polyethylene;

(c) the polyamide formed at step (ii) displays an increased water contact angle compared to the high-density polyethylene; and

(d) the polyamide formed at step (ii) displays an aggregated induced emission (AIE) effect-like fluorescence behavior when irradiated at 390 nm.