Synthesis Of Linear Aliphatic Polyesters

Technical Field

The present invention generally relates to polyesters and the method of preparing them. The present invention also relates to the use of such polyesters.

Background Art

The synthesis of polyesters from botanically derived monomers has been increasingly appealing for their environmentally friendly and sustainable features. Synthetic polymers are essential in industry and everyday use because they are affordable, lightweight, durable, and offer a wide range of properties and functions. As such, the development of functional polymers derived from renewable sources, serving as sustainable alternatives to those from fossil fuels, has been a crucial focus in polymer chemistry and green sustainable chemistry. Researchers in polymer chemistry, catalysis, and synthetic chemistry are particularly interested in designing and synthesizing renewable polymers, including random and block copolymers, using novel strategies and precise polymerization techniques.

In recent years, several different synthetic procedures for preparing polyesters have been disclosed and polycondensation of diols and diacids has been a common synthetic method for preparing polyesters. However, existing methods typically involve a distillation setup and inert reaction conditions to carry out the synthesis. Such synthetic methods are laborious and involve higher costs to carry out at an industrial scale.

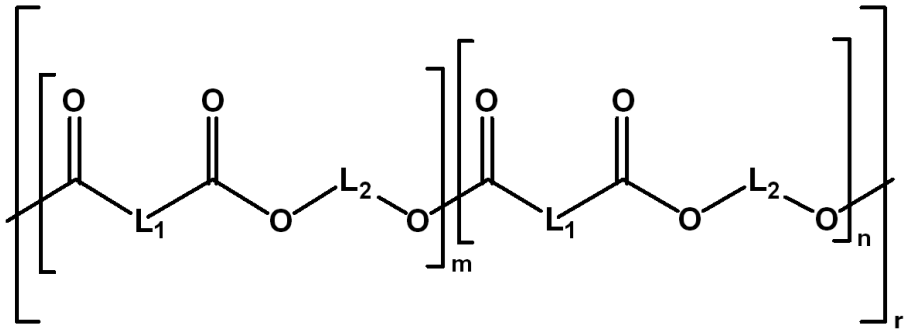
Furthermore, unsaturated polyesters are prone to discolouration as unsaturated fatty acids (and by extension unsaturated dimer acids) are prone to lipid peroxidation (rancidification) which causes discolouration. Elevated temperatures can accelerate this process leading to undesirable side products, hence conventional reaction conditions are unable to overcome this discolouration effect.

Conventional synthetic methods also employ catalysts that are difficult to remove, either making the purification procedure tedious or causing contamination of the final polyester product. For example, polyethylene terephthalate (PET) is usually synthesised using antimony trioxide, which is not removed from the final product.

Accordingly, there is a need to provide a polyester and a method of preparing the same that overcomes, or at least ameliorates, one or more of the disadvantages described above.

Summary

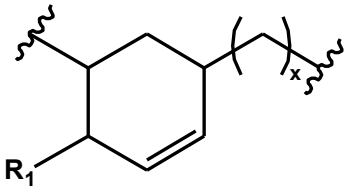
According to a first aspect, there is provided a polyester comprising a general formula (I):



(I),

wherein

L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted -C_{2-10}-alkenyl or substituted or unsubstituted -C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

~~~ is where the structure (A) attaches to the polyester of general formula (I);

and wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched;

m and n are each independently an integer from 1 to 10; and

r is an integer from 20 to 200.

Advantageously, the polyester may be more hydrophobic, chemically resistant and resistant to higher temperatures.

In an embodiment, the polyester may be based on odd-chained diols. Advantageously, such polyesters may not have been reported previously. In an embodiment, the high molecular weight polyester may be based on scarce C_{18}-dicarboxylic acids. Advantageously, such polyesters may not have been reported previously.

Advantageously, the polyester may be branched and/or unsaturated, wherein the branched and/or unsaturated polyesters will have lower melting temperatures and are softer materials.

Advantageously, the polyester produced may be unsaturated and the unsaturated polyesters disclosed in the present disclosure may be more resistant to discolouration. Unsaturated polyesters are typically prone to discolouration as unsaturated fatty acids (and by extension unsaturated dimer acids) are prone to lipid peroxidation (rancidification) which causes discoloration.
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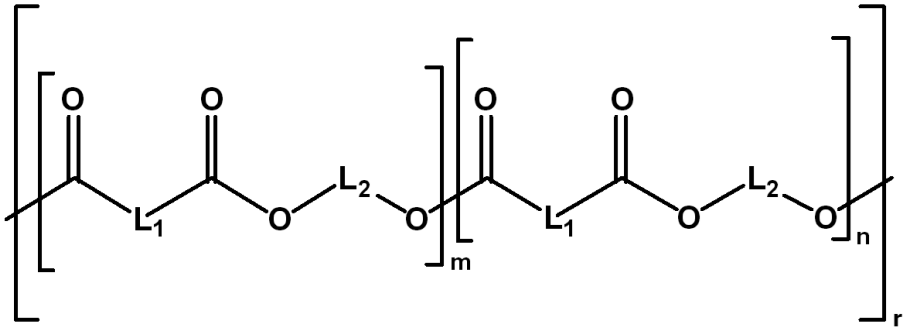
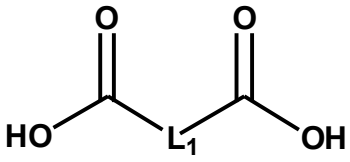
Advantageously, the polyester may be biodegradable, wherein the polyester may be decomposed organically to reduce pollution, making it environmentally friendly. Advantageously, the polyester may be a potential sustainable alternative to non-renewable and non-biodegradable polyethylene.

In another aspect, there is provided a method of preparing a polyester comprising a general formula (I):



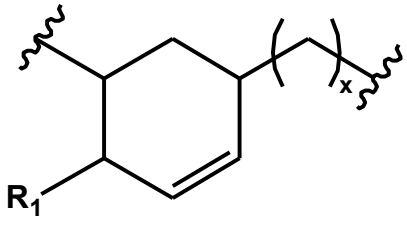
(I),

wherein the method comprises the steps of mixing a dicarboxylic acid having a general formula (II):



(II),

wherein L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



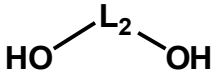
(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted -C_{2-10}-alkenyl or substituted or unsubstituted -C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

~~~ is where the structure (A) attaches to the dicarboxylic acid of general formula (II); and

a diol having a general formula (III),



(III)

wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;
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wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched;

m and n are each independently an integer from 1 to 10; and

r is an integer from 20 to 200.

Advantageously, the method may not require a distillation setup. The omission of a distillation step may allow the synthetic method to be less laborious and ensures higher product yields. Advantageously, the method may not require an inert gas stream. The omission of an inert gas stream may simplify the synthetic process to produce the polyester, allowing the synthetic method to be less laborious.

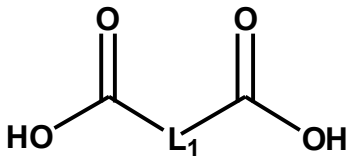
The method may comprise a mixing step comprising a catalyst. Advantageously, the method may comprise a simple purification step to remove the catalyst. The easy removal of the catalyst may ensure higher product yields of the polyester.

Advantageously, the method of producing the polyester is sustainable as the dicarboxylic acids used are produced in a sustainable manner, botanically and microbially.

Advantageously, the method of producing the polyester may require lower temperature in the range of 150 °C to 300 °C to carry out the reaction. Elevated temperatures may accelerate the rancidification process of unsaturated fatty acids (and by extension unsaturated dimer acids), leading to undesirable side products and discolouration of the polyester. Hence, conventional reaction conditions may not be suitable. Advantageously, the disclosed method herein may result in little to no discolouration in the unsaturated polyesters during the synthesis.

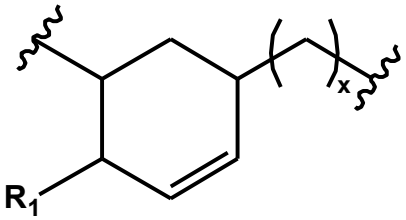
In another aspect, there is provided a polyester prepared by mixing:

a dicarboxylic acid having a general formula (II):



(II),

wherein L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted -C_{2-10}-alkenyl or substituted or unsubstituted -C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

~~~~ is where the structure (A) attaches to the dicarboxylic acid of general formula (II); and
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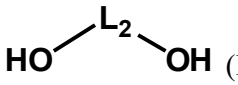
a diol having a general formula (III),


(III)

wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched.

Advantageously, the polyester may be bio-based, wherein the reactants may be produced from plants, such as biomass derived monomers, hence the production of the polyester may be sustainable. More advantageously, the polyester may be synthesized from affordable monomers, making them good alternatives for single-use plastics.

In another aspect, there is provided a use of the polyester as defined above for coating a substrate, as an adhesive, in textiles, bottles, films or plastics.

Definitions

The following are some definitions that may be helpful in understanding the description of the present invention. These are intended as general definitions and should in no way limit the scope of the present invention to those terms alone, but are put forth for a better understanding of the following description.

Unless the context requires otherwise or specifically stated to the contrary, integers, steps, or elements of the invention recited herein as singular integers, steps or elements clearly encompass both singular and plural forms of the recited integers, steps or elements.

Throughout this specification, unless specified otherwise, the terms "comprising" and "comprise", and grammatical variants thereof, are intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, unrecited elements.

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications. The invention also includes all of the steps, features and compounds referred to or indicated in this specification, individually or collectively, and any and all combinations or any two or more of said steps or features.

As used herein, the term "alkyl group" includes within its meaning monovalent (“alkyl”) and divalent (“alkylene”) straight chain or branched chain saturated aliphatic groups having from 1 to 20 carbon atoms, eg, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 or 20 carbon atoms. For example, the term alkyl includes, but is not limited to, methyl, ethyl, 1-propyl, isopropyl, 1-butyl, 2-butyl, isobutyl, tert-butyl, 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, decyl, undecyl, dodecyl, tridecyl, tetradecyl. pentadecyl, hexadecyl, heptadecyl, octadecyl, nonadecyl, icosyl and the like.

The term "alkenyl group" includes within its meaning monovalent (“alkenyl”) and divalent (“alkenylene”) straight or branched chain unsaturated aliphatic hydrocarbon groups having from 2 to 20 carbon atoms, eg, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 or 20 carbon atoms and having at least one double bond, of either E, Z, cis or trans stereochemistry where applicable, anywhere in the alkyl chain. Examples of alkenyl groups include but are not limited to ethenyl, vinyl, allyl, 1-methylvinyl, 1-propenyl, 2-propenyl, 2-methyl-1-propenyl, 2-methyl-1-propenyl, 1-butenyl, 2-butenyl, 3-butentyl, 1,3-butadienyl, 1-pentenyl, 2-pententyl, 3-pentenyl, 4-pentenyl, 1,3-pentadienyl, 2,4-pentadienyl, 1,4-pentadienyl, 3-methyl-2-butenyl, 1-hexenyl, 2-hexenyl, 3-hexenyl, 1,3-hexadienyl, 1,4-hexadienyl, 2-methylpentenyl, 1-heptenyl, 2-heptentyl, 3-heptenyl, 1-octenyl, 1-nonenyl, 1-decenyl, undecenyl, dodecenyl, tridecenyl, tetradecenyl. pentadecenyl, hexadecenyl, heptadecenyl, octadecenyl, nonadecenyl, icosenyl and the like.

The term "alkynyl group" as used herein includes within its meaning monovalent (“alkynyl”) and divalent (“alkynylene”) straight or branched chain unsaturated aliphatic hydrocarbon groups having from 2 to 20 carbon atoms and having at least one triple bond anywhere in the carbon chain. Examples of alkynyl groups include but are not limited to ethynyl, 1-propynyl, 1-butynyl, 2-butynyl, 1-methyl-2-butynyl, 3-methyl-1-butynyl, 1-pentynyl, 1-hexynyl, methylpentynyl, 1-heptynyl, 2-heptynyl, 1-octynyl, 2-octynyl, 1-nonyl, 1-decynyl, undecynyl, dodecynyl, tridecynyl, tetradecynyl. pentadecynyl, hexadecynyl, heptadecynyl, octadecynyl, nonadecynyl, icosynyl and the like.

The term "substituted" means that the specified group or moiety bears one or more substituents. The term "unsubstituted" means that the specified group bears no substituents. The term “substituents” refers to functional groups independently selected from acyl, alkyl, alkenyl, alkynyl, thioalkyl, cycloalkyl, cycloalkylalkyl, cycloalkenyl, cycloalkylalkenyl, heterocycloalkyl, cycloalkylheteroalkyl, cycloalkyloxy, cycloalkenyloxy, cycloamino, halo, carboxyl, haloalkyl, haloalkynyl, alkynyloxy, heteroalkyl, heteroalkenyl heteroalkynyl, heteroalkyloxy, hydroxyl, hydroxyalkyl, alkoxy, thioalkoxy, alkenyloxy, haloalkoxy, haloalkenyl, haloalkynyl, haloalkenyloxy, nitro, amino, nitroalkyl, nitroalkenyl, nitroalkynyl, nitroheterocyclyl, alkylamino, dialkylamino, alkenylamine, aminoalkyl, alkynylamino, acyl, alkyloxy, alkyloxyalkyl, alkyloxyaryl, alkyloxycarbonyl, alkyloxycycloalkyl, alkyloxyheteroaryl, alkyloxyheterocycloalkyl, alkenoyl, alkynoyl, acylamino, diacylamino, acyloxy, alkylsulfonyloxy, heterocyclic, heterocycloalkenyl, heterocycloalkyl, heterocycloalkylalkyl, heterocycloalkylalkenyl, heterocycloalkylalkenyl, heterocycloalkylheteroalkyl, heterocycloalkyloxy, heterocycloalkenyloxy, heterocycloxy, heterocycloamino, haloheterocycloalkyl, alkylsulfinyl, alkylsulfonyl, alkylsulfenyl, alkylcarbonyloxy, alkylthio, acylthio, aminosulfonyl, phosphorus-containing groups such as phosphono and phosphinyl, sulfinyl, sulfinylamino, sulfonyl, sulfonylamino, aryl, arylalkyl, arylalkyloxy, arylamino, Arylheteroalkyl, heteroaryl, heteroarylalkyl, heteroarylalkenyl, heteroarylalkynyl, heteroarylheteroalkyl, heteroarylamino, heteroaryloxy, arylalkenyl, arylalkyl, alkylaryl, alkylheteroaryl, aryloxy, arylsulfonyl, cyano, cyanate, isocyanate, -C(O)NH(alkyl), and -C(O)N(alkyl)$_2$ and the like.

The present invention includes within its scope all isomeric forms of the compounds disclosed herein, including all diastereomeric isomers, racemates and enantiomers. Thus, formulae (I) and (II) should be understood to include, for example, E, Z, cis, trans, (R), (S), (L), (D), (+), and/or (-) forms of the compounds, as appropriate in each case.

As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

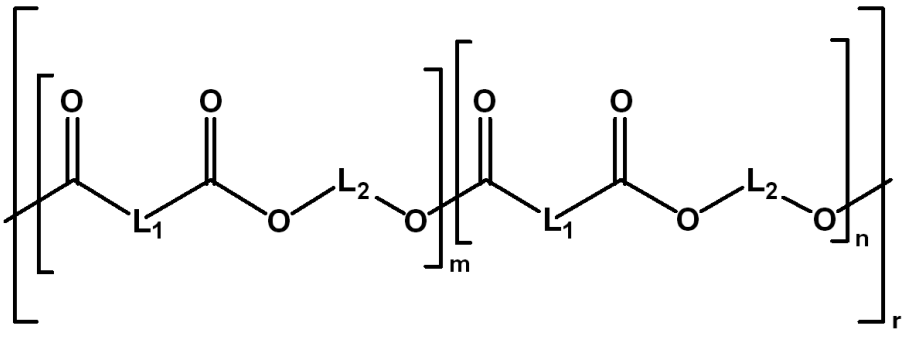
Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Certain embodiments may also be described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the disclosure. This includes the generic description of the embodiments with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

Detailed Disclosure of Embodiments

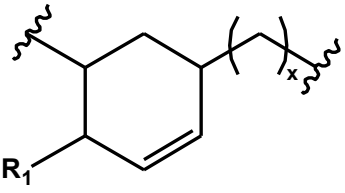
Exemplary, non-limiting embodiments of a polyester will now be disclosed.

There is provided a polyester comprising a general formula (I):



(I),

wherein

L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A) 

(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted -C_{2-10}-alkenyl or substituted or unsubstituted -C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

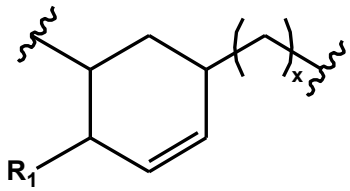
~~~~ is where the structure (A) attaches to the polyester of general formula (I);

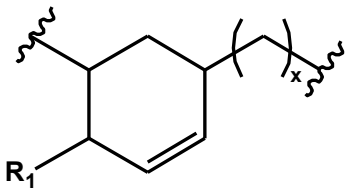
and wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched;

m and n are each independently an integer from 1 to 10; and

r is an integer from 20 to 200.

The substituent L_1 may each independently be absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A) 

(A). The substituent L_1 may each independently be absent. The substituent L_1 may each independently be linear -C_{1-20}-alkyl. The substituent L_1 may each independently be branched -C_{1-20}-alkyl, linear or branched -C_{2-20}-alkenyl, linear or branched -C_{2-20}-alkynyl or the following structure (A) 

(A).

The substituent L_1 may each independently be -C_{1-20}-alkyl, -C_{1-4}-alkyl, -C_{1-8}-alkyl, -C_{1-12}-alkyl, -C_{1-16}-alkyl, -C_{4-8}-alkyl, -C_{4-12}-alkyl, -C_{4-16}-alkyl, -C_{4-20}-alkyl, -C_{8-12}-alkyl, -C_{8-16}-alkyl, -C_{8-20}-alkyl, -C_{12-16}-alkyl, -C_{12-20}-alkyl or -C_{16-20}-alkyl. The substituent L_1 may each independently also be -C_{2-20}-alkenyl, -C_{2-4}-alkenyl, -C_{2-8}-alkenyl, -C_{2-12}-alkenyl, -C_{2-16}-alkenyl, -C_{4-8}-alkenyl, -C_{4-12}-alkenyl, -C_{4-16}-alkenyl, -C_{4-20}-alkenyl, -C_{8-12}-alkenyl, -C_{8-16}-alkenyl, -C_{8-20}-alkenyl, -C_{12-16}-alkenyl, -C_{12-20}-alkenyl or -C_{16-20}-alkenyl. The substituent L_1 may each independently also be -C_{2-20}-alkynyl, -C_{2-4}-alkynyl, -C_{2-8}-alkynyl, -C_{2-12}-alkynyl, -C_{2-16}-alkynyl, -C_{4-8}-alkynyl, -C_{4-12}-alkynyl, -C_{4-16}-alkynyl, -C_{4-20}-alkynyl, -C_{8-12}-alkynyl, -C_{8-16}-alkynyl, -C_{8-20}-alkynyl, -C_{12-16}-alkynyl, -C_{12-20}-alkynyl or -C_{16-20}-alkynyl. Furthermore, the substituent L_1 may each independently be octyl, hexadecyl, (E)-9-(non-3-en-1-yl)-10-octylnonadecyl or 3-heptyl-6-hexylcyclohex-1-enyl. The
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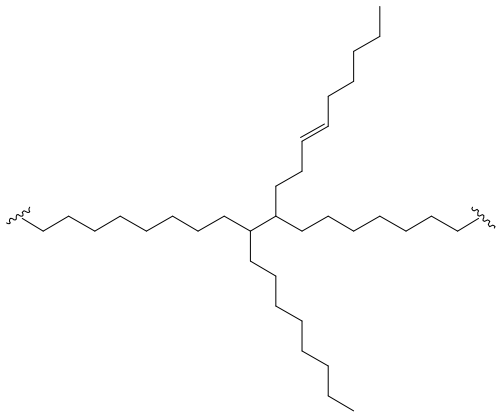
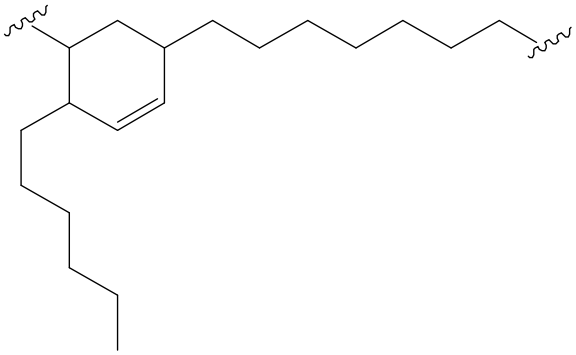
substituent L_1 may each independently be . The substituent L_1 may each independently be . The substituent L_1 may each independently be substituted or unsubstituted.

The substituent R_1 may be H. The substituent R_1 may be -C_{1-10}-alkyl, -C_{1-2}-alkyl, -C_{1-4}-alkyl, -C_{1-6}-alkyl, -C_{1-8}-alkyl, -C_{2-4}-alkyl, -C_{2-6}-alkyl, -C_{2-8}-alkyl, -C_{2-10}-alkyl, -C_{4-6}-alkyl, -C_{4-8}-alkyl, -C_{4-10}-alkyl, -C_{6-8}-alkyl, -C_{6-10}-alkyl or -C_{8-10}-alkyl. The substituent R_1 may also be -C_{2-10}-alkenyl, -C_{2-4}-alkenyl, -C_{2-6}-alkenyl, -C_{2-8}-alkenyl, -C_{4-6}-alkenyl, -C_{4-8}-alkenyl, -C_{4-10}-alkenyl, -C_{6-8}-alkenyl, -C_{6-10}-alkenyl or -C_{8-10}-alkenyl. The substituent R_1 may also be -C_{2-10}-alkynyl, -C_{2-4}-alkynyl, -C_{2-6}-alkynyl, -C_{2-8}-alkynyl, -C_{4-6}-alkynyl, -C_{4-8}-alkynyl, -C_{4-10}-alkynyl, -C_{6-8}-alkynyl, -C_{6-10}-alkynyl or -C_{8-10}-alkynyl. The substituent R_1 may be substituted or unsubstituted.

The integer x may have a value from 1 to 10, 1 to 4, 1 to 6, 1 to 8, 4 to 6, 4 to 8, 4 to 10, 6 to 8, 6 to 10 or 8 to 10.

The substituent L_2 may each independently be substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl. The substituent L_2 may each independently be -C_{2-20}-alkyl, -C_{2-5}-alkyl, -C_{2-7}-alkyl, -C_{2-9}-alkyl, -C_{2-11}-alkyl, -C_{2-13}-alkyl, -C_{2-15}-alkyl, -C_{2-17}-alkyl, -C_{2-19}-alkyl, -C_{5-7}-alkyl, -C_{5-9}-alkyl, -C_{5-11}-alkyl, -C_{5-13}-alkyl, -C_{5-15}-alkyl, -C_{5-17}-alkyl, -C_{5-19}-alkyl, -C_{5-20}-alkyl, -C_{7-9}-alkyl, -C_{7-11}-alkyl, -C_{7-13}-alkyl, -C_{7-15}-alkyl, -C_{7-17}-alkyl, -C_{7-19}-alkyl, -C_{7-20}-alkyl, -C_{9-11}-alkyl, -C_{9-13}-alkyl, -C_{9-15}-alkyl, -C_{9-17}-alkyl, -C_{9-19}-alkyl, -C_{9-20}-alkyl, -C_{11-13}-alkyl, -C_{11-15}-alkyl, -C_{11-17}-alkyl, -C_{11-19}-alkyl, -C_{11-20}-alkyl, -C_{13-15}-alkyl, -C_{13-17}-alkyl, -C_{13-19}-alkyl, -C_{13-20}-alkyl, -C_{15-17}-alkyl, -C_{15-19}-alkyl, -C_{15-20}-alkyl, , -C_{17-19}-alkyl, -C_{17-20}-alkyl, or -C_{19-20}-alkyl. The substituent L_2 may each independently also be -C_{3-20}-alkenyl, -C_{3-5}-alkenyl, -C_{3-7}-alkenyl, -C_{3-9}-alkenyl, -C_{3-11}-alkenyl, -C_{3-13}-alkenyl, -C_{3-15}-alkenyl, -C_{3-17}-alkenyl, -C_{3-19}-alkenyl, -C_{5-7}-alkenyl, -C_{5-9}-alkenyl, -C_{5-11}-alkenyl, -C_{5-13}-alkenyl, -C_{5-15}-alkenyl, -C_{5-17}-alkenyl, -C_{5-19}-alkenyl, -C_{5-20}-alkenyl, -C_{7-9}-alkenyl, -C_{7-11}-alkenyl, -C_{7-13}-alkenyl, -C_{7-15}-alkenyl, -C_{7-17}-alkenyl, -C_{7-19}-alkenyl, -C_{7-20}-alkenyl, -C_{9-11}-alkenyl, -C_{9-13}-alkenyl, -C_{9-15}-alkenyl, -C_{9-17}-alkenyl, -C_{9-19}-alkenyl, -C_{9-20}-alkenyl, -C_{11-13}-alkenyl, -C_{11-15}-alkenyl, -C_{11-17}-alkenyl, -C_{11-19}-alkenyl, -C_{11-20}-alkenyl, -C_{13-15}-alkenyl, -C_{13-17}-alkenyl, -C_{13-19}-alkenyl, -C_{13-20}-

alkenyl, -C_{15-17}-alkenyl, -C_{15-19}-alkenyl, -C_{15-20}-alkenyl, -C_{17-19}-alkenyl, -C_{17-20}-alkenyl or -C_{19-20}-alkenyl. The substituent L_2 may each independently also be -C_{3-20}-alkynyl, -C_{3-5}-alkynyl, -C_{3-7}-alkynyl, -C_{3-9}-alkynyl, -C_{3-11}-alkynyl, -C_{3-13}-alkynyl, -C_{3-15}-alkynyl, -C_{3-17}-alkynyl, -C_{3-19}-alkynyl, -C_{5-7}-alkynyl, -C_{5-9}-alkynyl, -C_{5-11}-alkynyl, -C_{5-13}-alkynyl, -C_{5-15}-alkynyl, -C_{5-17}-alkynyl, -C_{5-19}-alkynyl, -C_{5-20}-alkynyl, -C_{7-9}-alkynyl, -C_{7-11}-alkynyl, -C_{7-13}-alkynyl, -C_{7-15}-alkynyl, -C_{7-17}-alkynyl, -C_{7-19}-alkynyl, -C_{7-20}-alkynyl, -C_{9-11}-alkynyl, -C_{9-13}-alkynyl, -C_{9-15}-alkynyl, -C_{9-17}-alkynyl, -C_{9-19}-alkynyl, -C_{9-20}-alkynyl, -C_{11-13}-alkynyl, -C_{11-15}-alkynyl, -C_{11-17}-alkynyl, -C_{11-19}-alkynyl, -C_{11-20}-alkynyl, -C_{13-15}-alkynyl, -C_{13-17}-alkynyl, -C_{13-19}-alkynyl, -C_{13-20}-alkynyl, -C_{15-17}-alkynyl, -C_{15-19}-alkynyl, -C_{15-20}-alkynyl, -C_{17-19}-alkynyl, -C_{17-20}-alkynyl or -C_{19-20}-alkynyl. The substituent L_2 may each independently be ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl or decyl. The substituent L_2 may each independently be substituted or unsubstituted.

The integer m may have a value from 1 to 10, 1 to 4, 1 to 6, 1 to 8, 4 to 6, 4 to 8, 4 to 10, 6 to 8, 6 to 10 or 8 to 10. The integer n may have a value from 1 to 10, 1 to 4, 1 to 6, 1 to 8, 4 to 6, 4 to 8, 4 to 10, 6 to 8, 6 to 10 or 8 to 10.

The integer r may have a value from 20 to 200, 20 to 30, 20 to 50, 20 to 60, 20 to 75, 20 to 100, 20 to 150, 30 to 50, 30 to 60, 30 to 75, 30 to 100, 30 to 150, 30 to 200, 50 to 60, 50 to 75, 50 to 100, 50 to 150, 50 to 200, 60 to 75, 60 to 100, 60 to 150, 60 to 200, 75 to 100, 75 to 150, 75 to 200, 100 to 150, 100 to 200 or 150 to 200.

The polyester may be based on a C_{10}-dicarboxylic acid. The C_{10}-dicarboxylic acid may be sebacic acid obtained sustainably from castor oil. The polyester based on C_{10}-dicarboxylic acid may be useful in sustainable single-use plastics.

The polyester may be based on C_{18}-dicarboxylic acids. The polyester based on C_{18}-dicarboxylic acids may have a high molecular weight. Conventional polyesters are typically low molecular weight polyesters. However, the present disclosure discloses high molecular weight polyesters based on C_{18}-dicarboxylic acids, which has not been previously reported. The polyester based on C_{18}-dicarboxylic acids may be more hydrophobic, chemically resistant and resistant to higher temperatures because the C_{18}-dicarboxylic acids impart greater hydrophobicity, solvent resistance and higher melting temperature. The polyester based on C_{18}-dicarboxylic acids may be used as protective coatings that confer hydrophobicity and chemical resistance to a surface.

The polyester based on C_{21}-dicarboxylic acids and/or C_{36}-dicarboxylic acids may be hydrophobic and soft. The polyester based on C_{21}-dicarboxylic acids and/or C_{36}-dicarboxylic acids may be soft, in the form of gel or pastes at room temperature. The polyester based on C_{21}-dicarboxylic acids and/or C_{36}-dicarboxylic acids may be used as waterproof coatings or anti-fouling coatings.

The polyester may not comprise poly(1,2-ethylene 1,10-decanedioate); poly(1,3-propylene 1,10-decanedioate); poly(1,4-butylene 1,10-decanedioate); poly(1,5-pentylene 1,10-decanedioate); poly(1,6-hexylene 1,10-decanedioate); poly(1,8-octylene 1,10-decanedioate); poly(1,10-decylene 1,10-decanedioate); poly(1,2-ethylene 1,12-dodecanedioate); poly(1,3-propylene 1,12-dodecanedioate); poly(1,4-butylene 1,12-dodecanedioate); poly(1,5-pentylene 1,12-dodecanedioate); poly(1,6-hexylene 1,12-dodecanedioate); poly(1,7-heptylene 1,12-dodecanedioate); poly(1,8-octylene 1,12-dodecanedioate); poly(1,9-nonylene 1,12-dodecanedioate); poly(1,10-decylene 1,12-dodecanedioate); poly(1,11-undecylene 1,12-dodecanedioate); poly(1,12-dodecylene 1,12-dodecanedioate); poly(1,13-tridecylene 1,12-dodecanedioate); poly(1,14-tetradecylene 1,12-dodecanedioate); poly(1,15-pentadecylene 1,12-

dodecanedioate); poly(1,16-hexadecylene 1,12-dodecanedioate); poly(1,17-heptadecylene 1,12-dodecanedioate); poly(1,18-octadecylene 1,12-dodecanedioate); poly(1,19-nonadecylene 1,12-dodecanedioate); poly(1,20-icoscylene 1,12-dodecanedioate); poly(1,2-ethylene 1,18-octadecanedioate); poly(1,4-butylene 1,18-octadecanedioate); poly(1,6-hexylene 1,18-octadecanedioate); poly(1,8-octylene 1,18-octadecanedioate); poly(1,10-decylene 1,18-octadecanedioate); or poly(1,2-ethylene (E)-9-(non-3-en-1-yl)-10-octylnonadecanedioate).

The polyester may have a number average molecular weight between about 5,000 and about 80,000, about 5,000 and about 10,000, about 5,000 and about 15,000, about 5,000 and about 20,000, about 5,000 and about 30,000, about 5,000 and about 40,000, about 5,000 and about 50,000, about 5,000 and about 60,000, about 5,000 and about 70,000, about 10,000 and about 15,000, about 10,000 and about 20,000, about 10,000 and about 30,000, about 10,000 and about 40,000, about 10,000 and about 50,000, about 10,000 and about 60,000, about 10,000 and about 70,000, about 10,000 and about 80,000, about 15,000 and about 20,000, about 15,000 and about 30,000, about 15,000 and about 40,000, about 15,000 and about 50,000, about 15,000 and about 60,000, about 15,000 and about 70,000, about 15,000 and about 80,000, about 20,000 and about 30,000, about 20,000 and about 40,000, about 20,000 and about 50,000, about 20,000 and about 60,000, about 20,000 and about 70,000, about 20,000 and about 80,000, about 30,000 and about 40,000, about 30,000 and about 50,000, about 30,000 and about 60,000, about 20,000 and about 70,000, about 30,000 and about 80,000, about 40,000 and about 50,000, about 40,000 and about 60,000, about 40,000 and about 70,000, about 40,000 and about 80,000, about 50,000 and about 60,000, about 50,000 and about 70,000, about 50,000 and about 80,000, about 60,000 and about 70,000, about 60,000 and about 80,000 or about 70,000 and about 80,000.

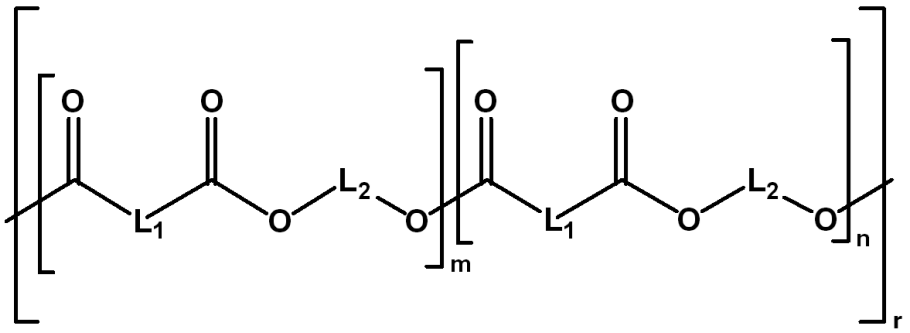
The polyester may have a dispersity between about 1.50 to about 3.00, about 1.50 to about 1.55, about 1.50 to about 1.60, about 1.50 to about 1.65, about 1.50 to about 1.70, about 1.50 to about 1.80, about 1.50 to about 1.90, about 1.50 to about 2.00, about 1.50 to about 2.10, about 1.50 to about 2.20, about 1.50 to about 2.30, about 1.50 to about 2.40, about 1.50 to about 2.50, about 1.50 to about 2.60, about 1.50 to about 2.70, about 1.50 to about 2.80, about 1.50 to about 2.90, about 1.55 to about 1.60, about 1.55 to about 1.65, about 1.55 to about 1.70, about 1.55 to about 1.80, about 1.55 to about 1.90, about 1.55 to about 2.00, about 1.55 to about 2.10, about 1.55 to about 2.20, about 1.55 to about 2.30, about 1.55 to about 2.40, about 1.55 to about 2.50, about 1.55 to about 2.60, about 1.55 to about 2.70, about 1.55 to about 2.80, about 1.55 to about 2.90, about 1.55 to about 3.00, about 1.60 to about 1.65, about about 1.60 to about 1.70, about 1.60 to about 1.80, about 1.60 to about 1.90, about 1.60 to about 2.00, about 1.60 to about 2.10, about 1.60 to about 2.20, about 1.60 to about 2.30, about 1.60 to about 2.40, about 1.60 to about 2.50, about 1.60 to about 2.60, about 1.60 to about 2.70, about 1.60 to about 2.80, about 1.60 to about 2.90, about 1.60 to about 3.00, about 1.70 to about 1.80, about 1.70 to about 1.90, about 1.70 to about 2.00, about 1.70 to about 2.10, about 1.70 to about 2.20, about 1.70 to about 2.30, about 1.70 to about 2.40, about 1.70 to about 2.50, about 1.70 to about 2.60, about 1.70 to about 2.70, about 1.70 to about 2.80, about 1.70 to about 2.90, about 1.70 to about 3.00, about 1.80 to about 1.90, about 1.80 to about 2.00, about 1.80 to about 2.10, about 1.80 to about 2.20, about 1.80 to about 2.30, about 1.80 to about 2.40, about 1.80 to about 2.50, about 1.80 to about 2.60, about 1.80 to about 2.70, about 1.80 to about 2.80, about 1.80 to about 2.90, about 1.80 to about 3.00, about 1.90 to about 2.00, about 1.90 to about 2.10, about 1.90 to about 2.20, about 1.90 to about 2.30, about 1.90 to about 2.40, about 1.90 to about 2.50, about 1.90 to about 2.60, about 1.90 to about 2.70, about 1.90 to about 2.80, about 1.90 to about 2.90, about 1.90 to about 3.00, about 2.00

to about 2.10, about 2.00 to about 2.20, about 2.00 to about 2.30, about 2.00 to about 2.40, about 2.00 to about 2.50, about 2.00 to about 2.60, about 2.00 to about 2.70, about 2.00 to about 2.80, about 2.00 to about 2.90, about 2.00 to about 3.00, about 2.10 to about 2.20, about 2.10 to about 2.30, about 2.10 to about 2.40, about 2.10 to about 2.50, about 2.10 to about 2.60, about 2.10 to about 2.70, about 2.10 to about 2.80, about 2.10 to about 2.90, about 2.10 to about 3.00, about 2.20 to about 2.30, about 2.20 to about 2.40, about 2.20 to about 2.50, about 2.20 to about 2.60, about 2.20 to about 2.70, about 2.20 to about 2.80, about 2.20 to about 2.90, about 2.20 to about 3.00, about 2.30 to about 2.40, about 2.30 to about 2.50, about 2.30 to about 2.60, about 2.30 to about 2.70, about 2.30 to about 2.80, about 2.30 to about 2.90, about 2.30 to about 3.00, about 2.40 to about 2.50, about 2.40 to about 2.60, about 2.40 to about 2.70, about 2.40 to about 2.80, about 2.40 to about 2.90, about 2.40 to about 3.00, about 2.50 to about 2.60, about 2.50 to about 2.70, about 2.50 to about 2.80, about 2.50 to about 2.90, about 2.50 to about 3.00, about 2.60 to about 2.70, about 2.60 to about 2.80, about 2.60 to about 2.90, about 2.60 to about 3.00, about 2.70 to about 2.80, about 2.70 to about 2.90, about 2.70 to about 3.00, about 2.80 to about 2.90, about 2.80 to about 3.00 or about 2.90 to about 3.00.

The polyester may have a melting temperature between about 0 °C and about 150 °C, about 0 °C and about 15 °C, about 0 °C and about 30 °C, about 0 °C and about 45 °C, about 0 °C and about 58 °C, about 0 °C and about 75 °C, about 0 °C and about 93 °C, about 0 °C and about 110 °C, about 0 °C and about 135 °C, about 15 °C and about 30 °C, about 15 °C and about 45 °C, about 15 °C and about 58 °C, about 15 °C and about 75 °C, about 15 °C and about 93 °C, about 15 °C and about 110 °C, about 15 °C and about 135 °C, about 15 °C and about 150 °C, about 30 °C and about 45 °C, about 30 °C and about 58 °C, about 30 °C and about 75 °C, about 30 °C and about 93 °C, about 30 °C and about 110 °C, about 30 °C and about 135 °C, about 30 °C and about 150 °C, about 45 °C and about 58 °C, about 45 °C and about 75 °C, about 45 °C and about 93 °C, about 45 °C and about 110 °C, about 45 °C and about 135 °C, about 45 °C and about 150 °C, about 58 °C and about 75 °C, about 58 °C and about 93 °C, about 58 °C and about 110 °C, about 58 °C and about 135 °C, about 58 °C and about 150 °C, about 75 °C and about 93 °C, about 75 °C and about 110 °C, about 75 °C and about 135 °C, about 75 °C and about 150 °C, about 93 °C and about 110 °C, about 93 °C and about 135 °C, about 93 °C and about 150 °C, about 110 °C and about 135 °C, about 110 °C and about 150 °C or about 135 °C and about 150 °C.

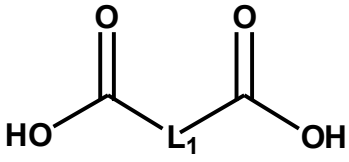
The polyester may have a decomposition temperature between about 300 °C and about 500 °C, about 300 °C and about 325 °C, about 300 °C and about 352 °C, about 300 °C and about 373 °C, about 300 °C and about 400 °C, about 300 °C and about 425 °C, about 300 °C and about 450 °C, about 300 °C and about 475 °C, about 325 °C and about 352 °C, about 325 °C and about 373 °C, about 325 °C and about 400 °C, about 325 °C and about 425 °C, about 325 °C and about 450 °C, about 325 °C and about 475 °C, about 325 °C and about 500 °C, about 352 °C and about 373 °C, about 352 °C and about 400 °C, about 352 °C and about 425 °C, about 352 °C and about 450 °C, about 352 °C and about 475 °C, about 352 °C and about 500 °C, about 373 °C and about 400 °C, about 373 °C and about 425 °C, about 373 °C and about 450 °C, about 373 °C and about 475 °C, about 373 °C and about 500 °C, about 400 °C and about 425 °C, about 400 °C and about 450 °C, about 400 °C and about 475 °C, about 400 °C and about 500 °C, about 425 °C and about 450 °C, about 425 °C and about 475 °C, about 425 °C and about 500 °C, about 450 °C and about 475 °C, about 450 °C and about 500 °C or about 475 °C and about 500 °C.

There is also provided a method of preparing a polyester comprising a general formula (I):



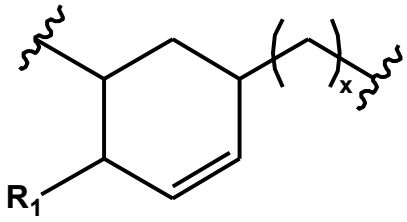
(I),

wherein the method comprises the steps of mixing a dicarboxylic acid having a general formula (II):



(II),

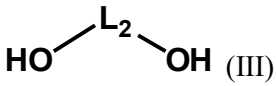
wherein L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted -C_{2-10}-alkenyl or substituted or unsubstituted -C_{2-10}-alkynyl;

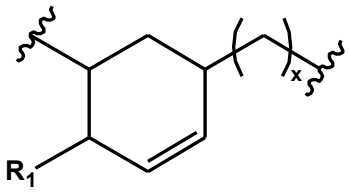
x is an integer from 0 to 10; and

~~~ is where the structure (A) attaches to the dicarboxylic acid of general formula (II); and

a diol having a general formula (III),



(III)

wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched;
~~~

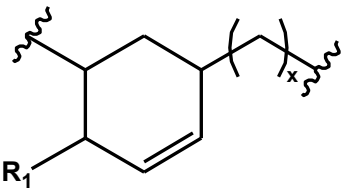
m and n are each independently an integer from 1 to 10; and

r is an integer from 20 to 200.

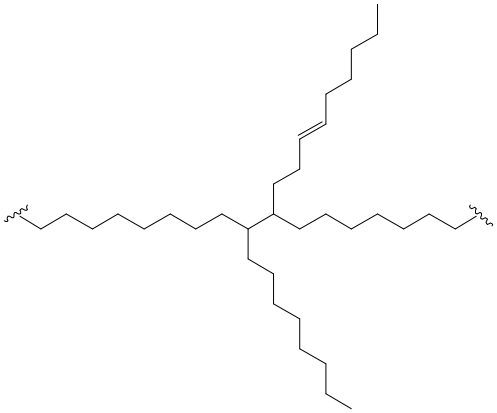
The method of preparing the polyester, wherein the substituent L_1 may each independently be absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



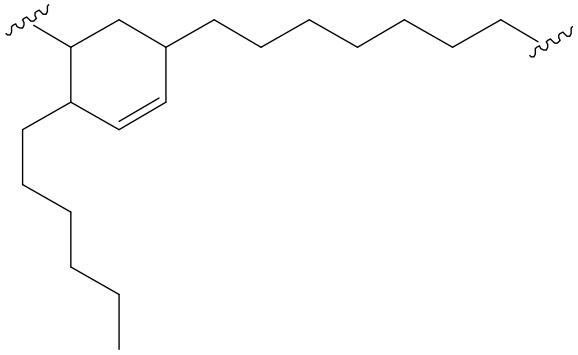
(A). The substituent L_1 may each independently be absent. The substituent L_1 may each independently be linear -C_{1-20}-alkyl. The substituent L_1 may each independently be branched -C_{1-20}-alkyl, linear or branched -C_{2-20}-alkenyl, linear or branched -C_{2-20}-alkynyl or the following structure (A)



(A). The substituent L_1 may each independently be -C_{1-20}-alkyl, -C_{1-4}-alkyl, -C_{1-8}-alkyl, -C_{1-12}-alkyl, -C_{1-16}-alkyl, -C_{4-8}-alkyl, -C_{4-12}-alkyl, -C_{4-16}-alkyl, -C_{4-20}-alkyl, -C_{8-12}-alkyl, -C_{8-16}-alkyl, -C_{8-20}-alkyl, -C_{12-16}-alkyl, -C_{12-20}-alkyl or -C_{16-20}-alkyl. The substituent L_1 may each independently also be -C_{2-20}-alkenyl, -C_{2-4}-alkenyl, -C_{2-8}-alkenyl, -C_{2-12}-alkenyl, -C_{2-16}-alkenyl, -C_{4-8}-alkenyl, -C_{4-12}-alkenyl, -C_{4-16}-alkenyl, -C_{4-20}-alkenyl, -C_{8-12}-alkenyl, -C_{8-16}-alkenyl, -C_{8-20}-alkenyl, -C_{12-16}-alkenyl, -C_{12-20}-alkenyl or -C_{16-20}-alkenyl. The substituent L_1 may each independently be -C_{2-20}-alkynyl, -C_{2-4}-alkynyl, -C_{2-8}-alkynyl, -C_{2-12}-alkynyl, -C_{2-16}-alkynyl, -C_{4-8}-alkynyl, -C_{4-12}-alkynyl, -C_{4-16}-alkynyl, -C_{4-20}-alkynyl, -C_{8-12}-alkynyl, -C_{8-16}-alkynyl, -C_{8-20}-alkynyl, -C_{12-16}-alkynyl, -C_{12-20}-alkynyl or -C_{16-20}-alkynyl. Furthermore, the substituent L_1 may each independently be octyl, hexadecyl, (E)-9-(non-3-en-1-yl)-10-octylnonadecyl or 3-heptyl-6-hexylcyclohex-1-enyl. The substituent L_1 may each independently be



. The substituent L_1 may



each independently be . The substituent L_1 may each independently be substituted or unsubstituted.

The method of preparing the polyester, wherein the substituent R_1 may be H. The substituent R_1 may be -C_{1-10}-alkyl, -C_{1-2}-alkyl, -C_{1-4}-alkyl, -C_{1-6}-alkyl, -C_{1-8}-alkyl, -C_{2-4}-alkyl, -C_{2-6}-alkyl, -C_{2-8}-alkyl, -C_{2-10}-alkyl, -C_{4-6}-alkyl, -C_{4-8}-alkyl, -C_{4-10}-alkyl, -C_{6-8}-alkyl, -C_{6-10}-alkyl or -C_{8-10}-alkyl. The substituent R_1 may also be -C_{2-10}-alkenyl, -C_{2-4}-alkenyl, -C_{2-6}-alkenyl, -C_{2-8}-alkenyl, -C_{4-6}-alkenyl, -C_{4-8}-alkenyl, -C_{4-10}-alkenyl, -C_{6-8}-alkenyl, -C_{6-10}-alkenyl or -C_{8-10}-alkenyl. The substituent R_1 may also be -C_{2-10}-alkynyl, -C_{2-4}-alkynyl, -C_{2-6}-alkynyl, -C_{2-8}-alkynyl, -C_{4-6}-alkynyl, -C_{4-8}-alkynyl, -C_{4-10}-alkynyl, -C_{6-8}-alkynyl, -C_{6-10}-alkynyl or -C_{8-10}-alkynyl. The substituent R_1 may be substituted or unsubstituted.

The method of preparing the polyester, wherein the integer x may have a value from 1 to 10, 1 to 4, 1 to 6, 1 to 8, 4 to 6, 4 to 8, 4 to 10, 6 to 8, 6 to 10 or 8 to 10.

The method of preparing the polyester, wherein the substituent L_2 may each independently be substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl. The substituent L_2 may each independently be -C_{2-20}-alkyl, -C_{2-5}-alkyl, -C_{2-7}-alkyl, -C_{2-9}-alkyl, -C_{2-11}-alkyl, -C_{2-13}-alkyl, -C_{2-15}-alkyl, -C_{2-17}-alkyl, -C_{2-19}-alkyl, -C_{5-7}-alkyl, -C_{5-9}-alkyl, -C_{5-11}-alkyl, -C_{5-13}-alkyl, -C_{5-15}-alkyl, -C_{5-17}-alkyl, -C_{5-19}-alkyl, -C_{5-20}-alkyl, -C_{7-9}-alkyl, -C_{7-11}-alkyl, -C_{7-13}-alkyl, -C_{7-15}-alkyl, -C_{7-17}-alkyl, -C_{7-19}-alkyl, -C_{7-20}-alkyl, -C_{9-11}-alkyl, -C_{9-13}-alkyl, -C_{9-15}-alkyl, -C_{9-17}-alkyl, -C_{9-19}-alkyl, -C_{9-20}-alkyl, -C_{11-13}-alkyl, -C_{11-15}-alkyl, -C_{11-17}-alkyl, -C_{11-19}-alkyl, -C_{11-20}-alkyl, -C_{13-15}-alkyl, -C_{13-17}-alkyl, -C_{13-19}-alkyl, -C_{13-20}-alkyl, -C_{15-17}-alkyl, -C_{15-19}-alkyl, -C_{15-20}-alkyl, , -C_{17-19}-alkyl, -C_{17-20}-alkyl, or -C_{19-20}-alkyl. The substituent L_2 may each independently also be -C_{3-20}-alkenyl, -C_{3-5}-alkenyl, -C_{3-7}-alkenyl, -C_{3-9}-alkenyl, -C_{3-11}-alkenyl, -C_{3-13}-alkenyl, -C_{3-15}-alkenyl, -C_{3-17}-alkenyl, -C_{3-19}-alkenyl, -C_{5-7}-alkenyl, -C_{5-9}-alkenyl, -C_{5-11}-alkenyl, -C_{5-13}-alkenyl, -C_{5-15}-alkenyl, -C_{5-17}-alkenyl, -C_{5-19}-alkenyl, -C_{5-20}-alkenyl, -C_{7-9}-alkenyl, -C_{7-11}-alkenyl, -C_{7-13}-alkenyl, -C_{7-15}-alkenyl, -C_{7-17}-alkenyl, -C_{7-19}-alkenyl, -C_{7-20}-alkenyl, -C_{9-11}-alkenyl, -C_{9-13}-alkenyl, -C_{9-15}-alkenyl, -C_{9-17}-alkenyl, -C_{9-19}-alkenyl, -C_{9-20}-alkenyl, -C_{11-13}-alkenyl, -C_{11-15}-alkenyl, -C_{11-17}-alkenyl, -C_{11-19}-alkenyl, -C_{11-20}-alkenyl, -C_{13-15}-alkenyl, -C_{13-17}-alkenyl, -C_{13-19}-alkenyl, -C_{13-20}-alkenyl, -C_{15-17}-alkenyl, -C_{15-19}-alkenyl, -C_{15-20}-alkenyl, -C_{17-19}-alkenyl, -C_{17-20}-alkenyl or -C_{19-20}-alkenyl. The substituent L_2 may each independently also be -C_{3-20}-alkynyl, -C_{3-5}-alkynyl, -C_{3-7}-alkynyl, -C_{3-9}-alkynyl, -C_{3-11}-alkynyl, -C_{3-13}-alkynyl, -C_{3-15}-alkynyl, -C_{3-17}-alkynyl, -C_{3-19}-alkynyl, -C_{5-7}-alkynyl, -C_{5-9}-alkynyl, -C_{5-11}-alkynyl, -C_{5-13}-alkynyl, -C_{5-15}-alkynyl, -C_{5-17}-alkynyl, -C_{5-19}-alkynyl, -C_{5-20}-alkynyl, -C_{7-9}-alkynyl, -C_{7-11}-alkynyl, -C_{7-13}-alkynyl, -C_{7-15}-alkynyl, -C_{7-17}-alkynyl, -C_{7-19}-alkynyl, -C_{7-20}-alkynyl, -C_{9-11}-alkynyl, -C_{9-13}-alkynyl, -C_{9-15}-alkynyl, -C_{9-17}-alkynyl, -C_{9-19}-alkynyl, -C_{9-20}-alkynyl, -C_{11-13}-alkynyl, -C_{11-15}-alkynyl, -C_{11-17}-alkynyl, -C_{11-19}-alkynyl, -C_{11-20}-alkynyl, -C_{13-15}-alkynyl, -C_{13-17}-alkynyl, -C_{13-19}-alkynyl, -C_{13-20}-alkynyl, -C_{15-17}-alkynyl, -C_{15-19}-alkynyl, -C_{15-20}-alkynyl, -C_{17-19}-alkynyl, -C_{17-20}-alkynyl or -C_{19-20}-alkynyl. The substituent L_2 may each independently be ethyl, propyl, butyl,

pentyl, hexyl, heptyl, octyl, nonyl or decyl. The substituent L_2 may each independently be substituted or unsubstituted.

The method of preparing the polyester, wherein the integer m may have a value from 1 to 10, 1 to 4, 1 to 6, 1 to 8, 4 to 6, 4 to 8, 4 to 10, 6 to 8, 6 to 10 or 8 to 10. The integer n may have a value from 1 to 10, 1 to 4, 1 to 6, 1 to 8, 4 to 6, 4 to 8, 4 to 10, 6 to 8, 6 to 10 or 8 to 10.

The method of preparing the polyester, wherein the integer r may have a value from 20 to 200, 20 to 30, 20 to 50, 20 to 60, 20 to 75, 20 to 100, 20 to 150, 30 to 50, 30 to 60, 30 to 75, 30 to 100, 30 to 150, 30 to 200, 50 to 60, 50 to 75, 50 to 100, 50 to 150, 50 to 200, 60 to 75, 60 to 100, 60 to 150, 60 to 200, 75 to 100, 75 to 150, 75 to 200, 100 to 150, 100 to 200 or 150 to 200.

The method may not comprise mixing decanedioic acid with ethanediol; decanedioic with propanediol; decanedioic with butanediol; decanedioic with pentanediol; decanedioic with hexanediol; decanedioic with octanediol; decanedioic with decanediol; dodecanedioic acid with ethanediol; dodecanedioic acid with propanediol; dodecanedioic acid with butanediol; dodecanedioic acid with pentanediol; dodecanedioic acid with hexanediol; dodecanedioic acid with heptanediol; dodecanedioic acid with octanediol; dodecanedioic acid with nonanediol; dodecanedioic acid with decanediol; dodecanedioic acid with undecanediol; dodecanedioic acid with dodecanediol; dodecanedioic acid with tridecanediol; dodecanedioic acid with tetradecanediol; dodecanedioic acid with pentadecanediol; dodecanedioic acid with hexadecanediol; dodecanedioic acid with heptadecanediol; dodecanedioic acid with octadecanediol; dodecanedioic acid with nonadecanediol; dodecanedioic acid with icosanediol; octadecanedioic acid with ethanediol; octadecanedioic acid with butanediol; octadecanedioic acid with hexanediol; octadecanedioic acid with octanediol; octadecanedioic acid with decanediol; or (E)-9-(non-3-en-1-yl)-10-octylnonadecanedioic acid with ethanediol.

The mixing step may comprise the dicarboxylic acid and diol mixed in a molar ratio in the range of between 2:1 and 1:2. The mixing step may comprise the dicarboxylic acid and diol mixed in a molar ratio in the range of between 1.5:1 and 1:1.5. The mixing step may comprise the dicarboxylic acid and diol mixed in a molar ratio of 1:1.

The mixing step may comprise a catalyst. The mixing step may also comprise the dicarboxylic acid and the catalyst mixed in a molar ratio in the range of 50:1 to 200:1. The mixing step may comprise the dicarboxylic acid and the catalyst mixed in a molar ratio in the range of 75:1 to 150:1. The mixing step may comprise the dicarboxylic acid and the catalyst mixed in a molar ratio of 100:1.

The catalyst may be a heterogeneous catalyst. The heterogeneous catalyst may be a metal.

The heterogeneous catalyst may be a metal selected from a group consisting of chromium, manganese, iron, cobalt, nickel, copper, zinc, tin and any mixture thereof. The heterogeneous catalyst may be tin.

The concentration of the catalyst may be in the range of about 0.1 to about 10 mol%, about 0.1 to about 0.5 mol%, about 0.1 to about 1 mol%, about 0.1 to about 2 mol%, about 0.1 to about 5 mol%, about 0.5 to about 1 mol%, about 0.5 to about 2 mol%, about 0.5 to about 5 mol%, about 0.5 to about 10 mol%, about 1 to about 2 mol%, about 1 to about 5 mol%, about 1 to about 10 mol%, about 2 to about 5 mol%, about 2 to about 10 mol% or about 5 to about 10 mol%.

The mixing step may be performed at a temperature in the range of about 150 °C to about 300 °C, about 150 °C to about 170 °C, about 150 °C to about 200 °C, about 150 °C to about 220 °C, about 150 °C to about 240 °C, about 150 °C to about 260 °C, about 150 °C to about 280 °C, about 170 °C to about 200 °C, about 170 °C to about 220 °C, about 170 °C to about 240 °C, about 170 °C to about 260 °C, about 170 °C to about 280 °C, about 170 °C to about 300 °C, about 200 °C to about 220 °C, about 200 °C to about 240 °C, about 200 °C to about 260 °C, about 200 °C to about 280 °C, about 200 °C to about 300 °C, about 220 °C to about 240 °C, about 220 °C to about 260 °C, about 220 °C to about 280 °C, about 220 °C to about 300 °C, about 240 °C to about 260 °C, about 240 °C to about 280 °C, about 240 °C to about 300 °C, about 260 °C to about 280 °C, about 260 °C to about 300 °C or about 280 °C to about 300 °C.

The mixing step may be performed at a pressure in the range of about 1,000 Pa to about 200,000 Pa, about 1,000 Pa to about 1,500 Pa, about 1,000 Pa to about 5,000 Pa, about 1,000 Pa to about 10,000 Pa, about 1,000 Pa to about 20,000 Pa, about 1,000 Pa to about 40,000 Pa, about 1,000 Pa to about 80,000 Pa, about 1,000 Pa to about 100,000 Pa, about 1,000 Pa to about 150,000 Pa, about 1,000 Pa to about 180,000 Pa, about 1,500 Pa to about 5,000 Pa, about 1,500 Pa to about 10,000 Pa, about 1,500 Pa to about 20,000 Pa, about 1,500 Pa to about 40,000 Pa, about 1,500 Pa to about 80,000 Pa, about 1,500 Pa to about 100,000 Pa, about 1,500 Pa to about 150,000 Pa, about 1,500 Pa to about 180,000 Pa, about 1,500 Pa to about 200,000 Pa, about 5,000 Pa to about 10,000 Pa, about 5,000 Pa to about 20,000 Pa, about 5,000 Pa to about 40,000 Pa, about 5,000 Pa to about 80,000 Pa, about 5,000 Pa to about 100,000 Pa, about 5,000 Pa to about 150,000 Pa, about 5,000 Pa to about 180,000 Pa, about 5,000 Pa to about 200,000 Pa, about 10,000 Pa to about 20,000 Pa, about 10,000 Pa to about 40,000 Pa, about 10,000 Pa to about 80,000 Pa, about 10,000 Pa to about 100,000 Pa, about 10,000 Pa to about 150,000 Pa, about 10,000 Pa to about 180,000 Pa, about 10,000 Pa to about 200,000 Pa, about 20,000 Pa to about 40,000 Pa, about 20,000 Pa to about 80,000 Pa, about 20,000 Pa to about 100,000 Pa, about 20,000 Pa to about 150,000 Pa, about 20,000 Pa to about 180,000 Pa, about 20,000 Pa to about 200,000 Pa, about 40,000 Pa to about 80,000 Pa, about 40,000 Pa to about 100,000 Pa, about 40,000 Pa to about 150,000 Pa, about 40,000 Pa to about 180,000 Pa, about 40,000 Pa to about 200,000 Pa, about 80,000 Pa to about 100,000 Pa, about 80,000 Pa to about 150,000 Pa, about 80,000 Pa to about 180,000 Pa, about 80,000 Pa to about 200,000 Pa, about 100,000 Pa to about 150,000 Pa, about 100,000 Pa to about 180,000 Pa, about 100,000 Pa to about 200,000 Pa, about 150,000 Pa to about 180,000 Pa, about 150,000 Pa to about 200,000 Pa, or about 180,000 Pa to about 200,000 Pa.

The mixing step may be performed for a duration in the range of about 16 hours to about 30 hours, about 16 hours to about 18 hours, about 16 hours to about 20 hours, about 16 hours to about 22 hours, about 16 hours to about 24 hours, about 16 hours to about 26 hours, about 16 hours to about 28 hours, about 18 hours to about 20 hours, about 18 hours to about 22 hours, about 18 hours to about 24 hours, about 18 hours to about 26 hours, about 18 hours to about 28 hours, about 18 hours to about 30 hours, about 20 hours to about 22 hours, about 20 hours to about 24 hours, about 20 hours to about 26 hours, about 20 hours to about 28 hours, about 20 hours to about 30 hours, about 22 hours to about 24 hours, about 22 hours to about 26 hours, about 22 hours to about 28 hours, about 22 hours to about 30 hours, about 24 hours to about 26 hours, about 24 hours to about 28 hours, about 24 hours to about 30 hours, about 26

hours to about 28 hours, about 26 hours to about 30 hours, or about 28 hours to about 30 hours.

The mixing step may comprise stirring at a speed in the range of about 250 rpm to about 2,000 rpm, about 250 rpm to about 300 rpm, about 250 rpm to about 500 rpm, about 250 rpm to about 750 rpm, about 250 rpm to about 1,000 rpm, about 250 rpm to about 1,250 rpm, about 250 rpm to about 1,500 rpm, about 250 rpm to about 1,750 rpm, about 300 rpm to about 500 rpm, about 300 rpm to about 750 rpm, about 300 rpm to about 1,000 rpm, about 300 rpm to about 1,250 rpm, about 300 rpm to about 1,500 rpm, about 300 rpm to about 1,750 rpm, about 300 rpm to about 2,000 rpm, about 500 rpm to about 750 rpm, about 500 rpm to about 1,000 rpm, about 500 rpm to about 1,250 rpm, about 500 rpm to about 1,500 rpm, about 500 rpm to about 1,750 rpm, about 500 rpm to about 2,000 rpm, about 750 rpm to about 1,000 rpm, about 750 rpm to about 1,250 rpm, about 750 rpm to about 1,500 rpm, about 750 rpm to about 1,750 rpm, about 750 rpm to about 2,000 rpm, about 1000 rpm to about 1,250 rpm, about 1000 rpm to about 1,500 rpm, about 1000 rpm to about 1,750 rpm, about 1000 rpm to about 2,000 rpm, about 1250 rpm to about 1,500 rpm, about 1250 rpm to about 1,750 rpm, about 1250 rpm to about 2,000 rpm, about 1500 rpm to about 1,750 rpm, about 1500 rpm to about 2,000 rpm, or about 1750 rpm to about 2,000 rpm.

The mixing step may comprise step (i) of mixing at a temperature in the range of about 150°C to about 190 °C, about 150°C to about 160 °C, about 150°C to about 165 °C, about 150°C to about 170 °C, about 150°C to about 175 °C, about 150°C to about 180 °C, about 150°C to about 185 °C, about 160°C to about 165 °C, about 160°C to about 170 °C, about 160°C to about 175 °C, about 160°C to about 180 °C, about 160°C to about 185 °C, about 160°C to about 190 °C, about 165°C to about 170 °C, about 165°C to about 175 °C, about 165°C to about 180 °C, about 165°C to about 185 °C, about 165°C to about 190 °C, about 170°C to about 175 °C, about 170°C to about 180 °C, about 170°C to about 185 °C, about 170°C to about 190 °C, about 175°C to about 180 °C, about 175°C to about 185 °C, about 175°C to about 190 °C, about 180°C to about 185 °C, about 180°C to about 190 °C, or about 185°C to about 190 °C.

The mixing step may comprise step (i) of mixing at a pressure in the range of about 50,000 Pa to about 200,000 Pa, about 50,000 Pa to about 75,000 Pa, about 50,000 Pa to about 100,000 Pa, about 50,000 Pa to about 125,000 Pa, about 50,000 Pa to about 150,000 Pa, about 50,000 Pa to about 175,000 Pa, about 75,000 Pa to about 100,000 Pa, about 75,000 Pa to about 125,000 Pa, about 75,000 Pa to about 150,000 Pa, about 75,000 Pa to about 175,000 Pa, about 75,000 Pa to about 200,000 Pa, about 100,000 Pa to about 125,000 Pa, about 100,000 Pa to about 150,000 Pa, about 100,000 Pa to about 175,000 Pa, about 100,000 Pa to about 200,000 Pa, about 125,000 Pa to about 150,000 Pa, about 125,000 Pa to about 175,000 Pa, about 125,000 Pa to about 200,000 Pa, about 150,000 Pa to about 175,000 Pa, about 150,000 Pa to about 200,000 Pa, or about 175,000 Pa to about 200,000 Pa.

The mixing step may comprise step (i) of mixing for a duration in the range of about 3 hours to about 5 hours, about 3 hours to about 3.5 hours, about 3 hours to about 4 hours, about 3 hours to about 4.5 hours, about 3.5 hours to about 4 hours, about 3.5 hours to about 4.5 hours, about 3.5 hours to about 5 hours, about 4 hours to about 4.5 hours, about 4 hours to about 5 hours or about 4.5 hours to about 5 hours.

The mixing step may comprise step (i) of stirring at a speed in the range of about 250 rpm to about 700 rpm, about 250 rpm to about 300 rpm, about 250 rpm to about 400 rpm, about 250 rpm to about 500 rpm, about 250 rpm to about 600 rpm, about 300 rpm to about 400 rpm, about 300 rpm to about 500 rpm, about 300 rpm to about 600 rpm, about 300 rpm to about 700 rpm, about 400 rpm to about 500 rpm, about 400 rpm to about 600 rpm, about 400 rpm to about 700 rpm, about 500 rpm to about 600 rpm, about 500 rpm to about 700 rpm or about 600 rpm to about 700 rpm.

The mixing step may further comprise step (ii) after step (i) of mixing at a temperature in the range of about 195°C to about 220 °C, about 195°C to about 200 °C, about 195°C to about 205 °C, about 195°C to about 210 °C, about 195°C to about 215 °C, about 200°C to about 205 °C, about 200°C to about 210 °C, about 200°C to about 215 °C, about 200°C to about 220 °C, about 205°C to about 210 °C, about 205°C to about 215 °C, about 205°C to about 220 °C, about 210°C to about 215 °C, about 210°C to about 220 °C or about 215°C to about 220 °C.

The mixing step may further comprise step (ii) after step (i) of mixing at a pressure in the range of about 1,000 to about 5,000 Pa, about 1,000 to about 1,500 Pa, about 1,000 to about 2,000 Pa, about 1,000 to about 3,000 Pa, about 1,000 to about 4,000 Pa, about 1,500 to about 2,000 Pa, about 1,500 to about 3,000 Pa, about 1,500 to about 4,000 Pa, about 1,500 to about 5,000 Pa, about 2,000 to about 3,000 Pa, about 2,000 to about 4,000 Pa, about 2,000 to about 5,000 Pa, about 3,000 to about 4,000 Pa, about 3,000 to about 5,000 Pa, or about 4,000 to about 5,000 Pa.

The mixing step may further comprise step (ii) after step (i) of mixing for a duration in the range of about 12 hours to about 20 hours, about 12 hours to about 13 hours, about 12 hours to about 15 hours, about 12 hours to about 17 hours, about 12 hours to about 19 hours, about 13 hours to about 15 hours, about 13 hours to about 17 hours, about 13 hours to about 19 hours, about 13 hours to about 20 hours, about 15 hours to about 17 hours, about 15 hours to about 19 hours, about 15 hours to about 20 hours, about 17 hours to about 19 hours, about 17 hours to about 20 hours, or about 19 hours to about 20 hours.

The mixing step may further comprise step (ii) after step (i) of stirring at a speed in the range of about 750 rpm to about 1,500 rpm, about 750 rpm to about 900 rpm, about 750 rpm to about 1,000 rpm, about 750 rpm to about 1,200 rpm, about 750 rpm to about 1,400 rpm, about 900 rpm to about 1,000 rpm, about 900 rpm to about 1,200 rpm, about 900 rpm to about 1,400 rpm, about 900 rpm to about 1,500 rpm, about 1,000 rpm to about 1,200 rpm, about 1,000 rpm to about 1,400 rpm, about 1,000 rpm to about 1,500 rpm, about 1,200 rpm to about 1,400 rpm, about 1,200 rpm to about 1,500 rpm, or about 1,400 rpm to about 1,500 rpm.

The mixing step may further comprise step (iii) following step (ii), of mixing at a temperature in the range of about 230°C to about 300 °C, about 230°C to about 240 °C, about 230°C to about 250 °C, about 230°C to about 260 °C, about 230°C to about 270 °C, about 230°C to about 280 °C, about 230°C to about 290 °C, about 240°C to about 250 °C, about 240°C to about 260 °C, about 240°C to about 270 °C, about 240°C to about 280 °C, about 240°C to about 290 °C, about 240°C to about 300 °C, about 250°C to about 260 °C, about 250°C to about 270 °C, about 250°C to about 280 °C, about 250°C to about 290 °C, about 250°C to about 300 °C, about 260°C to about 270 °C, about 260°C to about 280 °C, about 260°C to

about 290 °C, about 260°C to about 300 °C, about 270°C to about 280 °C, about 270°C to about 290 °C, about 270°C to about 300 °C, about 280°C to about 290 °C, about 280°C to about 300 °C, or about 290°C to about 300 °C.

The mixing step may further comprise step (iii) following step (ii), of mixing at a pressure in the range of about 1,000 to about 5,000 Pa, about 1,000 to about 1,500 Pa, about 1,000 to about 2,000 Pa, about 1,000 to about 3,000 Pa, about 1,000 to about 4,000 Pa, about 1,500 to about 2,000 Pa, about 1,500 to about 3,000 Pa, about 1,500 to about 4,000 Pa, about 1,500 to about 5,000 Pa, about 2,000 to about 3,000 Pa, about 2,000 to about 4,000 Pa, about 2,000 to about 5,000 Pa, about 3,000 to about 4,000 Pa, about 3,000 to about 5,000 Pa, or about 4,000 to about 5,000 Pa.

The mixing step may further comprise step (iii) following step (ii), of mixing for a duration in the range of about 3 hours to about 5 hours, about 3 hours to about 3.5 hours, about 3 hours to about 4 hours, about 3 hours to about 4.5 hours, about 3.5 hours to about 4 hours, about 3.5 hours to about 4.5 hours, about 3.5 hours to about 5 hours, about 4 hours to about 4.5 hours, about 4 hours to about 5 hours or about 4.5 hours to about 5 hours.

The mixing step may further comprise step (iii) following step (ii) of stirring at a speed in the range of about 750 rpm to about 2,500 rpm, about 750 rpm to about 1,000 rpm, about 750 rpm to about 1,250 rpm, about 750 rpm to about 1,500 rpm, about 750 rpm to about 1,750 rpm, about 750 rpm to about 2,000 rpm, about 750 rpm to about 2,250 rpm, about 1,000 rpm to about 1,250 rpm, about 1,000 rpm to about 1,500 rpm, about 1,000 rpm to about 1,750 rpm, about 1,000 rpm to about 2,000 rpm, about 1,000 rpm to about 2,250 rpm, about 1,000 rpm to about 2,500 rpm, about 1,250 rpm to about 1,500 rpm, about 1,250 rpm to about 1,750 rpm, about 1,250 rpm to about 2,000 rpm, about 1,250 rpm to about 2,250 rpm, about 1,250 rpm to about 2,500 rpm, about 1,500 rpm to about 1,750 rpm, about 1,500 rpm to about 2,000 rpm, about 1,500 rpm to about 2,250 rpm, about 1,500 rpm to about 2,500 rpm, about 1,750 rpm to about 2,000 rpm, about 1,750 rpm to about 2,250 rpm, about 1,750 rpm to about 2,500 rpm, about 2,000 rpm to about 2,250 rpm, about 2,000 rpm to about 2,500 rpm, or about 2,250 rpm to about 2,500 rpm.

The method may further comprise the step of cooling the polyester to room temperature. The room temperature may be in the range of about 20°C to about 30 °C, about 20°C to about 22 °C, about 20°C to about 25 °C, about 20°C to about 27 °C, about 22°C to about 25 °C, about 22°C to about 27 °C, about 22°C to about 30 °C, about 25°C to about 27 °C, about 25°C to about 30 °C, or about 27°C to about 30 °C. The room temperature may be about 25 °C.

The cooling step may refer to removing a product of the mixing step from the heat source and may further include leaving a product of the mixing step at room temperature, introducing an air stream over a product of the mixing step or immersing a product of the mixing step in a cool water bath.

The dicarboxylic acid may be selected from the group consisting of propanedioic acid, butanedioic acid, pentanedioic acid, hexanedioic acid, heptanedioic acid, octanedioic acid, nonanedioic acid, decanedioic acid, undecanedioic acid, dodecanedioic acid, tridecanedioic acid, tetradecanedioic acid, pentadecanedioic acid, hexadecanedioic acid, heptadecanedioic acid, octadecanedioic acid, nonadecanedioic acid, icosanedioic acid, heneicosanedioic acid, docosanedioic acid, propenedioic acid, butenedioic acid, pentenedioic acid, hexenedioic acid,

heptenedioic acid, octenedioic acid, nonenedioic acid, decenedioic acid, undecenedioic acid, dodecenedioic acid, tridecenedioic acid, tetradecenedioic acid, pentadecenedioic acid, hexadecenedioic acid, heptadecenedioic acid, octadecenedioic acid, nonadecenedioic acid, icosenedioic acid, heneicosenedioic acid, docosenedioic acid, propynedioic acid, butynedioic acid, pentynedioic acid, hexynedioic acid, heptynedioic acid, octynedioic acid, nonynedioic acid, decynedioic acid, undecynedioic acid, dodecynedioic acid, tridecynedioic acid, tetradecynedioic acid, pentadecynedioic acid, hexadecynedioic acid, heptadecynedioic acid, octadecynedioic acid, nonadecynedioic acid, icosynedioic acid, heneicosynedioic acid, docosynedioic acid and any mixture thereof. The dicarboxylic acid may be selected from the group consisting of decanedioic acid, octadecanedioic acid, (E)-9-(non-3-en-1-yl)-10-octylnonadecanedioic acid, 5-(7-carboxyheptyl)-2-hexylcyclohex-3-ene-1-carboxylic acid and any mixture thereof. The dicarboxylic acid may be substituted or unsubstituted.

The diol may be selected from the group consisting of ethanediol, propanediol, butanediol, pentanediol, hexanediol, heptanediol, octanediol, nonanediol, decanediol, undecanediol, dodecanediol, tridecanediol, tetradecanediol, pentadecanediol, hexadecanediol, heptadecanediol, octadecanediol, nonadecanediol, icosanediol, propenediol, butenediol, pentenediol, hexenediol, heptenediol, octenediol, nonenediol, decenediol, undecenediol, dodecenediol, tridecenediol, tetradecenediol, pentadecenediol, hexadecenediol, heptadecenediol, octadecenediol, nonadecenediol, icosenediol, propynediol, butynediol, pentynediol, hexynediol, heptynediol, octynediol, nonynediol, decynediol, undecynediol, dodecynediol, tridecynediol, tetradecynediol, pentadecynediol, hexadecynediol, heptadecynediol, octadecynediol, nonadecynediol, icosynediol and any mixture thereof. The diol may be selected from the group consisting of ethanediol, propanediol, butanediol, pentanediol, hexanediol, heptanediol, octanediol, nonanediol, decanediol and any mixture thereof. The diol may be substituted or unsubstituted.

The method may further comprise a step of purifying the polyester.

The purification step may comprise a step of dissolving the polyester in a first solvent selected from the group consisting of dichloromethane, chloroform, 1,2-dichloroethane, carbon tetrachloride, 1,1,2,2-tetrachloroethane, phenol, 3-methylphenol, chlorobenzene, dichlorobenzene, tetrahydrofuran, pentane, hexane, heptane, benzene, toluene, xylene and any combination thereof, to form a solution and filtering the solution.

The filtration step may comprise gravity filtration, dialysis, centrifugation or vacuum filtration.

The method may further comprise a step of concentrating the solution. The solution comprising the polyester may be concentrated by removing about 80% w/w to about 99% w/w of the solvent. The solvent removal method may comprise rotary evaporation, vacuum, heating or continuous stirring.

The solution comprising the polyester may be at a concentration in the range of about 1% w/w to about 20% w/w, about 1% w/w to about 5% w/w, about 1% w/w to about 7% w/w, about 1% w/w to about 10% w/w, about 1% w/w to about 13% w/w, about 1% w/w to about 15% w/w, about 1% w/w to about 18% w/w, about 5% w/w to about 7% w/w, about 5% w/w to about 10% w/w, about 5% w/w to about 13% w/w, about 5% w/w to about 15% w/w, about 5% w/w to about 18% w/w, about 5% w/w to about 20% w/w, about 7% w/w to about 10% w/w, about 7% w/w to about 13% w/w, about 7% w/w to about 15% w/w, about 7% w/w to about 18% w/w, about 7% w/w to about 20% w/w, about 10% w/w to about 13%

w/w, about 10% w/w to about 15% w/w, about 10% w/w to about 18% w/w, about 10% w/w to about 20% w/w, about 13% w/w to about 15% w/w, about 13% w/w to about 18% w/w, about 13% w/w to about 20% w/w, about 15% w/w to about 18% w/w, about 15% w/w to about 20% w/w, or about 18% w/w to about 20% w/w. The solution comprising the polyester may be at a concentration of about 10% w/w.

The method may further comprise a step of precipitating the polyester.

The precipitation step may comprise precipitating the polyester from a second solvent selected from the group consisting of water, methanol, ethanol, propanol, isopropanol, butanol, N-methyl-2-pyrrolidone, methyl ethyl ketone, methyl isobutyl ketone, diethyl ether, dipropyl ether, pentane, hexane, heptane, benzene, toluene, xylene and any combination thereof.

The second solvent may be present in an excess of 30 to 60 times, 30 to 35 times, 30 to 40 times, 30 to 45 times, 30 to 50 times, 30 to 55 times, 35 to 40 times, 35 to 45 times, 35 to 50 times, 35 to 55 times, 35 to 60 times, 40 to 45 times, 40 to 50 times, 40 to 55 times, 40 to 60 times, 45 to 50 times, 45 to 55 times, 45 to 60 times, 50 to 55 times, 50 to 60 times or 55 to 60 times in volume of the solution.

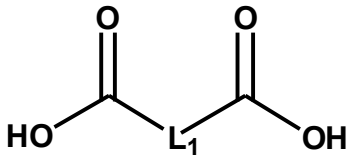
The precipitated polyester may be dried under vacuum for a duration in the range of about 12 hours to about 36 hours, about 12 hours to about 16 hours, about 12 hours to about 20 hours, about 12 hours to about 24 hours, about 12 hours to about 28 hours, about 12 hours to about 32 hours, about 16 hours to about 20 hours, about 16 hours to about 24 hours, about 16 hours to about 28 hours, about 16 hours to about 32 hours, about 16 hours to about 36 hours, about 20 hours to about 24 hours, about 20 hours to about 28 hours, about 20 hours to about 32 hours, about 20 hours to about 36 hours, about 24 hours to about 28 hours, about 24 hours to about 32 hours, about 24 hours to about 36 hours, about 28 hours to about 32 hours, about 28 hours to about 36 hours, or about 32 hours to about 36 hours. The precipitated polyester may be dried under vacuum for a duration of about 24 hours.

The precipitated polyester may also be dried under vacuum at a temperature in the range of about 30 to about 60 °C, about 30 to about 35 °C, about 30 to about 40 °C, about 30 to about 45 °C, about 30 to about 50 °C, about 30 to about 55 °C, about 35 to about 40 °C, about 35 to about 45 °C, about 35 to about 50 °C, about 35 to about 55 °C, about 35 to about 60 °C, about 40 to about 45 °C, about 40 to about 50 °C, about 40 to about 55 °C, about 40 to about 60 °C, about 45 to about 50 °C, about 45 to about 55 °C, about 45 to about 60 °C, about 50 to about 55 °C, about 50 to about 60 °C, or about 55 to about 60 °C. The precipitated polyester may also be dried under vacuum at a temperature of about 40 °C.

The method may not require distillation. The distillation step may refer to the separation of liquids based on the different boiling points. The method may not require an inert environment for the preparation of the polyester. An inert environment may refer to an environment consisting of nitrogen gas or argon gas.

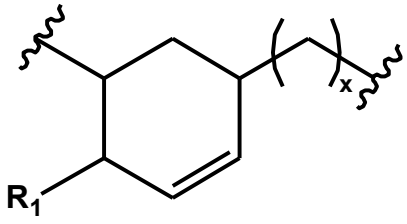
There is also provided a polyester prepared by mixing:

a dicarboxylic acid having a general formula (II):



(II),

wherein L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



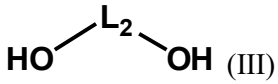
(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted -C_{2-10}-alkenyl or substituted or unsubstituted -C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

~~~ is where the structure (A) attaches to the dicarboxylic acid of general formula (II); and

a diol having a general formula (III),



(III)

wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched.

The polyester may be a random copolymer or random block copolymer. The polyester may be a random copolymer.

There is also provided a use of the polyester for coating a substrate, as an adhesive, in textiles, bottles, films or plastics.

The substrate may refer to a metal, wood, textile, rock, ceramics or glass laminates. The metal may be aluminium, titanium, manganese, iron, cobalt, nickel, copper, zinc, tin, steel, stainless steel or any mixture thereof. The wood may be cedar, oak, fir, redwood, ash, cherry, birch, pine, teak, maple, mahogany or any mixtures thereof. The textile may refer to silk, cotton, wool, linen, leather, nylon, hemp, lace, jute or any mixture thereof. The rock may be igneous, sedimentary, metamorphic or any mixtures thereof. The rock may be granite, marble or basalt.

The adhesive may refer to adhesives based on polyester resins and may be unsaturated polyester adhesives or saturated polyester adhesives. The unsaturated polyester adhesives may be thermosetting, wherein they may cure or harden when exposed to heat. The saturated
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polyester adhesives may be room temperature curing, wherein they may not require heat for the curing process.

The bottle may refer to liquid containers such as water bottle, oil containers or mouthwash bottles.

The film may refer to photolithography masks, protective mask, optical displays, film insulation or food packaging.

The plastic may refer to synthetic fibre material formed from polyester polymer. The plastic may refer to high density plastic or low density plastic. The plastic may refer to thermoplastic. The plastic may be used in automobile parts, such as bumpers, fascia, door panels, steering wheel or instrument panel.

Brief Description of Drawings

The accompanying drawings illustrate a disclosed embodiment and serves to explain the principles of the disclosed embodiment. It is to be understood, however, that the drawings are designed for purposes of illustration only, and not as a definition of the limits of the invention.

Fig. 1

Fig.1 is a schematic diagram showing a process of obtaining a polyester according to the disclosure, wherein q and q' refer to the number of repeating units in the oligomers and polymers respectively.

Fig. 2

Fig. 2 is a possible chemical formula of a polyester according to the disclosure, wherein a is an integer from 0 to 20, b is an integer from 2 to 20 and c is an integer from 40 to 4000.

Fig. 3A

Fig. 3A is a schematic diagram showing a process of obtaining a polyester based on 1,6-hexanediol and sebacic acid (PE-6,10) according to the disclosure, wherein d and d' refers to the proton adjacent to the -OH and -O(C=O) group respectively, and e refers to the number of repeating units of the ester.

Fig. 3B

Fig. 3B is a series of nuclear magnetic resonance (NMR) spectra of the reaction mixture for the synthesis of PE-6,10 over the polymerization time (*t*), where *p* refers to the extent of reaction of diols and dicarboxylic acids, and d and d' refers to the proton signal at 3.64 ppm and 4.06 ppm respectively.

Fig. 4

Fig. 4 is a wide-angle X-ray scattering (WAXS) spectrum of PE-6,10.

Fig. 5

Fig. 5 is a photographic image of a sample of PE-6,10.

Detailed Description of Drawings

Referring to Fig. 1, there is provided a process of synthesizing a polyester by first reacting a dicarboxylic acid and a diol under reaction condition 102, which is at a temperature of 180 °C for 4 hours at atmospheric pressure with 1 mol% tin catalyst 104 to obtain oligomers 106, which have average molecular weight of less than 10,000. The oligomers are then subjected to reaction condition 108 where the reaction mixture is first reacted at a temperature of 200 °C at 20 mbar pressure for 16 hours, followed by a temperature of 250 °C at 20 mbar pressure for another 4 hours to obtain the desired high molecular weight polyester 110, which are polymers with average molecular weight of more than 10,000.

Referring to Fig. 3, there is provided a process of synthesizing a polyester by first reacting sebacic acid and 1,6-hexanediol with 0.01 molar equivalents of tin catalyst 302, under reaction condition 304, whereby the reaction condition 304 comprises a first step of reacting the mixture at a temperature of 180 °C for 4 hours at atmospheric pressure, followed by second step at a temperature of 200 °C at 20 mbar pressure for 16 hours and then third step at a temperature of 250 °C at 20 mbar pressure for another 4 hours to obtain the desired high molecular weight polyester.

Examples

Non-limiting examples of the invention and a comparative example will be further described in greater detail by reference to specific Examples, which should not be construed as in any way limiting the scope of the invention.

Materials

The diols that had been used were ethylene glycol (> 99.5%), 1,3-propanediol (> 98.0%), 1,4-butanediol (> 99.0%), 1,5-pentanediol (> 97.0%), 1,6-hexanediol (> 97.0%), 1,7-heptanediol (> 98.0%), 1,8-octanediol (> 99.0%), 1,9-nonanediol (> 98.0%) and 1,10-decanediol (> 97.0%), all purchased from Tokyo Chemical Industry Co. Ltd (Tokyo, Japan). The dicarboxylic acids that had been used were sebacic acid (SA) (> 99.5%) and 1,18 octadecanedioic acid (ODDA) (> 98.0%), all provided by Wilmar International Limited (Singapore) and were used as received. The final polyesters obtained are summarized in Table 1, wherein PE-X,Y refers to the final polyester product, where X is the number of carbon atoms in the diol and Y is the number of carbon atoms in the dicarboxylic acid (inclusive of the 2 carboxyl carbon atoms).

Example 1: Preparation of a polyester

<u>General Synthesis of polyester</u>

As shown in Fig. 1, a dicarboxylic acid and a diol were first added in a 1:1 molar ratio to a 25 mL reaction tube and stirred continuously with a magnetic stir bar at about 500 revolutions per minute (rpm). Tin powder (0.01 molar ratio to dicarboxylic acid or diol) (10 μm, >99.0%, Sigma Aldrich, St. Louis, Missouri, United States of America) was then added to the reaction

mixture. The reaction mixture was then heated at 180 °C using Heidolph Hei-PLATE Mix 'n' Heat Core+ (Heidolph Instruments, Schwabach, Germany) for 4 hours at atmospheric pressure while being vented with a 3 way stopcock left in the "open" position so there was a small opening to allow any steam to escape throughout the 4 hour reaction period.

After 4 hours, the temperature was raised to 200 °C and a vacuum of 20 mbar was applied using Vacuubrand MZ 1C Vario Chemistry Diaphragm Pump (Vacuubrand Gmbh + Co Kg, Wertheim, Germany), where the stopcock was turned to the side position and connected to the vacuum. The reaction mixture was also stirred at an increased speed of about 1000 rpm for another 16 hours.

After 16 hours, the temperature was further raised to 250 °C while the reaction mixture remained stirring at about 1000 rpm under a pressure of 20 mbar for another 4 hours.

After 4 hours, the reaction mixture was left to cool gradually to room temperature between 20 °C and 30 °C.

An excess amount of chloroform was added to the reaction mixture until all the solidified polyester dissolved in the polymer solution, where about 200 mL of chloroform (≥ 99.8%, Fisher Scientific International, Inc., Hampton, New Hampshire, United States of America) was added to dissolve each gram of the polyester. The polymer solution was then filtered through a 11 μm pore size fluted filter paper via gravity filtration to remove any insoluble precipitate, impurities and the tin powder catalyst. The filtrate was subsequently concentrated by removing the excess solvent via rotary evaporation until the polymer solution had a concentration of about 10 w/w%.

The concentrated polymer solution was then added dropwise into a large excess of ethanol (>99%, International Scientific Pte Ltd, Singapore) (approximately 40 times the volume of the concentrated polymer solution) to precipitate the polyester.

The ethanolic mixture comprising the polyester precipitate was subsequently filtered via centrifugation to obtain the polyester precipitate before the polyester precipitate was dried under vacuum for 24 hours. The polyester obtained had a generic structure as seen in Fig. 2. The yield was determined using Equation 1.

$$Yield = \frac{mass\ of\ polymer}{mass\ of\ diol + mass\ of\ diacid - mass\ of\ water\ produced\ assuming\ 100\%\ reaction} \times 100\% \quad (1)$$

Table 1. Summary of polyesters synthesised

Entry	Diol	Diacid	$[Diol]_0/[Diacid]_0/[Sn]_0$ (mol equiv.)	Polymer
1	C2	C10	1/1/0.01	PE-2,10
2	C3	C10	1.02/1/0.01	PE-3,10
3	C4	C10	1.01/1/0.01	PE-4,10
4	C5	C10	1.03/1/0.01	PE-5,10
5	C6	C10	1.03/1/0.01	PE-6,10
6	C7	C10	1.02/1/0.01	PE-7,10
7	C8	C10	1.01/1/0.01	PE-8,10
8	C9	C10	1.02/1/0.01	PE-9,10
9	C10	C10	1.03/1/0.01	PE-10,10
10	C2	C18	1/1.02/0.01	PE-2,18
11	C3	C18	1/1/0.01	PE-3,18
12	C4	C18	1/1.01/0.01	PE-4,18
13	C5	C18	1.01/1/0.01	PE-5,18
14	C6	C18	1.01/1/0.01	PE-6,18
15	C7	C18	1/1/0.01	PE-7,18
16	C8	C18	1/1.01/0.01	PE-8,18
17	C9	C18	1/1/0.01	PE-9,18
18	C10	C18	1.01/1/0.01	PE-10,18

In entries 1-9, 1 mol equivalent refers to 5 mmol of diol/diacid used. In entries 10-18, 1 mol equivalent refers to 2.5 mmol of diol/diacid used.

The final yield of the polyesters obtained and the extent of the reaction between the dicarboxylic acids and the diols are summarized in Tables 2 and 3 respectively. The extent of the reaction between the dicarboxylic acids and the diols was measured by monitoring the amount of functional group reacted (Table 3), which will be elaborated further below. The difference in values between the Tables 2 and 3 were attributed to side-product formation,

the removal of small oligomers/unreacted monomers during purification, or the inevitable loss of large polymers during purification.

Table 2. Summary of recovered yield of the polyesters

Diol / Diacid	C2	C3	C4	C5	C6	C7	C8	C9	C10
C10	80.0%	74.0%	87.8%	84.2%	75.9%	82.1%	84.3%	80.6%	86.7%
C18	82.6%	88.1%	90.4%	89.3%	92.7%	85.7%	88.1%	90.2%	81.9%
C21	-	-	-	-	54.6%	-	-	-	-
C36	-	-	-	-	75.3%	-	-	-	-

Table 3. Summary of extent of the reaction (p) between the dicarboxylic acids and the diols

Diol / Diacid	C2	C3	C4	C5	C6	C7	C8	C9	C10
C10	98%	99%	99%	99%	99%	99%	99%	98%	98%
C18	97%	98%	98%	97%	98%	98%	96%	99%	99%

Characterization of polyester

The synthesised polyester was characterised using gel permeation chromatography (GPC) to determine the M_n and dispersity ($Đ$), where $Đ = M_n/M_w$ and M_w is the weight-average molecular weight and M_n is number-average molecular weight. The number-average degree of polymerisation (DP_n) was calculated from the M_n value of the polymer and the molecular weights of the monomers. Tetrahydrofuran (THF) (≥ 99.8%, Fisher Scientific International, Inc., Hampton, New Hampshire, United States of America) was used as the eluent in the GPC analysis performed on a Shimadzu LC-2030C Plus liquid chromatograph (Shimadzu Corporation, Kyoto, Japan) equipped with both a Shodex KF-804L mixed gel column (300 × 8.0 mm; bead size = 7 μm; pore size = 1500 Å) (Resonac Europe GmbH, Wiesbaden, Germany) and a Shodex LF-804 mixed gel column (300 × 8.0 mm; bead size = 6 μm; pore size = 3000 Å) (Resonac Europe GmbH, Wiesbaden, Germany). The flow rate was set at 0.7 mL/min (at 40°C). Sample detection and quantification were conducted using a Shimadzu refractive index detector RID-20A (Shimadzu Corporation, Kyoto, Japan). The column system was calibrated with Shodex poly(methyl methacrylate)s (PMMA) (Resonac Europe GmbH, Wiesbaden, Germany) as the standard.

The number-average molecular weight and dispersity of the polyesters are summarized in Tables 4 and 5 respectively.

Table 4. Summary of the number-average molecular weight (M_n) of the polyesters.

Diol / Diacid	C2	C3	C4	C5	C6	C7	C8	C9	C10
C10	10,000	20,000	26,000	38,000	48,000	26,000	35,000	47,000	45,000
C18	10,000	18,000	19,000	39,000	42,000	28,000	48,000	43,000	48,000
C21	-	-	-	-	11,000	-	-	-	-
C36	-	-	-	-	37,000	-	-	-	-

Table 5. Summary of the dispersity ($Đ$) of the polyesters.

Diol / Diacid	C2	C3	C4	C5	C6	C7	C8	C9	C10
C10	1.67	1.64	1.67	1.61	1.77	1.60	1.63	1.96	1.86
C18	1.93	2.20	2.27	2.02	1.82	1.80	1.86	1.80	2.74
C21	-	-	-	-	2.64	-	-	-	-
C36	-	-	-	-	1.83	-	-	-	-

The synthesised polymers were also characterised using NMR spectroscopy to confirm the synthesis of the polymer as well as to determine the reaction extent (p). Polyester samples were dissolved in approximately 0.5 mL of chloroform-d ($CDCl_3$) (Cambridge Isotope Laboratories, Tewksbury, Massachusetts, United States of America) before being filtered through a 0.45 μm filter. The ^{1}H NMR spectra were recorded using Bruker BBFO400 spectrometer (400 MHz) (Bruker, Germany) at ambient temperature and $CDCl_3$ was used as the NMR solvent. The chemical shift was calibrated using residual undeuterated solvent or tetramethylsilane (TMS) as the internal standard. The methylene protons (d) neighbouring to a hydroxy group ($C\underline{H_2}$–OH) of the diol monomer appeared around 3.6 ppm and its peak area decayed over time, while a new peak corresponding to the methylene protons (d') neighbouring to the ester linkage ($C\underline{H_2}$–OC(=O)) of the generated polyester appeared around 4.1 ppm and its peak area increased over time. Based on the peak area ratio of the d and d' protons, the p value was determined (Fig. 3).

WAXS spectra of the polyesters were obtained using Bruker D8 Advance X-ray diffractometer (Bruker, Germany) with Cu Kα radiation (1.54 Å), working at 40 kV and 40 mA. Samples were scanned from $2\theta = 10°$ to $2\theta = 80°$ with a step size of 0.023° and an acquisition time of 1 second per step. The crystallinities were determined using Equation (2), based on the area under crystalline peaks (Fig. 4).

$$Crystallinity = \frac{Area\ under\ crystalline\ peaks}{Area\ under\ all\ peaks} \times 100\% \quad (2)$$

The crystallinities and X-ray diffraction peaks of some polyesters in comparison with polyethylene are summarized in Table 6.

Table 6. Summary of crystallinities and X-ray diffraction peaks of selected polyesters compared to polyethylene (PE).

Diol	Diacid	Crystallinity (%)	Peak 1 (°)	Peak 2 (°)	Peak 3 (°)	Peak 4 (°)	Peak 5 (°)	Peak 6 (°)
C6	C10	32.5	21.6	24.4	30.2	36.0	41.2	43.8
C10	C10	40.2	21.7	24.2	30.3	36.2	40.9	44.0
C6	C18	32.6	21.6	24.2	30.1	36.0	40.7	43.7
C10	C18	36.3	21.5	23.9	30.0	36.1	40.7	43.7
PE[1,2]		20 to 65	21.6	23.9	30.1	36.3	40.7	43.8

[1] *Journal of Physics Conference Series* **2018**, *994*, 012011.
[2] *Materials* **2019**, *12* (11), 1746.

As seen in Table 6, the crystal structures of the polyesters disclosed in the present invention are very similar to polyethylene, suggesting that the bio-based and biodegradable polyesters of the present invention may be viable replacements for polyethylene, which is non-renewable and non-biodegradable.

Thermal properties of polyester

Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) were performed to determine the thermal properties of the synthesised polymer. TGA was done using TA Instruments Q500 thermogravimetric analyser (TA Instruments, New Castle, Delaware, United States of America). TGA was carried out in platinum pans under flowing air at a flow rate of 60 mL/minute with a heating rate of 10°C/minute at a temperature range of 30-550 °C. DSC was done using TA Instruments Q20 differential scanning calorimeter (TA Instruments, New Castle, Delaware, United States of America). DSC analysis was conducted using an aluminium sample pan under flowing nitrogen at a flow rate of 50 mL/minute. In the first cycle, the samples were equilibrated at -80°C before being heated up to 200°C with a heating rate of 10°C/minute. In the second cycle, the samples were cooled down to −80°C with a cooling rate of 10°C/minute and heated up to 200°C with a heating rate of 10°C/minute.

The melting temperature, decomposition temperature and glass transition temperature of the polyesters are summarized in Tables 7, 8 and 9 respectively.

Table 7. Summary of the melting temperature of the polyesters.

Diol / Diacid	C2	C3	C4	C5	C6	C7	C8	C9	C10
C10	75°C	58°C	65°C	58°C	66°C	60°C	70°C	62°C	77°C
C18	93°C	80°C	84°C	78°C	86°C	81°C	87°C	86°C	90°C

Table 8. Summary of decomposition temperature of the polyesters, where the temperature corresponds to 5% weight loss in the polyester when decomposition begins.

Diol / Diacid	C2	C3	C4	C5	C6	C7	C8	C9	C10
C10	352°C	354°C	359°C	362°C	360°C	356°C	362°C	356°C	373°C
C18	360°C	367°C	371°C	366°C	364°C	372°C	372°C	367°C	364°C

Table 9. Summary of glass transition temperature of the polyesters

Diol / Diacid	C2	C3	C4	C5	C6	C7	C8	C9	C10
C10	-15	-40	-30	-30	-30	-30	-20	-25	-25
C18	-5	-20	-10	-10	-20	-10	-10	-10	-10

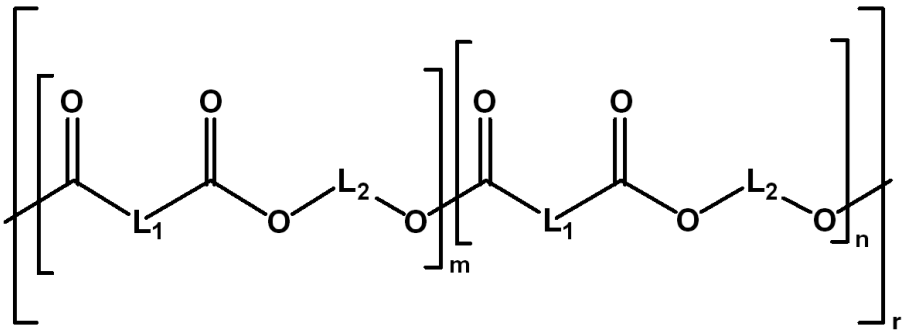
Industrial Applicability

The polyester as defined above may be useful for coating a substrate, as an adhesive, in textiles, bottles, films or plastics. The method of producing the polyester as defined above may be useful in providing sustainable single-use plastics which are more environmentally friendly.

It will be apparent that various other modifications and adaptations of the invention will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the invention and it is intended that all such modifications and adaptations come within the scope of the appended claims.

Claims

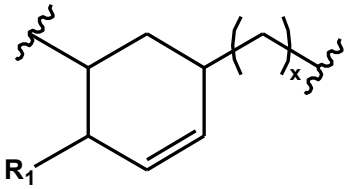
1. A polyester comprising a general formula (I):



(I),

wherein

L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted -C_{2-10}-alkenyl or substituted or unsubstituted -C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

∿∿∿ is where the structure (A) attaches to the polyester of general formula (I);

and wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched;

m and n are each independently an integer from 1 to 10; and

r is an integer from 20 to 200.

2. The polyester of claim 1, wherein the polyester does not comprise:

poly(1,2-ethylene 1,10-decanedioate);

poly(1,3-propylene 1,10-decanedioate);

poly(1,4-butylene 1,10-decanedioate);

poly(1,5-pentylene 1,10-decanedioate);

poly(1,6-hexylene 1,10-decanedioate);

poly(1,8-octylene 1,10-decanedioate);

poly(1,10-decylene 1,10-decanedioate);

poly(1,2-ethylene 1,12-dodecanedioate);

poly(1,3-propylene 1,12-dodecanedioate);

poly(1,4-butylene 1,12-dodecanedioate);

poly(1,5-pentylene 1,12-dodecanedioate);

poly(1,6-hexylene 1,12-dodecanedioate);

poly(1,7-heptylene 1,12-dodecanedioate);

poly(1,8-octylene 1,12-dodecanedioate);

poly(1,9-nonylene 1,12-dodecanedioate);

poly(1,10-decylene 1,12-dodecanedioate);

poly(1,11-undecylene 1,12-dodecanedioate);

poly(1,12-dodecylene 1,12-dodecanedioate);

poly(1,13-tridecylene 1,12-dodecanedioate);

poly(1,14-tetradecylene 1,12-dodecanedioate);

poly(1,15-pentadecylene 1,12-dodecanedioate);

poly(1,16-hexadecylene 1,12-dodecanedioate);

poly(1,17-heptadecylene 1,12-dodecanedioate);

poly(1,18-octadecylene 1,12-dodecanedioate);

poly(1,19-nonadecylene 1,12-dodecanedioate);

poly(1,20-icoscylene 1,12-dodecanedioate);

poly(1,2-ethylene 1,18-octadecanedioate);

poly(1,4-butylene 1,18-octadecanedioate);

poly(1,6-hexylene 1,18-octadecanedioate);

poly(1,8-octylene 1,18-octadecanedioate);

poly(1,10-decylene 1,18-octadecanedioate); or

poly(1,2-ethylene (E)-9-(non-3-en-1-yl)-10-octylnonadecanedioate).

3. The polyester according to claim 1 or 2, wherein r is an integer from 50 to 200.

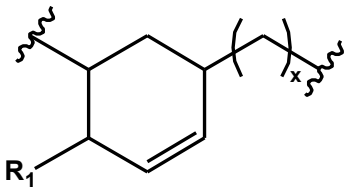
4. The polyester according to claim 1, wherein L_1 is octyl, hexadecyl, (E)-9-(non-3-en-1-yl)-10-octylnonadecyl or 3-heptyl-6-hexylcyclohex-1-enyl.

5. The polyester according to claim 1, wherein L_2 is ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl or decyl.

6. The polyester according to any one of the preceding claims, wherein the polyester has a number average molecular weight between 5,000 and 80,000.

7. The polyester according to any one of the preceding claims, wherein the polyester has a dispersity between 1.50 to 3.00, a melting temperature between 0 °C and 150 °C, or between 58°C to 93°C or a decomposition temperature between 300 °C and 500 °C, or between 352°C to 373°C.

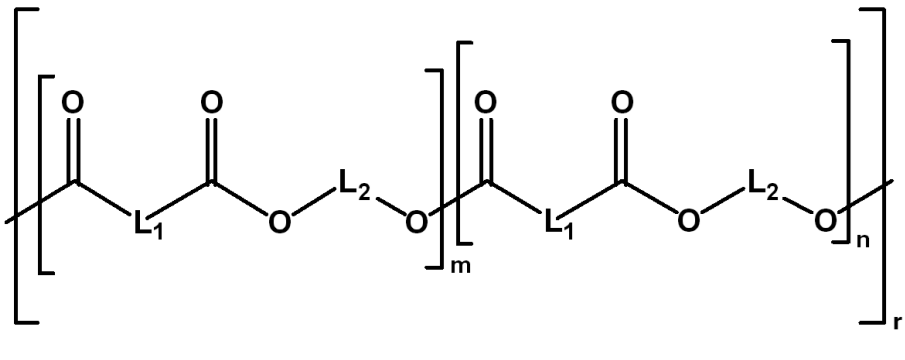
8. The polyester according to any one of the preceding claims, wherein L_1 is linear -C_{1-20}-alkyl.

9. The polyester according to any one of claims 1 to 7, wherein L_1 is each independently branched -C_{1-20}-alkyl, linear or branched -C_{2-20}-alkenyl, linear or branched -C_{2-20}-alkynyl or the following structure (A)  (A);

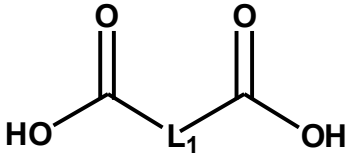
wherein R_1 is H or -C_{1-10}-alkyl, -C_{2-10}-alkenyl or -C_{2-10}-alkynyl; x is an integer from 0 to 10; and

~~~~ is where the structure (A) attaches to the polyester of general formula (I).

10. A method of preparing a polyester comprising a general formula (I):

 (I),

wherein the method comprises the steps of mixing a dicarboxylic acid having a general formula (II):

 (II),
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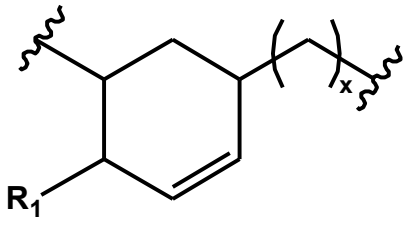
wherein L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A) 

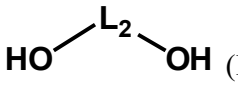
(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted - C_{2-10}-alkenyl or substituted or unsubstituted - C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

~~~ is where the structure (A) attaches to the dicarboxylic acid of general formula (II); and

a diol having a general formula (III),



(III)

wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched;

m and n are each independently an integer from 1 to 10; and

r is an integer from 20 to 200.

11. The method of claim 10, wherein the method does not comprise mixing:
decanedioic acid with ethanediol;
decanedioic with propanediol;
decanedioic with butanediol;
decanedioic with pentanediol;
decanedioic with hexanediol;
decanedioic with octanediol;
decanedioic with decanediol;
dodecanedioic acid with ethanediol;
dodecanedioic acid with propanediol;
dodecanedioic acid with butanediol;
dodecanedioic acid with pentanediol;
dodecanedioic acid with hexanediol;
dodecanedioic acid with heptanediol;
dodecanedioic acid with octanediol;
dodecanedioic acid with nonanediol;
dodecanedioic acid with decanediol;
dodecanedioic acid with undecanediol;
dodecanedioic acid with dodecanediol;
dodecanedioic acid with tridecanediol;
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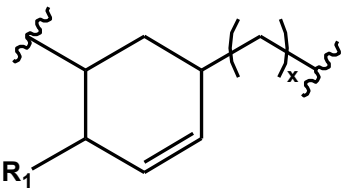
dodecanedioic acid with tetradecanediol;
dodecanedioic acid with pentadecanediol;
dodecanedioic acid with hexadecanediol;
dodecanedioic acid with heptadecanediol;
dodecanedioic acid with octadecanediol;
dodecanedioic acid with nonadecanediol;
dodecanedioic acid with icosanediol;
octadecanedioic acid with ethanediol;
octadecanedioic acid with butanediol;
octadecanedioic acid with hexanediol;
octadecanedioic acid with octanediol;
octadecanedioic acid with decanediol; or
(E)-9-(non-3-en-1-yl)-10-octylnonadecanedioic acid with ethanediol.

12. The method according to claim 10, wherein r is an integer from 50 to 200.

13. The method according to any one of claims 10 to 12, wherein L_1 is linear -C_{1-20}-alkyl.

14. The method according to any one of claims 10 to 12, wherein L_1 is each independently branched -C_{1-20}-alkyl, linear or branched -C_{2-20}-alkenyl, linear or branched -C_{2-20}-alkynyl or the following structure (A)



(A);

wherein R_1 is H or -C_{1-10}-alkyl, - C_{2-10}-alkenyl or - C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

~~~~ is where the structure (A) attaches to the polyester of general formula (I).

15. The method according to claim 10, wherein in the mixing step, the dicarboxylic acid and diol are mixed in a molar ratio in the range of between 2:1 and 1:2, preferably 1.5:1 and 1:1.5, and more preferably 1:1.

16. The method according to claims 10 to 15, wherein the mixing step comprises a catalyst and the ratio of the dicarboxylic acid to the catalyst is in the range of 50:1 to 200:1, preferably 75:1 to 150:1, more preferably 100:1.

17. The method according to claim 16, wherein the catalyst is a heterogeneous catalyst.

18. The method according to claim 17, wherein the heterogeneous catalyst is a metal selected from a group consisting of chromium, manganese, iron, cobalt, nickel, copper, zinc, tin and any mixture thereof, preferably, wherein the heterogeneous catalyst is tin.
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19. The method according to any one of claims 10 to 18, wherein the mixing step is performed at a temperature in the range of 150 °C to 300 °C, at a pressure in the range of 1,000 Pa to 200,000 Pa, for a duration in the range of 16 hours to 30 hours, or wherein the mixing step comprise stirring at a speed in the range of 250 rpm to 2,000 rpm, preferably wherein the mixing step is performed at a temperature in the range of 170°C to 260 °C, at a pressure in the range of 1,500 Pa to 150,000 Pa, for a duration in the range of 20 hours to 28 hours, or preferably wherein the mixing step comprise stirring at a speed in the range of 300 rpm to 1,500 rpm.

20. The method according to any one of claims 10 to 18, wherein the mixing step comprises step (i) of mixing at a temperature in the range of 150°C to 190 °C, at a pressure in the range of 50,000 Pa to 200,000 Pa, for a duration in the range of 3 hours to 5 hours, or wherein step (i) comprises stirring at a speed in the range of 250 rpm to 700 rpm, preferably wherein step (i) of mixing is performed at a temperature in the range of 170°C to 185 °C, at a pressure in the range of 75,000 Pa to 150,000 Pa, for a duration in the range of 3.5 hours to 4.5 hours, or preferably wherein step (i) comprises stirring at a speed in the range of 400 rpm to 600 rpm.

21. The method according to claim 20, wherein the mixing step further comprises step (ii) after step (i), of mixing at a temperature in the range of 195°C to 220 °C , at a pressure in the range of 1,000 to 5,000 Pa, for a duration in the range of 12 hours to 20 hours, or wherein step (ii) comprises stirring at a speed in the range of 750 rpm to 1,500 rpm, preferably wherein step (ii) of mixing takes place at a temperature in the range of 200°C to 210 °C, at a pressure in the range of 1,500 to 3,000 Pa, for a duration in the range of 15 hours to 17 hours, or preferably wherein step (ii) comprises stirring at a speed of in the range of 900 rpm to 1,200 rpm.

22. The method according to claim 21, wherein the mixing step further comprises step (iii) following step (ii), of mixing at a temperature in the range of 230°C to 300 °C, a pressure in the range of 1,000 to 5,000 Pa, for a duration in the range of 3 hours to 5 hours, or wherein step (iii) comprises stirring at a speed in the range of 750 rpm to 2,500 rpm, preferably wherein step (iii) of mixing takes place at a temperature in the range of 240°C to 260 °C, at a pressure in the range of 1,500 to 3,000 Pa, for a duration in the range of 3.5 hours to 4.5 hours, or preferably wherein step (iii) comprises stirring at a speed in the range of 1,000 rpm to 2,000 rpm.

23. The method according to any one of claims 20 to 22, further comprising the step of cooling the polyester to room temperature.

24. The method according to any one of claims 10 to 23, wherein the dicarboxylic acid is selected from the group consisting of decanedioic acid, octadecanedioic acid, (E)-9-(non-3-en-1-yl)-10-octylnonadecanedioic acid, 5-(7-carboxyheptyl)-2-hexylcyclohex-3-ene-1-carboxylic acid and any mixture thereof.

25. The method according to any one of claims 10 to 24, wherein the diol is selected from the group consisting of ethanediol, propanediol, butanediol, pentanediol, hexanediol, heptanediol, octanediol, nonanediol, decanediol and any mixture thereof.

26. The method according to any one of claims 10 to 25, wherein the method further comprises a step of purifying the polyester.

27. The method according to claim 26, wherein the purification step comprises a step of dissolving the polyester in a first solvent selected from the group consisting of dichloromethane, chloroform, 1,2-dichloroethane, carbon tetrachloride, 1,1,2,2-tetrachloroethane, phenol, 3-methylphenol, chlorobenzene, dichlorobenzene, tetrahydrofuran, pentane, hexane, heptane, benzene, toluene, xylene and any combination thereof, to form a solution and filtering the solution using gravity filtration or vacuum filtration.

28. The method according to claim 27, wherein the method further comprises a step of concentrating the solution.

29. The method according to claim 28, wherein the solution comprises the polyester at a concentration in the range of 5% w/w to 20% w/w, preferably in the range of 7% w/w to 15% w/w, more preferably at a concentration of 10% w/w.

30. The method according to any one of claims 28 to 29, wherein the method further comprises a step of precipitating the polyester.

31. The method according to claim 30, wherein the precipitation step comprises precipitating the polyester from a second solvent selected from the group consisting of water, methanol, ethanol, propanol, isopropanol, butanol, N-methyl-2-pyrrolidone, methyl ethyl ketone, methyl isobutyl ketone, diethyl ether, dipropyl ether, pentane, hexane, heptane, benzene, toluene, xylene and any combination thereof.

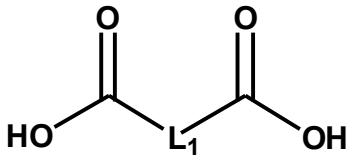
32. The method according to claim 31, wherein the second solvent is present in an excess of 30 to 60 times in volume of the solution, preferably in an excess of 35 to 50 times in volume of the solution, and more preferably in an excess of 40 to 45 times in volume of the solution.

33. The method according to any one of claims 31 to 32, wherein the precipitated polyester is dried under vacuum for a duration in the range of 12 hours to 36 hours, or under vacuum at a temperature in the range of 30 to 60 °C, preferably wherein the precipitated polyester is dried under vacuum for a duration of 24 hours or under vacuum at a temperature of 40 °C.

34. The method according to any one of claims 10 to 33, wherein the method does not require distillation or the method does not require an inert environment for the preparation of the polyester.

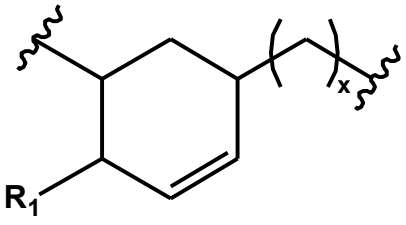
35. A polyester prepared by mixing:

    a dicarboxylic acid having a general formula (II):



(II),

wherein L_1 is each independently absent, substituted or unsubstituted -C_{1-20}-alkyl, substituted or unsubstituted -C_{2-20}-alkenyl, substituted or unsubstituted -C_{2-20}-alkynyl, or the following structure (A)



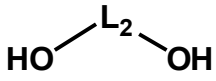
(A);

wherein R_1 is H or substituted or unsubstituted -C_{1-10}-alkyl, substituted or unsubstituted - C_{2-10}-alkenyl or substituted or unsubstituted - C_{2-10}-alkynyl;

x is an integer from 0 to 10; and

~~~ is where the structure (A) attaches to the dicarboxylic acid of general formula (II); and

a diol having a general formula (III),



(III)

wherein L_2 is each independently substituted or unsubstituted -C_{2-20}-alkyl, substituted or unsubstituted -C_{3-20}-alkenyl, or substituted or unsubstituted -C_{3-20}-alkynyl;

wherein the alkyl, alkenyl or alkynyl of L_1 and L_2 are each independently linear or branched.

36. The polyester according to claim 35, wherein the polyester is a random copolymer.

37. A use of the polyester according to any one of claims 1 to 9 or 35 to 36 for coating a substrate, as an adhesive, in textiles, bottles, films or plastics.
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