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(54) Title: PROCESS FOR IMPROVING THE THERMAL AND LIGHT STABILITY OF POLYESTERS

(57) Abstract: The present invention describes a process for improving the thermal and light stability of polyesters, especially polyester fibers, which comprises adding to the polyesters a chain extender. Especially preferred chain extenders are dianhydrides, alcohols and hindered phenolic aromatic phosphates or mixtures thereof.

Process for improving the thermal and light stability of polyesters

The present invention relates to process for improving the thermal and light stability of polyesters, especially polyester fibers, which comprises adding to the polyesters a chain extender.

U.S. 6,469,078 discloses a process for increasing the molecular weight and/or for the modification of polycondensates during processing in the melt, which comprised adding to the polycondensate a blend comprising a) at least one polyfunctional anhydride (polyanhydride); b) at least one polyfunctional compound, the functional groups of which can react with the anhydride groups of component a); and c) at least one phosphonate.

WO-A-2004/101666 discloses masterbatches useful for modifying thermoplastic polymers, in particular to masterbatches comprising dispersed polyol branching agent and/or chain coupling agents, such as for example dianhydrides.

These known processes for preparing polyesters do not satisfy in every respect the high requirements which a polyester is required to meet, especially with regard to thermal and light stability of polyesters which are used as polyester fibers. As a result there continues to be a need for an improved process for the preparation of polyesters with improved thermal and light stability.

The instant invention pertains therefore to a a process for improving the thermal and light stability of polyesters which comprises adding to the polyesters a chain extender.

Of interest is a process for improving the thermal and light stability of polyesters which are polyester fibers.

The polyester is particularly preferably polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polyethylene naphthalate, polytrimethylene terephthalate (PTT) or copolyesters. Especially preferred are polyethylene terephthalate or polyethylene naphthalate.

The polyesters may be homopolyesters or copolyesters which are composed of aliphatic, cycloaliphatic or aromatic dicarboxylic acids and diols or hydroxycarboxylic acids.

The polyesters can be prepared by direct esterification (PTA process) and also by transesterification (DMT process). Any of the known catalyst systems may be used for the preparation.

Preferred diacids are selected from the group consisting of aromatic dicarboxylic acids having 8 to 14 carbon atoms, aliphatic dicarboxylic acids having 4 to 12 carbon atoms, cycloaliphatic dicarboxylic acids having 8 to 12 carbon atoms, and mixtures thereof.

Preferably such diacids are terephthalic acid, isophthalic acid, o-phthalic acid, naphthalene dicarboxylic acid, cyclohexane dicarboxylic acid, cyclohexanediacetic acid, diphenyl-4,4'-dicarboxylic acid, succinic acid, glutaric acid, adipic acid, sebacic acid and mixtures thereof.

Especially preferred are terephthalic acid and 2,6-naphthalene dicarboxylic acid.

Preferred diols are compounds of the formula A

$$HO-R-OH \qquad (A)$$

wherein R is an aliphatic, cycloaliphatic or aromatic moiety of 2 to 18 carbon atoms.

Preferably such diols are for example ethylene glycol, diethylene glycol, triethylene glycol, propane-1,3-diol, propane -1,2-diol, butane-1,4-diol, pentane-1,5-diol, hexane-1,6-diol, 1,4-cyclohexanedimethanol, 3-methylpentane-2,4-diol, 2-methylpentane-1,4-diol, 2,2-diethylpropane-1,3-diol, 1,4-di-(hydroxyethoxy)benzene, 2,2-bis(4-hydroxycyclohexyl)-propane, 2,4-dihydroxy-1,1,3,3-tetramethylcyclobutane, 2,2-bis-(3-hydroxyethoxyphenyl)propane, 2,2-bis-(4-hydroxypropoxyphenyl)ethane and mixtures thereof.

Most preferably, the diol is ethylene glycol or 1,4-cyclohexanedimethanol.

Instead of, or in addition to the diacids mentioned above, various diesters may be used. For example, diesters that correspond in respect of their acid moiety to the aforementioned diacids may be used. Suitable diesters therefore also include the aliphatic and the aromatic kind. Very suitable diesters are for example the $C_1$-$C_4$alkyl esters of terephthalic acid, isophthalic acid, o-phthalic acid or naphthalene dicarboxylic acid.

Preferably, the esterification and transesterification processes are carried out in the presence of a catalyst.

Catalysts of interest for the esterification process are for example antimony or germanium compounds, e.g. antimony(III)oxide ($Sb_2O_3$) or germanium dioxide ($GeO_2$). Of interest are also titanium catalysts as disclosed for example in DE-A-19 513 056 or titanium based catalysts in combination with cobalt and phosphorous based compounds as disclosed for example in DE-A-19 518 943.

Catalysts of interest for the transesterification process are for example titanium compounds, e.g. titanium(IV)butoxide.

The catalysts are preferably used in the preparation of polyesters in an amount of 0.005 to 0.035 % by weight of the total amount of reactants.

Polyesters may be produced in a conventional batch process, wherein the product of the transesterification or esterification is formed in one vessel and then transferred to a second vessel for polymerization. The second vessel is agitated and the polymerization reaction is continued until the power used by the agitator reaches a level indicating that the polyester melt has achieved the desired intrinsic viscosity and therefore, the desired molecular weight. For example, in the preparation of polyethylene terephthalate (PET), the esterification or transesterification is typically conducted at an elevated temperature between for example 200 to 350°C to produce a polyester having an intrinsic viscosity of 0.3 to 0.8 dl/g, commonly about 0.6 to 0.75 dl/g (determined by ASTM D-4603-86 at 30°C in a mixture of 60 % by weight of phenol and 40 % by weight of tetrachloroethane).

Alternatively, these steps may also be carried out in a continuous process. For example, the continuous process disclosed in WO-A-97/44376 is conducted by combining the diol with

the diacid or diester at a temperature of about 240 to 290°C and at a pressure of from about 30 to 600 kPa for about 1 to 5 hours to yield low molecular weight oligomers and water. In general, a continuous feed of reactants is used employing a molar ratio of diol to diacid or diester of from about 1.0 to 1.6. The water or alcohol so produced is removed as the reaction proceeds.

In the second stage of the continuous process, which is a polycondensation stage generally conducted in a series of 2 or more vessels, the oligomers are agitated at a temperature of about 240 to 305°C for about 1 to 4 hours in the presence of a polymerization catalyst to form the polyester melt.

Typically, the polycondensation reaction begins in a first vessel operated at a pressure range of from about 0 to 10 kPa. Diol produced in the polycondensation is removed from the polyester melt using an applied vacuum. The polyester melt is typically agitated to allow the diol to escape from the polyester melt.

As the polyester melt is fed into successive vessels, the molecular weight and thus the intrinsic viscosity of the polyester melt increases. The temperature of each vessel is generally increased and the pressure decreased to allow greater polymerization in each successive vessel. The final vessel is generally operated at a pressure of from about 0 to 5.5 kPa. Each of the polymerization vessels communicates with a flash vessel. The retention time in the polymerization vessels and the feed ratio of the reactants into the continuous process are determined in part based on the target molecular weight of the polyester.

The polymerization catalyst employed in the continuous process is generally added prior to, at the start of, or during the polymerization stage.

Also the chain extender employed may already be added prior to, at the start of, or during the polymerization stage.

When the polymerization process is completed, the resulting polyester, which is still in the form of a melt, is generally filtered and the typically extruded and pelletized before being worked up into specific polyester articles or injection molded in a preform or coating into an

item such as a bottle. Such steps are also typically labeled as "polyester processing" but refer of course to later working of the finished polyester rather than to the chemical processing steps used to form the polyester in the first place.

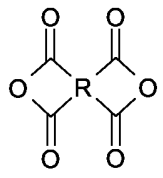
For example, polyester melt may be extruded into polyester sheets, filaments, pellets, chips or similar particles (so-called primary extrusion step). Preferably, the polyester melt is extruded shortly or immediately after exiting the polycondensation stage, whereupon it is quenched, for example in a water trough or alternative cooling unit. The formation of pellets or chips is particularly convenient for storage, transport and handling purposes.

The pellets of chips may be subjected to solid state polymerization (SSP), for example, to raise the intrinsic viscosity to 0.7 to 1.2 dl/g, preferably to about 0.83 dl/g.

In order to produce the final polyester articles, in the form of fibers, bottles, filaments, sheets, molded articles and the like, the pellets or chips are re-melted and re-extruded or injection molded. The extrusion and injection molding conditions are conventional. For example, the polyester may be extruded at a temperature in the range of 240 to 315°C

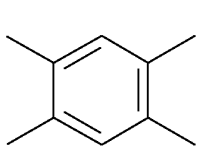
Of interest is a process for improving the thermal and light stability of polyesters which comprises adding to the polyesters a chain extender which is selected from the group consisting of anhydrides, epoxides, oxazolines, oxazolones, oxazines, isocyanates, acyllactams, maleimides, alcohols and hindered phenolic aromatic phosphates or mixtures thereof.

Polyfunctional, in particular difunctional, compounds of the anhydride class as chain extenders in the sense of this invention are known and are, for example, compounds of the formula B



(B)

in which R is a radical of the formulae (Ba) – (BK)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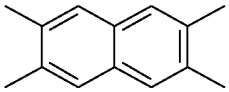
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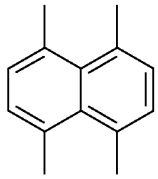
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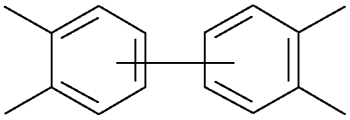
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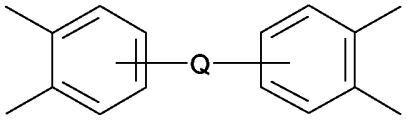

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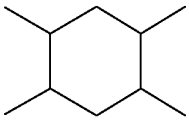
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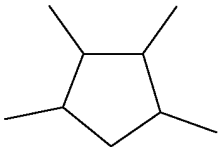
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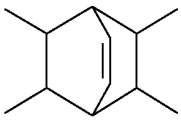
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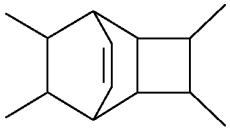
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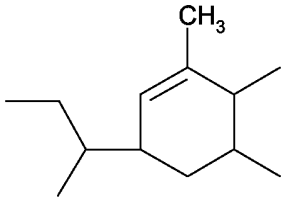

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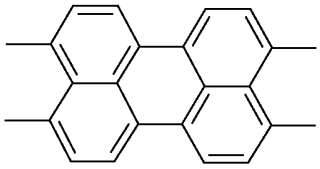

(Bk),

wherein Q is $-CH_2-$, $-CH(CH_3)-$, $-C(CH_3)_2-$, $-C(CF_3)_2-$, -S-, -O-, $-SO_2-$, -NHCO-, -CO- or $>P(O)(C_1-C_{20}alkyl)$ and wherein the aromatic rings in the formulae (Ba)-(Be) are unsubstituted or substituted by one or several $C_1-C_6$alkyl groups, $C_1-C_6$alkoxy groups or halogen atoms.

If R is an alkanetetrayl radical, then the tetracarboxylic dianhydride may be, for example, butane-1,2,3,4-tetracarboxylic dianhydride.

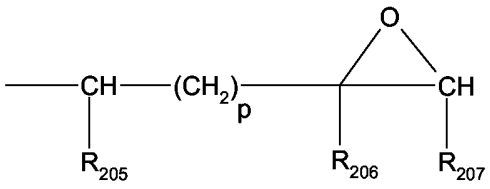
Preferred tetracarboxylic dianhydrides are those containing aromatic rings.

Particularly preferred are pyromellitic dianhydride, 3,3',4,4'-benzophenonetetracarboxylic dianhydride, 3,3',4,4'-biphenyltetracarboxylic dianhydride and oxydiphthalic dianhydride.

Where appropriate it is also possible to use a blend of tetracarboxylic dianhydrides of different structure.

Individual particularly preferred tetracarboxylic dianhydrides are: pyromellitic dianhydride, benzophenonetetracarboxylic dianhydride, 1,1,2,2-ethanetetracarboxylic dianhydride, 1,2,3,4-cyclopentanetetracarboxylic dianhydride, diphenylsulfonetetracarboxylic dianhydride, 5-(2,5-dioxotetrahydro-3-furanyl)-3-methyl-3 cyclohexane-1,2-dicarboxylic dianhydride, bis(3,4-dicarbonacidphenyl) ether dianhydride, bis(3,4-dicarboxylic acid phenyl)thioether dianhydride, bisphenol A bisether dianhydride, 2,2-bis(3,4-dicarboxylic phenyl)hexafluoropropane dianhydride, 2,3,6,7-naphthalenetetracarboxylic dianhydride, bis(3,4-dicarboxylic acid phenyl)sulfone dianhydride, 1,2,5,6-naphthalenetetracarboxylic dianhydride, *2,2',3,3'*-biphenyltetracarboxylic dianhydride, hydroquinone bisether dianhydride, 3,4,9,10-perylenetetracarboxylic dianhydride, 1,2,3,4-cyclobutanetetracarboxylic dianhydride, 3,4-dicarboxy-1,2,3,4-tetrahydro-1-naphthalenesuccinic dianhydride, bicyclo(2,2)oct-7-ene-2,3,5,6-tetracarboxylic dianhydride, tetrahydrofuran-2,3,4,5-tetracarboxylic dianhydride, 2,2-bis(3,4-dicarboxyphenyl)propane dianhydride, 3,3',4,4'-biphenyltetracarboxylic dianhydride, 4,4'-oxydiphthalic dianhydride (ODPA), ethylenediaminetetracarboxylic dianhydride (DDTAH), or a combination of these dianhydrides.

The epoxides contain, for example, two epoxy radicals, for example those of formula C




(C)

which radicals are directly bound to carbon, oxygen, nitrogen or sulfur atoms, wherein, if $R_{205}$ and $R_{207}$ are hydrogen, $R_{206}$ is hydrogen or methyl and p=0; or, if $R_{205}$ and $R_{207}$ together are

$-CH_2-CH_2-$ or $-CH_2-CH_2-CH_2-$ , $R_{206}$ is hydrogen and p=0 or 1.

Examples of epoxides to be mentioned are:

1. Diglycidyl ester and di(β-methylglycidyl)ester obtainable by reacting a compound containing two carboxyl groups in the molecule with epichlorohydrin or glycerol

dichlorohydrin or β-methylepichlorohydrin. The reaction is usefully carried out in the presence of bases.

Compounds containing two carboxyl groups in the molecule may be aliphatic dicarboxylic acids. Examples of these dicarboxylic acids are glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid or dimerised or trimerised linolic acid.

However, it is also possible to use cycloaliphatic dicarboxylic acids, such as tetrahydrophthalic acid, 4-methyltetrahydrophthalic acid, hexahydrophthalic acid or 4-methylhexahydrophthalic acid.

Aromatic dicarboxylic acids may also be used, such as phthalic acid or isophthalic acid.

2. Diglycidyl ether or di(β-methylglycidyl)ether obtainable by reacting a compound containing two free alcoholic hydroxyl groups and/or phenolic hydroxyl groups with a suitably substituted epichlorohydrin under alkaline conditions or in the presence of an acid catalyst with subsequent treatment with alkali.

Ethers of this type are derived, for example, from acyclic alcohols, such as ethylene glycol, diethylene glycol and higher poly(oxyethylene)glycols, propane-1,2-diol, or poly(oxypropylene)glycols, propane-1,3-diol, butane-1,4-diol, poly(oxytetramethylene)glycols, pentane-1,5-diol, hexane-1,6-diol, sorbitol, and from polyepichlorohydrins.

They are also derived, for example, from cycloaliphatic alcohols such as 1,3- or 1,4-dihydroxycyclohexane, bis(4-hydroxycyclohexyl)methane, 2,2-bis(4-hydroxycyclohexyl)propane or 1,1-bis(hydroxymethyl)-cyclohex-3-ene, or they have aromatic nuclei such as N,N-bis(2-hydroxyethyl)aniline or p,p'-bis(2-hydroxyethylamino)diphenylmethane.

The epoxides can also be derived from mononuclear phenols, for example from resorcinol, pyrocatechol or hydroquinone; or they are based on polynuclear phenols such as on 4,4'-dihydroxybiphenyl, bis(4-hydroxyphenyl)methane, 2,2-bis(4-hydroxyphenyl)propane, 2,2-bis(3,5-dibromo-4-hydroxyphenyl)propane, 4,4'-dihydroxydiphenylsulfone, 9,9'-bis(4-hydroxyphenyl)fluorene, or on condensates, obtained under acid conditions, of phenols with formaldehyde such as phenol novolaks.

3. Di(N-glycidyl) compounds are obtainable, for example, by dehydrochlorination of the reaction products of epichlorhydrin with amines containing two aminohydrogen atoms. These amines are, for example, aniline, toluidine, n-butylamine, bis(4-aminophenyl)methane, m-xylylenediamine or bis(4-methylaminophenyl)methane.

The di(N-glycidyl) compounds also include N,N'-diglycidyl derivatives of cycloalkylene ureas, such as ethylene urea or 1,3-propylene urea, and N,N'-diglycidyl derivatives of hydantoins, such as of 5,5-dimethylhydantoin.

4. Di(S-glycidyl) compounds, such as di-S-glycidyl derivatives, which are derived from di-thiols, such as ethane-1,2-dithiol or bis(4-mercaptomethylphenyl) ether.

5. Epoxides containing a radical of formula C, wherein $R_{205}$ and $R_{207}$ together are $-CH_2-CH_2-$ and n is 0, for example bis(2,3-epoxycyclopentyl) ether, 2,3-epoxycyclopentyl glycidyl ether or 1,2-bis(2,3-epoxycyclopentyloxy)ethane; epoxides containing a radical of formula C, wherein $R_{205}$ and $R_{207}$ together are $-CH_2-CH_2-$ and n is 1, for example 3,4-epoxy-6-methyl-cyclohexanecarboxylic acid-(3',4'-epoxy-6'-methylcyclohexyl)methyl ester.

Due to e.g. the process for their preparation, the difunctional epoxides mentioned above can contain minor amounts of mono- or trifunctional components.

Diglycidyl compounds having aromatic structures are mainly used.

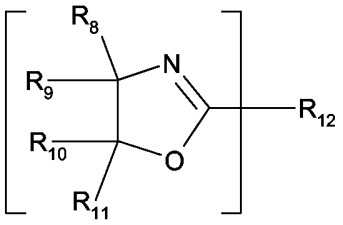
Where appropriate, it is also possible to use a blend of epoxides of different structure.
On the other hand it is also possible to use tri- and polyfunctional epoxides as supplement in order to obtain branchings, if desired. Such epoxides are, for example, a) liquid diglycidyl ethers of bisphenol A such as Araldit® GY 240, Araldit® GY 250, Araldit® GY 260, Araldit® GY 266, Araldit® GY 2600, Araldit® MY 790; b) solid diglycidyl ethers of bisphenol A such as Araldit® GT 6071, Araldit® GT 7071, Araldit® GT 7072, Araldit® GT 6063, Araldit® GT 7203, Araldit® GT 6064, Araldit® GT 7304, Araldit® GT 7004, Araldit® GT 6084, Araldit® GT 1999, Araldit® GT 7077, Araldit® GT 6097, Araldit® GT 7097, Araldit® GT 7008, Araldit® GT 6099, Araldit® GT 6608, Araldit® GT 6609, Araldit® GT 6610; c) liquid diglycidyl ethers of bisphenol F

such as Araldit® GY 281, Araldit® GY282, Araldit® PY 302, Araldit® PY 306; d) solid polyglycidyl ethers of tetraphenylethane such as CG Epoxy resin® 0163; e) solid and liquid polyglycidyl ethers of phenolformaldehyde novolak such as EPN 1138, EPN 1139, GY 1180, PY 307; f) solid and liquid polyglycidyl ethers of o-cresolformaldehyde novolak such as ECN 1235, ECN 1273, ECN 1280, ECN 1299; g) liquid glycidyl ethers of alcohols such as Shell® glycidyl ether 162, Araldit® DY 0390, Araldit® DY 0391; h) liquid glycidyl esters of carboxylic acids such as Shell® Cardura E terephthalate, trimellitate, Araldit® PY 284 or mixtures of aromatic glycidyl esters such as Araldit® PT 910; i) solid heterocyclic epoxy resins (triglycidyl isocyanurate) such as Araldit® PT 810; j) liquid cycloaliphatic epoxy resins such as Araldit® CY 179; k) liquid N,N,O-triglycidyl ethers of p-aminophenol such as Araldit® MY 0510; l) tetraglycidyl-4-4'-methylenebenzamine or N,N,N',N'-tetraglycidyldiaminophenylmethane such as Araldit® MY 720, Araldit® MY 721.

Particularly preferred difunctional epoxides are diglycidyl ethers based on bisphenols, for example based on 2,2-bis(4-hydroxyphenyl)propane (bisphenol A), bis(4-hydroxyphenyl)-sulfone (bisphenol S), mixtures of bis(ortho/para-hydroxyphenyl)methane (bisphenol F) or Araldit® MT 0163.

Solid epoxides of the diglycidyl ether of bisphenol A type are very particularly preferred, e.g.: Araldit® GT 6071, GT 7071, GT 7072, GT 6097 and GT 6099 or liquid epoxides of the bisphenol F type such as Araldit® GY 281 or PY 306.

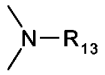
Polyfunctional, in particular trifunctional, compounds from the class of the oxazolines in the sense of this invention are known and are described, inter alia, in EP-A-0583807 and are, for example, compounds of formula D




(D),

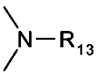
wherein $R_8$, $R_9$, $R_{10}$ and $R_{11}$ are each independently of one another hydrogen, halogen, $C_1$-$C_{20}$alkyl, $C_4$-$C_{15}$cycloalkyl, unsubstituted or $C_1$-$C_4$alkyl-substituted phenyl; $C_1$-$C_{20}$alkoxy or $C_2$-$C_{20}$carboxyalkyl,

if t = 3,

$R_{12}$ is a trivalent linear, branched or cyclic aliphatic radical containing 1 to 18 carbon atoms which may be interrupted by oxygen, sulfur or  , or $R_{12}$ is also an unsubstituted or

$C_1$-$C_4$alkyl-substituted benzenetriyl,

if t = 2,

$R_{12}$ is a divalent linear, branched or cyclic aliphatic radical containing 1 to 18 carbon atoms which may be interrupted by oxygen, sulfur or  , or $R_{12}$ is also an unsubstituted or

$C_1$-$C_4$alkyl-substituted phenylene, $R_{13}$ is $C_1$-$C_8$alkyl, and t is 2 or 3.

Halogen is, for example, fluoro, chloro, bromo or iodo. Chloro is particularly preferred.

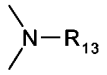
Alkyl containing up to 20 carbon atoms is a branched or unbranched radical, for example methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, 2-ethylbutyl, n-pentyl, isopentyl, 1-methylpentyl, 1,3-dimethylbutyl, n-hexyl, 1-methylhexyl, n-heptyl, isoheptyl, 1,1,3,3-tetramethylbutyl, 1-methylheptyl, 3-methylheptyl, n-octyl, 2-ethylhexyl, 1,1,3-trimethylhexyl, 1,1,3,3-tetramethylpentyl, nonyl, decyl, undecyl, 1-methylundecyl, dodecyl, 1,1,3,3,5,5-hexamethylhexyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, eicosyl or docosyl. A preferred meaning of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ is $C_1$-$C_{12}$alkyl, in particular $C_1$-$C_8$alkyl, e.g. $C_1$-$C_4$alkyl.

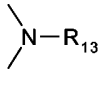
$C_4$-$C_{15}$Cycloalkyl, in particular $C_5$-$C_{12}$cycloalkyl, is e.g. cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl or cyclododecyl. $C_5$-$C_8$Cycloalkyl is preferred, in particular cyclohexyl.

$C_1$-$C_4$Alkyl-substituted phenyl which preferably contains 1 to 3, more preferably 1 or 2, alkyl groups is, for example, o-, m- or p-methylphenyl, 2,3-dimethylphenyl, 2,4-dimethylphenyl, 2,5-dimethylphenyl, 2,6-dimethylphenyl, 3,4-dimethylphenyl, 3,5-dimethylphenyl, 2-methyl-6-ethylphenyl, 4-tert-butylphenyl, 2-ethylphenyl or 2,6-diethylphenyl.

Alkoxy containing up to 20 carbon atoms is a branched or unbranched radical, for example methoxy, ethoxy, propoxy, isopropoxy, n-butoxy, isobutoxy, pentoxy, isopentoxy, hexoxy, heptoxy, octoxy, decyloxy, tetradecyloxy, hexadecyloxy or octadecyloxy. A preferred meaning of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ is alkoxy containing 1 to 12, preferably 1 to 8, e.g. 1 to 4, carbon atoms.

Carboxyalkyl containing 2 up to 20 carbon atoms is a branched or unbranched radical, for example carboxymethyl, carboxyethyl, carboxypropyl, carboxybutyl, carboxypentyl, carboxyhexyl, carboxyheptyl, carboxyoctyl, carboxynonyl, carboxydecyl, carboxyundecyl, carboxydodecyl, 2-carboxy-1-propyl, 2-carboxy-1-butyl or 2-carboxy-1-pentyl. A preferred meaning of $R_8$, $R_9$, $R_{10}$ and $R_{11}$ is $C_2$-$C_{12}$carboxyalkyl, in particular $C_2$-$C_8$carboxyalkyl, e.g. $C_2$-$C_4$carboxyalkyl.

A trivalent linear, branched or cyclic aliphatic radical containing 1 to 18 carbon atoms, which radical may be interrupted by oxygen, sulfur or  , means that the three bonding sites may be at the same atom or at different atoms. Examples thereof are methanetriyl, 1,1,1-ethanetriyl, 1,1,1-propanetriyl, 1,1,1-butanetriyl, 1,1,1-pentanetriyl, 1,1,1-hexanetriyl, 1,1,1-heptanetriyl, 1,1,1-octanetriyl, 1,1,1-nonanetriyl, 1,1,1-decanetriyl, 1,1,1-undecanetriyl, 1,1,1-dodecanetriyl, 1,2,3-propanetriyl, 1,2,3-butanetriyl, 1,2,3-pentanetriyl, 1,2,3-hexanetriyl, 1,1,3-cyclopentanetriyl, 1,3,5-cyclohexanetriyl, 3-oxo-1,1,5-pentanetriyl, 3-thio-1,1,5-pentanetriyl or 3-methylamino-1,1,5-pentanetriyl.

A divalent linear, branched or cyclic aliphatic radical containing 1 to 18 carbon atoms, which radical may be interrupted by oxygen, sulfur or  , means that the two bonding sites may be at the same atom or at different atoms. Examples thereof are methylene, ethylene,

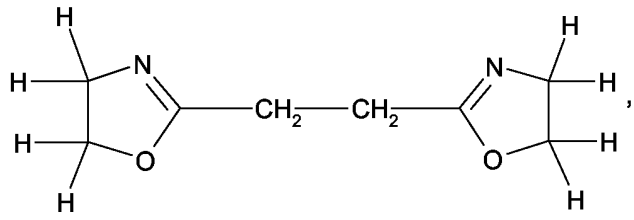
propylene, butylene, pentylene, hexylene, heptylene, octylene, nonylene, decylene, undecylene or dodecylene.

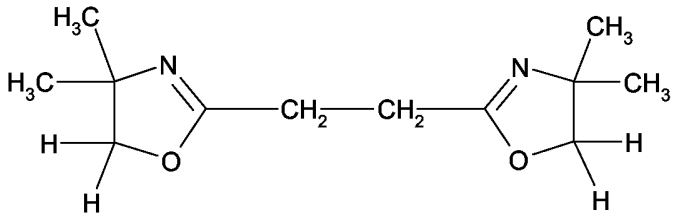
Unsubstituted or $C_1$-$C_4$alkyl-substituted benzenetriyl which preferably contains 1 to 3, more preferably 1 or 2, alkyl groups is, for example, 1,2,4-benzenetriyl, 1,3,5-benzenetriyl, 3-methyl-1,2,4-benzoltriyl or 2-methyl-1,3,5-benzenetriyl. 1,2,4-Benzenetriyl and 1,3,5-benzenetriyl are particularly preferred.

Particularly interesting compounds are those of formula D, wherein
$R_8$, $R_9$, $R_{10}$ and $R_{11}$ are each independently of one another hydrogen or $C_1$-$C_4$alkyl, and
$R_{12}$ is 1,2,4-benzenetriyl or 1,3,5-benzenetriyl.

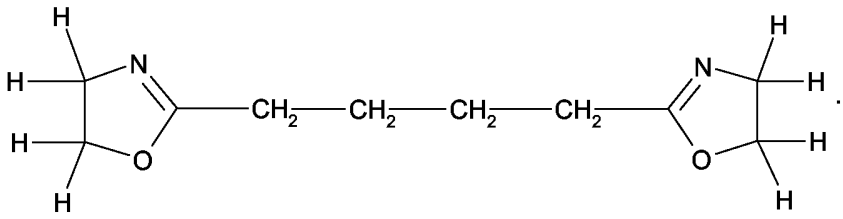
Especially interesting are compounds of formula D, such as 2,2',2''-(1,3,5-benzoltriyl)-tris-2-oxazoline; 2,2',2''-(1,2,4-benzoltriyl)-tris-4,4-dimethyl-2-oxazoline; 2,2',2''-(1,3,5-benzoltriyl)-tris-4,4-dimethyl-2-oxazoline; 2,2',2''-(1,2,4-benzoltriyl)-tris-5-methyl-2-oxazoline; or 2,2',2''-(1,3,5-benzoltriyl)-tris-5-methyl-2-oxazoline.

Preferred difunctional compounds from the class of the bisoxazolines in the sense of this invention are described by T. Loontjens et al., Makromol. Chem., Macromol. Symp. 75, 211-216 (1993) and are, for example, compounds of formulae

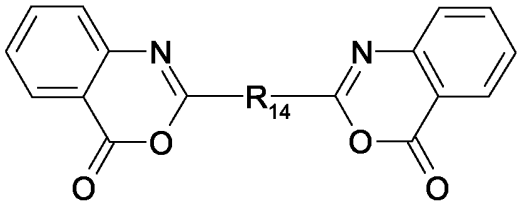




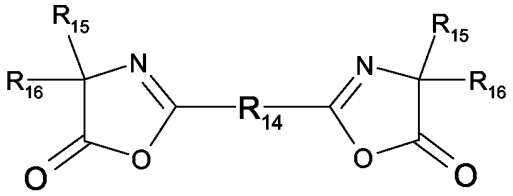
or



Polyfunctional, in particular difunctional, compounds from the oxazine or oxazolone class of chain extenders in the sense of this invention are known and have been desribed, for example, by H. Inata et al., J. Applied Polymer Science Vol. 32, 4581-4594 (1986) and are, for example, compounds of the formula Ea or Eb



(Ea)



(Eb)

in which

$R_{14}$ is a direct bond or unsubstituted or $C_1$-$C_4$alkyl-substituted phenylene, and

$R_{15}$ and $R_{16}$, independently of one another, are hydrogen or $C_1$-$C_4$alkyl.

Special preference is given to compounds of the formula Ea and Eb in which $R_{14}$ is a direct bond, in particular 2,2'-bis(4H-3,1-benzoxazin-4-one).

Polyfunctional, in particular difunctional, compounds from the class of the isocyanates in the sense of this invention are known and are, for example, compounds of formula F

$$O=C=N-R_{23}-N=C=O \qquad (F),$$

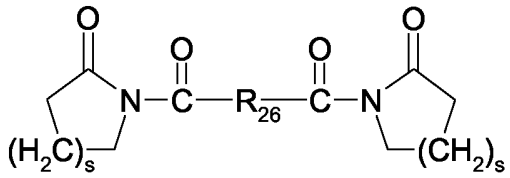
wherein $R_{23}$ is $C_1$-$C_{20}$alkylene or polymethylene, arylene, aralkylene or cycloalkylene.

Preferred diisocyanates are tetramethylenediisocyanate, hexamethylenediisocyanate, dodecamethylenediisocyanate, eicosan-1,20-diisocyanate, 4-butylhexamethylenediisocyanate, 2,2,4- or 2,4,4-trimethylhexamethylenediisocyanate, $OCN(CH_2)_2O(CH_2)_2NCO$, toluene-2,4-diisocyanate, p-phenylenediisocyanate, xylylenediisocyanate, 3-isocyanatomethyl-3,5,5-trimethylcyclohexylisocyanate, naphthalenediisocyanate, sulfonyldiisocyanate, 3,3'-, 4,4'- and 3,4'-diisocyanates of diphenylmethane, 2,2-diphenylpropane and diphenyl ether, 3,3'-dimethyl-4,4'-diisocyanatodiphenyl, 3,3'-dimethoxy-4,4'-diisocyanatodiphenyl and 4,4'-diisocyanatodiphenylmethane.

The diisocyanates listed above are commercially available or can be prepared from commercially available amines.

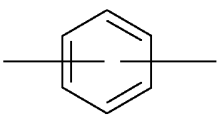
It is also possible to use diisocyanate generators, such as polymeric urethanes, uretdion dimers and higher oligomers, cyanurate polymers, urethanes and polymeric urethanes of cyanurate polymers and thermally dissociable adducts of Schiff's bases.

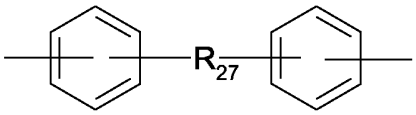
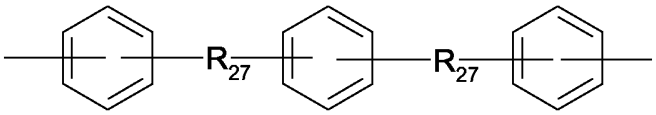
Polyfunctional, in particular difunctional, compounds from the acyllactam class of chain extenders in the sense of this invention are known and are, for example, compounds of the formula G

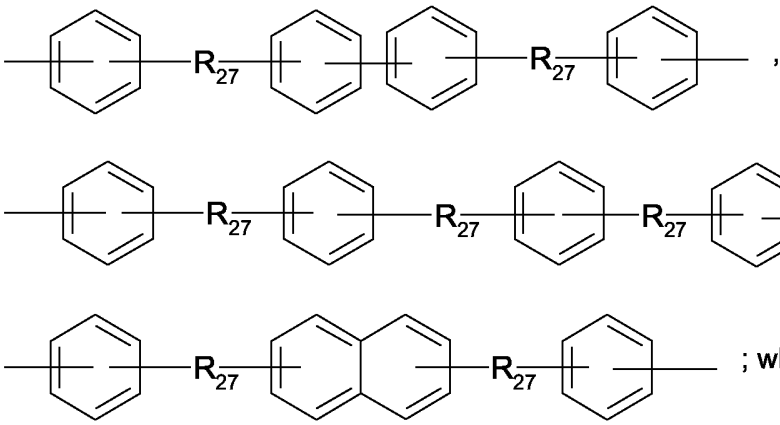


(G)

in which s is a number from 1 to 16, in particular from 5 to 10, and

$R_{26}$ is an aromatic radical, for example one of the formulae:  ,

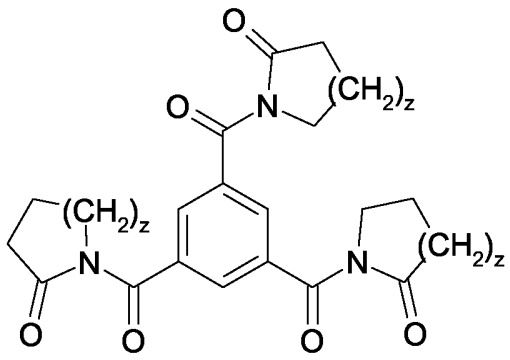
 ,  ,



; where $R_{27}$ is one of the radicals

$-CH_2-$, $-C(O)-$, $-P(O)(C_1-C_{18}alkyl)-$, $-(O)S(O)-$, $-O-$ or $-S-$.

Trifunctional compounds form the acyllactam class in the sense of this inventino are known and are, for example, compounds of the formula Ga

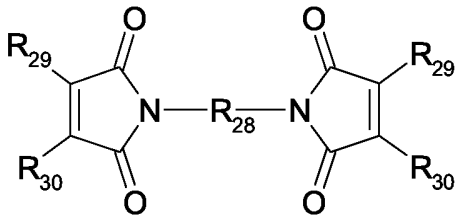


(Ga)

in which z is a number from 1 to 16, in particular from 3 to 9.

Preference is given to trifunctional acyllactams of the formula Ga in which the lactam rings are caprolactam or laurolactam.

Polyfunctional, in particular difunctional, compounds form the maleimide class as chain extenders in the sense of this invention are known and are, for example, compounds of the formula H



(H)

in which

$R_{28}$ is an aliphatic, aromatic, cycloaliphatic or heterocyclic radical; and

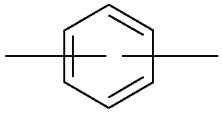
$R_{29}$ and $R_{30}$, independently of one another, are hydrogen, $C_1$-$C_4$alkyl, $C_1$-$C_6$alkoxy, phenyl or phenoxy.

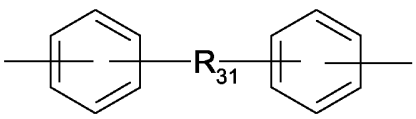
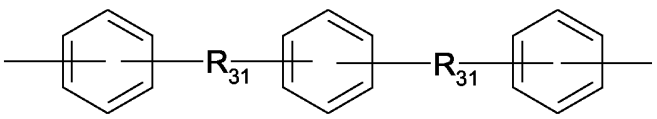
The aliphatic, aromatic, cycloaliphatic or heterocyclic radicals have a maximum of 40 carbon atoms, can be unsubstituted or substituted, and can also be interrupted by –O-, -S-, $-(CH_2)_{1-6}$, -C(O)-, -P(O)($C_1$-$C_{18}$alkyl)- or –(O)S(O)- (sulfone). Examples of possible substituents are $C_1$-$C_{18}$alkyl, $C_1$-$C_{18}$alkoxy, hydroxyl, phenyl and phenoxy.

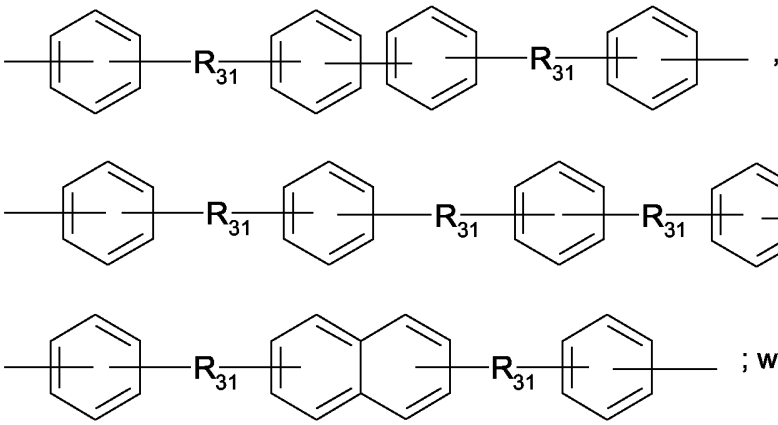
An aromatic radical $R_{28}$ is, for example, a radical having 6-40 carbon atoms, such as phenylene, biphenylene or naphthylene or represents phenylene or biphenylene radicals linked by one of the groups such as –O-, -S-, $-(CH_2)_{1-6}$, -C(O)-, -P(O)($C_1$-$C_{18}$alkyl)- or –(O)S(O)-.

A cycloaliphatic radical $R_{28}$ is, for example, a radical having 5-10 carbon atoms, such as cyclopentylene, cyclohexylene or cyclooctylene.

A heterocyclic radical $R_{28}$ is, for example, an N-containing 5- or 6-membered ring, such as pyridylene, pyridazylene or pyrazolylene.

$R_{28}$ is preferably an aromatic radical of one of the formulae: formulae:  ,

 ,  ,

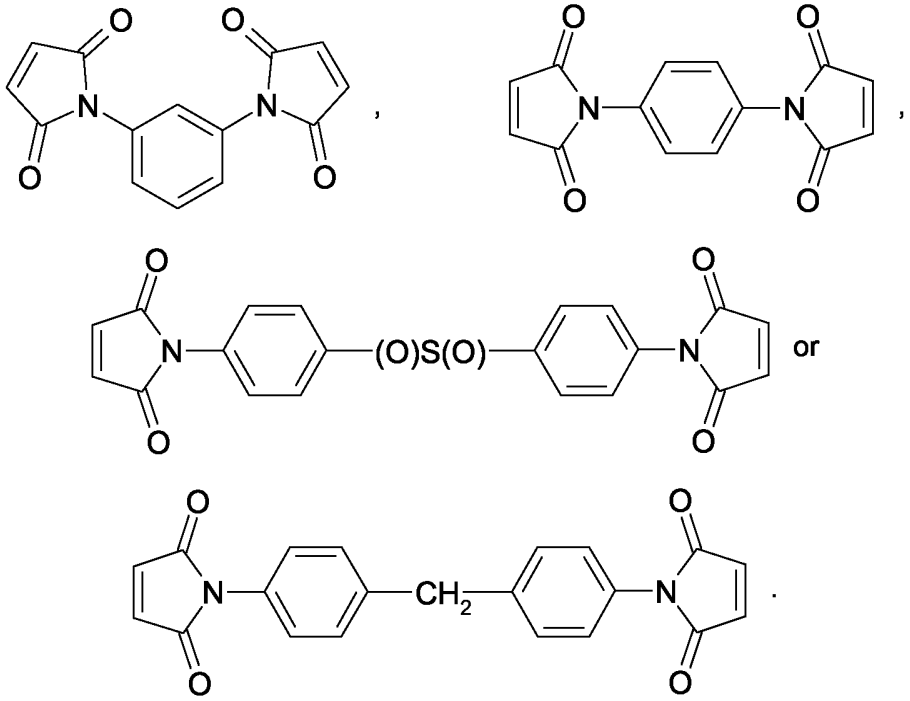


; where $R_{31}$ is one of the radicals

$-CH_2-$, $-C(O)-$, $-P(O)(C_1-C_{18}alkyl)-$, $-(O)S(O)-$, $-O-$ or $-S-$.

$R_{29}$ and $R_{30}$, independently of one another, are preferably hydrogen or $C_1-C_4$alkyl; $R_{29}$ is particularly preferably hydrogen and $R_{30}$ is particularly preferably hydrogen or methyl; and $R_{29}$ and $R_{30}$ are very particularly preferably hydrogen.

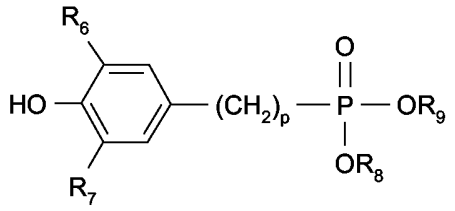
Very particular preference is given to compounds of the formula



Bismaleimides are obtained by reacting diamines with maleic anhydride, and some are commercially available. Further suitable bismaleimides are described in WO-A-93/24488.

Polyfunctional compounds from the alcohol class as chain extenders in the sense of this invention are known and are, for example, pentaerythritol, dipentaerythritol, tripentaerythritol, bistrimethylolpropane, bistrimethylolethane, trismethylolpropane, sorbitol, maltitol, isomaltitol, lactitol, lycasine, mannitol, lactose, leucrose, tris(hydroxyethyl)isocyanurate, palatinitol, tetramethylolcyclohexanol, tetramethylolcycopentanol, tetramethylolcyclopyranol, glycerol, diglycerol, polyglycerol or 1-O-α-D-glycopyranosyl-D-mannitol dihydrate. Particular preference is given to pentaerythritol, dipentaerythritol and tris(hydroxyethyl)isocyanurate.

Preferred hindered phenolic aromatic phosphates are compounds of the formula I



(I)

wherein

$R_6$ is isopropyl, tert-butyl, cyclohexyl or cyclohexyl which is substituted by 1-3 $C_1$-$C_4$alkyl groups,

$R_7$ is hydrogen, $C_1$-$C_4$alkyl, cyclohexyl or cyclohexyl which is substituted by 1-3 $C_1$-$C_4$alkyl groups,

$R_8$ is $C_1$-$C_{20}$alkyl, unsubstituted or $C_1$-$C_4$alkyl-substituted phenyl or naphthyl,

$R_9$ is hydrogen, $C_1$-$C_{20}$alkyl, unsubstituted or $C_1$-$C_4$alkyl-substituted phenyl or naphthyl; or is

$$\frac{M^{r+}}{r} \quad ;$$

$M^{r+}$ is an r-valent metal cation,

p is 1, 2, 3, 4, 5 or 6, and

r is 1, 2 or 3.

$C_1$-$C_{20}$alkyl substituents are radicals such as methyl, ethyl, propyl, butyl, pentyl, hexyl, octyl, stearyl or corresponding branched isomers; $C_2$-$C_4$alkyl radicals are preferred.

$C_1$-$C_4$alkyl-substituted phenyl or naphthyl, which preferably contains 1 to 3, in particular 1 or 2, alkyl groups, is, for example, o-, m- or p-methylphenyl, 2,3-dimethylphenyl, 2,4-dimethylphenyl, 2,5-dimethylphenyl, 2,6-dimethylphenyl, 3,4-dimethylphenyl, 3,5-dimethylphenyl, 2-methyl-6-ethylphenyl, 4-tert-butylphenyl, 2-ethylphenyl, 2,6-diethylphenyl, 1-methylnaphthyl, 2-methylnaphthyl, 4-methylnaphthyl, 1,6-dimethylnaphthyl or 4-tert-butylnaphthyl.

$C_1$-$C_4$alkyl-substituted cyclohexyl, which preferably contains 1 to 3, in particular 1 or 2, branched or unbranched alkyl radicals, is, for example, cyclopentyl, methylcyclopentyl, dimethylcyclopentyl, cyclohexyl, methylcyclohexyl, dimethylcyclohexyl, trimethylcyclohexyl or tert-butylcyclohexyl.

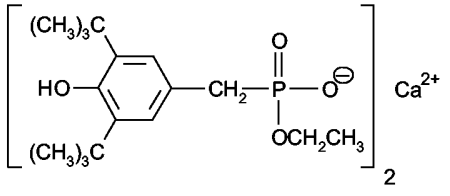
A monovalent, divalent or trivalent metal cation is preferably an alkali metal cation, alkaline earth metal cation, heavy-metal cation or aluminium cation, for example, $Na^+$, $K^+$, $Mg^{++}$, $Ca^{++}$, $Ba^{++}$, $Zn^{++}$ or $Al^{+++}$. Particular preference is given to $Ca^{++}$.

Preferred compounds of the formula I are those which contain at least one tert-butyl group as $R_6$ and $R_7$. Very particular preference is given to compounds in which $R_6$ and $R_7$ are simultaneously tert-butyl.

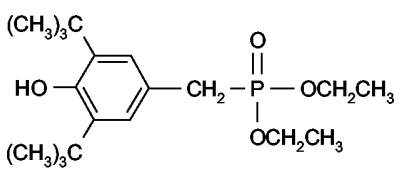
p is preferably 1 or 2, very particularly preferably 1.

Very particularly preferred compounds of the formula I are the compounds of the formual Ia and Ib

(Ia)



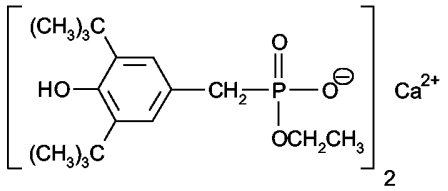
(Ib)

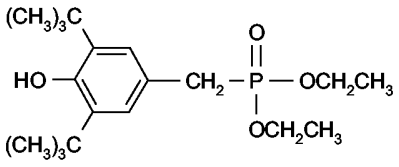


or mixtures thereof.

Of interest is a process for improving the thermal and light stability of polyesters which comprises adding to the polyesters a chain extender selected from the group consisting of anhydrides, alcohols and hindered phenolic aromatic phosphates or mixtures thereof.

Of very special interest is a process for improving the thermal and light stability of polyesters which comprises adding to the polyesters a chain extender selected from the group consisting of pyromellitic dianhydride, pentaerythritol, a compound of the formula Ia and Ib

(Ia) 



(Ib)

or mixtures thereof.

The chain extender is preferably added to the polyester to be stabilized against thermal and light-induced degradation in an amount of from 0.01 to 10 %, in particular from 0.01 to 5 %, for example from 0.01 to 2 %, based on the weight of the polyester.

The novel process for improving the thermal and light stability of polyesters which comprises adding to the polysters a chain extender may comprise further costabilizers (additives) such as, for example, the following:

1. Antioxidants

1.1. Alkylated monophenols, for example 2,6-di-tert-butyl-4-methylphenol, 2-tert-butyl-4,6-dimethylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,6-di-tert-butyl-4-n-butylphenol, 2,6-di-tert-butyl-4-isobutylphenol, 2,6-dicyclopentyl-4-methylphenol, 2-(α-methylcyclohexyl)-4,6-dimethylphenol, 2,6-dioctadecyl-4-methylphenol, 2,4,6-tricyclohexylphenol, 2,6-di-tert-butyl-4-methoxymethylphenol, nonylphenols which are linear or branched in the side chains, for example, 2,6-di-nonyl-4-methylphenol, 2,4-dimethyl-6-(1'-methylundec-1'-yl)phenol, 2,4-

dimethyl-6-(1'-methylheptadec-1'-yl)phenol, 2,4-dimethyl-6-(1'-methyltridec-1'-yl)phenol and mixtures thereof.

1.2. Alkylthiomethylphenols, for example 2,4-dioctylthiomethyl-6-tert-butylphenol, 2,4-dioctylthiomethyl-6-methylphenol, 2,4-dioctylthiomethyl-6-ethylphenol, 2,6-di-dodecylthiomethyl-4-nonylphenol.

1.3. Hydroquinones and alkylated hydroquinones, for example 2,6-di-tert-butyl-4-methoxyphenol, 2,5-di-tert-butylhydroquinone, 2,5-di-tert-amylhydroquinone, 2,6-diphenyl-4-octadecyloxyphenol, 2,6-di-tert-butylhydroquinone, 2,5-di-tert-butyl-4-hydroxyanisole, 3,5-di-tert-butyl-4-hydroxyanisole, 3,5-di-tert-butyl-4-hydroxyphenyl stearate, bis(3,5-di-tert-butyl-4-hydroxyphenyl) adipate.

1.4. Tocopherols, for example α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol and mixtures thereof (vitamin E).

1.5. Hydroxylated thiodiphenyl ethers, for example 2,2'-thiobis(6-tert-butyl-4-methylphenol), 2,2'-thiobis(4-octylphenol), 4,4'-thiobis(6-tert-butyl-3-methylphenol), 4,4'-thiobis(6-tert-butyl-2-methylphenol), 4,4'-thiobis(3,6-di-sec-amylphenol), 4,4'-bis(2,6-dimethyl-4-hydroxyphenyl)disulfide.

1.6. Alkylidenebisphenols, for example 2,2'-methylenebis(6-tert-butyl-4-methylphenol), 2,2'-methylenebis(6-tert-butyl-4-ethylphenol), 2,2'-methylenebis[4-methyl-6-(α-methylcyclohexyl)-phenol], 2,2'-methylenebis(4-methyl-6-cyclohexylphenol), 2,2'-methylenebis(6-nonyl-4-methylphenol), 2,2'-methylenebis(4,6-di-tert-butylphenol), 2,2'-ethylidenebis(4,6-di-tert-butylphenol), 2,2'-ethylidenebis(6-tert-butyl-4-isobutylphenol), 2,2'-methylenebis[6-(α-methylbenzyl)-4-nonylphenol], 2,2'-methylenebis[6-(α,α-dimethylbenzyl)-4-nonylphenol], 4,4'-methylenebis(2,6-di-tert-butylphenol), 4,4'-methylenebis(6-tert-butyl-2-methylphenol), 1,1-bis(5-tert-butyl-4-hydroxy-2-methylphenyl)butane, 2,6-bis(3-tert-butyl-5-methyl-2-hydroxybenzyl)-4-methylphenol, 1,1,3-tris(5-tert-butyl-4-hydroxy-2-methylphenyl)butane, 1,1-bis(5-tert-butyl-4-hydroxy-2-methyl-phenyl)-3-n-dodecylmercaptobutane, ethylene glycol bis[3,3-bis(3'-tert-butyl-4'-hydroxyphenyl)butyrate], bis(3-tert-butyl-4-hydroxy-5-methyl-phenyl)dicyclopentadiene, bis[2-(3'-tert-butyl-2'-hydroxy-5'-methylbenzyl)-6-tert-butyl-4-methylphenyl]terephtha-

late, 1,1-bis-(3,5-dimethyl-2-hydroxyphenyl)butane, 2,2-bis(3,5-di-tert-butyl-4-hydroxyphenyl)propane, 2,2-bis(5-tert-butyl-4-hydroxy2-methylphenyl)-4-n-dodecylmercaptobutane, 1,1,5,5-tetra-(5-tert-butyl-4-hydroxy-2-methylphenyl)pentane.

1.7. O-, N- and S-benzyl compounds, for example 3,5,3',5'-tetra-tert-butyl-4,4'-dihydroxydibenzyl ether, octadecyl-4-hydroxy-3,5-dimethylbenzylmercaptoacetate, tridecyl-4-hydroxy-3,5-di-tert-butylbenzylmercaptoacetate, tris(3,5-di-tert-butyl-4-hydroxybenzyl)amine, bis(4-tert-butyl-3-hydroxy-2,6-dimethylbenzyl)dithioterephthalate, bis(3,5-di-tert-butyl-4-hydroxybenzyl)sulfide, isooctyl-3,5-di-tert-butyl-4-hydroxybenzylmercaptoacetate.

1.8. Hydroxybenzylated malonates, for example dioctadecyl-2,2-bis(3,5-di-tert-butyl-2-hydroxybenzyl)malonate, di-octadecyl-2-(3-tert-butyl-4-hydroxy-5-methylbenzyl)malonate, didodecylmercaptoethyl-2,2-bis (3,5-di-tert-butyl-4-hydroxybenzyl)malonate, bis[4-(1,1,3,3-tetramethylbutyl)phenyl]-2,2-bis(3,5-di-tert-butyl-4-hydroxybenzyl)malonate.

1.9. Aromatic hydroxybenzyl compounds, for example 1,3,5-tris(3,5-di-tert-butyl-4-hydroxybenzyl)-2,4,6-trimethylbenzene, 1,4-bis(3,5-di-tert-butyl-4-hydroxybenzyl)-2,3,5,6-tetramethylbenzene, 2,4,6-tris(3,5-di-tert-butyl-4-hydroxybenzyl)phenol.

1.10. Triazine compounds, for example 2,4-bis(octylmercapto)-6-(3,5-di-tert-butyl-4-hydroxyanilino)-1,3,5-triazine, 2-octylmercapto-4,6-bis(3,5-di-tert-butyl-4-hydroxyanilino)-1,3,5-triazine, 2-octylmercapto-4,6-bis(3,5-di-tert-butyl-4-hydroxyphenoxy)-1,3,5-triazine, 2,4,6-tris-(3,5-di-tert-butyl-4-hydroxyphenoxy)-1,2,3-triazine, 1,3,5-tris(3,5-di-tert-butyl-4-hydroxybenzyl)isocyanurate, 1,3,5-tris(4-tert-butyl-3-hydroxy-2,6-dimethylbenzyl)isocyanurate, 2,4,6-tris(3,5-di-tert-butyl-4-hydroxyphenylethyl)-1,3,5-triazine, 1,3,5-tris(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)-hexahydro-1,3,5-triazine, 1,3,5-tris(3,5-dicyclohexyl-4-hydroxybenzyl)isocyanurate.

1.11. Acylaminophenols, for example 4-hydroxylauranilide, 4-hydroxystearanilide, octyl N-(3,5-di-tert-butyl-4-hydroxyphenyl)carbamate.

1.12. Esters of β-(3,5-di-tert-butyl-4-hydroxyphenyl)propionic acid with mono- or polyhydric alcohols, e.g. with methanol, ethanol, n-octanol, i-octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethy-

lene glycol, triethylene glycol, pentaerythritol, tris(hydroxyethyl)isocyanurate, N,N'-bis(hydroxyethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane.

1.13. Esters of β-(5-tert-butyl-4-hydroxy-3-methylphenyl)propionic acid with mono- or polyhydric alcohols, e.g. with methanol, ethanol, n-octanol, i-octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, pentaerythritol, tris(hydroxyethyl)isocyanurate, N,N'-bis(hydroxyethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane; 3,9-bis[2-{3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propionyloxy}-1,1-dimethylethyl]-2,4,8,10-tetraoxaspiro[5.5]undecane.

1.14. Esters of β-(3,5-dicyclohexyl-4-hydroxyphenyl)propionic acid with mono- or polyhydric alcohols, e.g. with methanol, ethanol, octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, pentaerythritol, tris(hydroxyethyl)isocyanurate, N,N'-bis(hydroxyethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane.

1.15. Esters of 3,5-di-tert-butyl-4-hydroxyphenyl acetic acid with mono- or polyhydric alcohols, e.g. with methanol, ethanol, octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, pentaerythritol, tris(hydroxyethyl)isocyanurate, N,N'-bis(hydroxyethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane.

1.16. Amides of β-(3,5-di-tert-butyl-4-hydroxyphenyl)propionic acid e.g. N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)hexamethylenediamide, N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)trimethylenediamide, N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)hydrazide, N,N'-bis[2-(3-[3,5-di-tert-butyl-4-hydroxyphenyl]propionyloxy)ethyl]oxamide (Naugard®XL-1, supplied by Uniroyal).

1.17. Ascorbic acid (vitamin C)

1.18. Aminic antioxidants, for example N,N'-di-isopropyl-p-phenylenediamine, N,N'-di-sec-butyl-p-phenylenediamine, N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine, N,N'-bis(1-ethyl-3-methylpentyl)-p-phenylenediamine, N,N'-bis(1-methylheptyl)-p-phenylenediamine, N,N'-dicyclohexyl-p-phenylenediamine, N,N'-diphenyl-p-phenylenediamine, N,N'-bis(2-naphthyl)-p-phenylenediamine, N-isopropyl-N'-phenyl-p-phenylenediamine, N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine, N-(1-methylheptyl)-N'-phenyl-p-phenylenediamine, N-cyclohexyl-N'-phenyl-p-phenylenediamine, 4-(p-toluenesulfamoyl)diphenylamine, N,N'-dimethyl-N,N'-di-sec-butyl-p-phenylenediamine, diphenylamine, N-allyldiphenylamine, 4-isopropoxydiphenylamine, N-phenyl-1-naphthylamine, N-(4-tert-octylphenyl)-1-naphthylamine, N-phenyl-2-naphthylamine, octylated diphenylamine, for example p,p'-di-tert-octyldiphenylamine, 4-n-butylaminophenol, 4-butyrylaminophenol, 4-nonanoylaminophenol, 4-dodecanoylaminophenol, 4-octadecanoylaminophenol, bis(4-methoxyphenyl)amine, 2,6-di-tert-butyl-4-dimethylamino-methylphenol, 2,4'-diaminodiphenylmethane, 4,4'-diaminodiphenylmethane, N,N,N',N'-tetra-methyl-4,4'-diaminodiphenylmethane, 1,2-bis[(2-methylphenyl)amino]ethane, 1,2-bis(phenylamino)propane, (o-tolyl)biguanide, bis[4-(1',3'-dimethylbutyl)phenyl]amine, tert-octylated N-phenyl-1-naphthylamine, a mixture of mono- and dialkylated tert-butyl/tert-octyldiphenylamines, a mixture of mono- and dialkylated nonyldiphenylamines, a mixture of mono- and dialkylated dodecyldiphenylamines, a mixture of mono- and dialkylated isopropyl/isohexyldiphenylamines, a mixture of mono- and dialkylated tert-butyldiphenylamines, 2,3-dihydro-3,3-dimethyl-4H-1,4-benzothiazine, phenothiazine, a mixture of mono- and dialkylated tert-butyl/tert-octylphenothiazines, a mixture of mono- and dialkylated tert-octyl-phenothiazines, N-allylphenothiazine, N,N,N',N'-tetraphenyl-1,4-diaminobut-2-ene.

2. UV absorbers and light stabilizers

2.1. 2-(2'-Hydroxyphenyl)benzotriazoles, for example 2-(2'-hydroxy-5'-methylphenyl)-benzotriazole, 2-(3',5'-di-tert-butyl-2'-hydroxyphenyl)benzotriazole, 2-(5'-tert-butyl-2'-hydroxyphenyl)benzotriazole, 2-(2'-hydroxy-5'-(1,1,3,3-tetramethylbutyl)phenyl)benzotriazole, 2-(3',5'-di-tert-butyl-2'-hydroxyphenyl)-5-chloro-benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-methylphenyl)-5-chloro-benzotriazole, 2-(3'-sec-butyl-5'-tert-butyl-2'-hydroxyphenyl)benzotriazole, 2-

(2'-hydroxy-4'-octyloxyphenyl)benzotriazole, 2-(3',5'-di-tert-amyl-2'-hydroxyphenyl)benzotriazole, 2-(3',5'-bis-(α,α-dimethylbenzyl)-2'-hydroxyphenyl)benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-octyloxycarbonylethyl)phenyl)-5-chloro-benzotriazole, 2-(3'-tert-butyl-5'-[2-(2-ethylhexyloxy)-carbonylethyl]-2'-hydroxyphenyl)-5-chloro-benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-methoxycarbonylethyl)phenyl)-5-chloro-benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-methoxycarbonylethyl)phenyl)benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-octyloxycarbonylethyl)phenyl)benzotriazole, 2-(3'-tert-butyl-5'-[2-(2-ethylhexyloxy)carbonylethyl]-2'-hydroxyphenyl)benzotriazole, 2-(3'-dodecyl-2'-hydroxy-5'-methylphenyl)benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-isooctyloxycarbonylethyl)phenylbenzotriazole, 2,2'-methylene-bis[4-(1,1,3,3-tetramethylbutyl)-6-benzotriazole-2-ylphenol]; the transesterification product of 2-[3'-tert-butyl-5'-(2-methoxycarbonylethyl)-2'-hydroxyphenyl]-2H-benzotriazole with polyethylene glycol 300; $\left[R-CH_2CH_2-COO-CH_2CH_2\right]_2$, where R = 3'-tert-butyl-4'-hydroxy-5'-2H-benzotriazol-2-ylphenyl, 2-[2'-hydroxy-3'-(α,α-dimethylbenzyl)-5'-(1,1,3,3-tetramethylbutyl)-phenyl]benzotriazole; 2-[2'-hydroxy-3'-(1,1,3,3-tetramethylbutyl)-5'-(α,α-dimethylbenzyl)-phenyl]benzotriazole.

2.2. 2-Hydroxybenzophenones, for example the 4-hydroxy, 4-methoxy, 4-octyloxy, 4-decyloxy, 4-dodecyloxy, 4-benzyloxy, 4,2',4'-trihydroxy and 2'-hydroxy-4,4'-dimethoxy derivatives.

2.3. Esters of substituted and unsubstituted benzoic acids, for example 4-tert-butyl-phenyl salicylate, phenyl salicylate, octylphenyl salicylate, dibenzoyl resorcinol, bis(4-tert-butylbenzoyl)resorcinol, benzoyl resorcinol, 2,4-di-tert-butylphenyl 3,5-di-tert-butyl-4-hydroxybenzoate, hexadecyl 3,5-di-tert-butyl-4-hydroxybenzoate, octadecyl 3,5-di-tert-butyl-4-hydroxybenzoate, 2-methyl-4,6-di-tert-butylphenyl 3,5-di-tert-butyl-4-hydroxybenzoate.

2.4. Acrylates, for example ethyl α-cyano-β,β-diphenylacrylate, isooctyl α-cyano-β,β-diphenylacrylate, methyl α-carbomethoxycinnamate, methyl α-cyano-β-methyl-p-methoxycinnamate, butyl α-cyano-β-methyl-p-methoxy-cinnamate, methyl α-carbomethoxy-p-methoxycinnamate, N-(β-carbomethoxy-β-cyanovinyl)-2-methylindoline, neopentyl tetra(α-cyano-β,β-diphenylacrylate.

2.5. Nickel compounds, for example nickel complexes of 2,2'-thio-bis[4-(1,1,3,3-tetramethylbutyl)phenol], such as the 1:1 or 1:2 complex, with or without additional ligands such as n-butylamine, triethanolamine or N-cyclohexyldiethanolamine, nickel dibutyldithiocarbamate, nickel salts of the monoalkyl esters, e.g. the methyl or ethyl ester, of 4-hydroxy-3,5-di-tert-butylbenzylphosphonic acid, nickel complexes of ketoximes, e.g. of 2-hydroxy-4-methylphenylundecylketoxime, nickel complexes of 1-phenyl-4-lauroyl-5-hydroxypyrazole, with or without additional ligands.

2.6. Sterically hindered amines, for example bis(2,2,6,6-tetramethyl-4-piperidyl)sebacate, bis(2,2,6,6-tetramethyl-4-piperidyl)succinate, bis(1,2,2,6,6-pentamethyl-4-piperidyl)sebacate, bis(1-octyloxy-2,2,6,6-tetramethyl-4-piperidyl)sebacate, bis(1,2,2,6,6-pentamethyl-4-piperidyl) n-butyl-3,5-di-tert-butyl-4-hydroxybenzylmalonate, the condensate of 1-(2-hydroxyethyl)-2,2,6,6-tetramethyl-4-hydroxypiperidine and succinic acid, linear or cyclic condensates of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine and 4-tert-octylamino-2,6-dichloro-1,3,5-triazine, tris(2,2,6,6-tetramethyl-4-piperidyl)nitrilotriacetate, tetrakis(2,2,6,6-tetramethyl-4-piperidyl)-1,2,3,4-butanetetracarboxylate, 1,1'-(1,2-ethanediyl)-bis(3,3,5,5-tetramethylpiperazinone), 4-benzoyl-2,2,6,6-tetramethylpiperidine, 4-stearyloxy-2,2,6,6-tetramethylpiperidine, bis(1,2,2,6,6-pentamethylpiperidyl)-2-n-butyl-2-(2-hydroxy-3,5-di-tert-butylbenzyl)malonate, 3-n-octyl-7,7,9,9-tetramethyl-1,3,8-triazaspiro[4.5]decane-2,4-dione, bis(1-octyloxy-2,2,6,6-tetramethylpiperidyl)sebacate, bis(1-octyloxy-2,2,6,6-tetramethylpiperidyl)succinate, linear or cyclic condensates of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine and 4-morpholino-2,6-dichloro-1,3,5-triazine, the condensate of 2-chloro-4,6-bis(4-n-butylamino-2,2,6,6-tetramethylpiperidyl)-1,3,5-triazine and 1,2-bis(3-aminopropylamino)ethane, the condensate of 2-chloro-4,6-di-(4-n-butylamino-1,2,2,6,6-pentamethylpiperidyl)-1,3,5-triazine and 1,2-bis(3-aminopropylamino)ethane, 8-acetyl-3-dodecyl-7,7,9,9-tetramethyl-1,3,8-triazaspiro[4.5]decane-2,4-dione, 3-dodecyl-1-(2,2,6,6-tetramethyl-4-piperidyl)pyrrolidine-2,5-dione, 3-dodecyl-1-(1,2,2,6,6-pentamethyl-4-piperidyl)pyrrolidine-2,5-dione, a mixture of 4-hexadecyloxy- and 4-stearyloxy-2,2,6,6-tetramethylpiperidine, a condensate of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine and 4-cyclohexylamino-2,6-dichloro-1,3,5-triazine, a condensate of 1,2-bis(3-aminopropylamino)ethane and 2,4,6-trichloro-1,3,5-triazine as well as 4-butylamino-2,2,6,6-tetramethylpiperidine (CAS Reg. No. [136504-96-6]); a condensate of 1,6-hexanediamine and 2,4,6-trichloro-1,3,5-triazine as well as N,N-dibutylamine and 4-butylamino-2,2,6,6-tetramethylpiperidine (CAS Reg. No.

[192268-64-7]); N-(2,2,6,6-tetramethyl-4-piperidyl)-n-dodecylsuccinimide, N-(1,2,2,6,6-pentamethyl-4-piperidyl)-n-dodecylsuccinimide, 2-undecyl-7,7,9,9-tetramethyl-1-oxa-3,8-diaza-4-oxo-spiro[4,5]decane, a reaction product of 7,7,9,9-tetramethyl-2-cycloundecyl-1-oxa-3,8-diaza-4-oxospiro-[4,5]decane and epichlorohydrin, 1,1-bis(1,2,2,6,6-pentamethyl-4-piperidyloxycarbonyl)-2-(4-methoxyphenyl)ethene, N,N'-bis-formyl-N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine, a diester of 4-methoxymethylenemalonic acid with 1,2,2,6,6-pentamethyl-4-hydroxypiperidine, poly[methylpropyl-3-oxy-4-(2,2,6,6-tetramethyl-4-piperidyl)]siloxane, a reaction product of maleic acid anhydride-α-olefin copolymer with 2,2,6,6-tetramethyl-4-aminopiperidine or 1,2,2,6,6-pentamethyl-4-aminopiperidine, 2,4-bis[N-(1-cyclohexyloxy-2,2,6,6-tetramethylpiperidine-4-yl)-N-butylamino]-6-(2-hydroxyethyl)amino-1,3,5-triazine, 1-(2-hydroxy-2-methylpropoxy)-4-octadecanoyloxy-2,2,6,6-tetramethylpiperidine, 5-(2-ethylhexanoyl)oxymethyl-3,3,5-trimethyl-2-morpholinone, Sanduvor (Clariant; CAS Reg. No. 106917-31-1], 5-(2-ethylhexanoyl)oxymethyl-3,3,5-trimethyl-2-morpholinone, the reaction product of 2,4-bis[(1-cyclohexyloxy-2,2,6,6-piperidine-4-yl)butylamino]-6-chloro-s-triazine with N,N'-bis(3-aminopropyl)ethylenediamine), 1,3,5-tris(N-cyclohexyl-N-(2,2,6,6-tetramethylpiperazine-3-one-4-yl)amino)-s-triazine, 1,3,5-tris(N-cyclohexyl-N-(1,2,2,6,6-pentamethylpiperazine-3-one-4-yl)amino)-s-triazine.

2.7. Oxamides, for example 4,4'-dioctyloxyoxanilide, 2,2'-diethoxyoxanilide, 2,2'-dioctyloxy-5,5'-di-tert-butoxanilide, 2,2'-didodecyloxy-5,5'-di-tert-butoxanilide, 2-ethoxy-2'-ethyloxanilide, N,N'-bis(3-dimethylaminopropyl)oxamide, 2-ethoxy-5-tert-butyl-2'-ethoxanilide and its mixture with 2-ethoxy-2'-ethyl-5,4'-di-tert-butoxanilide, mixtures of o- and p-methoxy-disubstituted oxanilides and mixtures of o- and p-ethoxy-disubstituted oxanilides.

2.8. 2-(2-Hydroxyphenyl)-1,3,5-triazines, for example 2,4,6-tris(2-hydroxy-4-octyloxyphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-octyloxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2,4-dihydroxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2,4-bis(2-hydroxy-4-propyloxyphenyl)-6-(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-octyloxyphenyl)-4,6-bis(4-methylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-dodecyloxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-tridecyloxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-[2-hydroxy-4-(2-hydroxy-3-butyloxypropoxy)phenyl]-4,6-bis(2,4-dimethyl)-1,3,5-triazine, 2-[2-hydroxy-4-(2-hydroxy-3-octyloxypropyloxy)phenyl]-4,6-bis(2,4-dimethyl)-1,3,5-triazine, 2-[4-(dodecyloxy/tridecyloxy-2-hydroxypropoxy)-2-hydroxyphenyl]-4,6-bis(2,4-dimethylphenyl)-

1,3,5-triazine, 2-[2-hydroxy-4-(2-hydroxy-3-dodecyloxypropoxy)phenyl]-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-hexyloxy)phenyl-4,6-diphenyl-1,3,5-triazine, 2-(2-hydroxy-4-methoxyphenyl)-4,6-diphenyl-1,3,5-triazine, 2,4,6-tris[2-hydroxy-4-(3-butoxy-2-hydroxypropoxy)phenyl]-1,3,5-triazine, 2-(2-hydroxyphenyl)-4-(4-methoxyphenyl)-6-phenyl-1,3,5-triazine, 2-{2-hydroxy-4-[3-(2-ethylhexyl-1-oxy)-2-hydroxypropyloxy]phenyl}-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2,4-bis(4-[2-ethylhexyloxy]-2-hydroxyphenyl)-6-(4-methoxyphenyl)-1,3,5-triazine.

3. Metal deactivators, for example N,N'-diphenyloxamide, N-salicylal-N'-salicyloyl hydrazine, N,N'-bis(salicyloyl)hydrazine, N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)hydrazine, 3-salicyloylamino-1,2,4-triazole, bis(benzylidene)oxalyl dihydrazide, oxanilide, isophthaloyl dihydrazide, sebacoyl bisphenylhydrazide, N,N'-diacetyladipoyl dihydrazide, N,N'-bis(salicyloyl)oxalyl dihydrazide, N,N'-bis(salicyloyl)thiopropionyl dihydrazide.

4. Phosphites and phosphonites, for example triphenyl phosphite, diphenylalkyl phosphites, phenyldialkyl phosphites, tris(nonylphenyl) phosphite, trilauryl phosphite, trioctadecyl phosphite, distearylpentaerythritol diphosphite, tris(2,4-di-tert-butylphenyl) phosphite, diisodecyl pentaerythritol diphosphite, bis(2,4-di-tert-butylphenyl)pentaerythritol diphosphite, bis(2,4-dicumylphenyl)pentaerythritol diphosphite, bis(2,6-di-tert-butyl-4-methylphenyl)pentaerythritol diphosphite, diisodecyloxypentaerythritol diphosphite, bis(2,4-di-tert-butyl-6-methylphenyl)-pentaerythritol diphosphite, bis(2,4,6-tris(tert-butylphenyl)pentaerythritol diphosphite, tristearyl sorbitol triphosphite, tetrakis(2,4-di-tert-butylphenyl) 4,4'-biphenylene diphosphonite, 6-isooctyloxy-2,4,8,10-tetra-tert-butyl-12H-dibenz[d,g]-1,3,2-dioxaphosphocin, bis(2,4-di-tert-butyl-6-methylphenyl)methyl phosphite, bis(2,4-di-tert-butyl-6-methylphenyl)ethyl phosphite, 6-fluoro-2,4,8,10-tetra-tert-butyl-12-methyl-dibenz[d,g]-1,3,2-dioxaphosphocin, 2,2',2''-nitrilo-[triethyltris(3,3',5,5'-tetra-tert-butyl-1,1'-biphenyl-2,2'-diyl)phosphite], 2-ethylhexyl(3,3',5,5'-tetra-tert-butyl-1,1'-biphenyl-2,2'-diyl)phosphite, 5-butyl-5-ethyl-2-(2,4,6-tri-tert-butylphenoxy)-1,3,2-dioxaphosphirane.

5. Hydroxylamines, for example N,N-dibenzylhydroxylamine, N,N-diethylhydroxylamine, N,N-dioctylhydroxylamine, N,N-dilaurylhydroxylamine, N,N-ditetradecylhydroxylamine, N,N-dihexadecylhydroxylamine, N,N-dioctadecylhydroxylamine, N-hexadecyl-N-octadecylhydroxylamine, N-heptadecyl-N-octadecylhydroxylamine, N,N-dialkylhydroxylamine derived from hydrogenated tallow amine.

6. Nitrones, for example, N-benzyl-alpha-phenylnitrone, N-ethyl-alpha-methylnitrone, N-octyl-alpha-heptylnitrone, N-lauryl-alpha-undecylnitrone, N-tetradecyl-alpha-tridecylnnitrone, N-hexadecyl-alpha-pentadecylnitrone, N-octadecyl-alpha-heptadecylnitrone, N-hexadecyl-alpha-heptadecylnitrone, N-ocatadecyl-alpha-pentadecylnitrone, N-heptadecyl-alpha-heptadecylnitrone, N-octadecyl-alpha-hexadecylnitrone, nitrone derived from N,N-dialkylhydroxylamine derived from hydrogenated tallow amine.

7. Thiosynergists, for example dilauryl thiodipropionate, dimistryl thiodipropionate, distearyl thiodipropionate or distearyl disulfide.

8. Peroxide scavengers, for example esters of β-thiodipropionic acid, for example the lauryl, stearyl, myristyl or tridecyl esters, mercaptobenzimidazole or the zinc salt of 2-mercaptobenzimidazole, zinc dibutyldithiocarbamate, dioctadecyl disulfide, pentaerythritol tetrakis(β-dodecylmercapto)propionate.

9. Polyamide stabilizers, for example copper salts in combination with iodides and/or phosphorus compounds and salts of divalent manganese.

10. Basic co-stabilizers, for example melamine, polyvinylpyrrolidone, dicyandiamide, triallyl cyanurate, urea derivatives, hydrazine derivatives, amines, polyamides, polyurethanes, alkali metal salts and alkaline earth metal salts of higher fatty acids, for example calcium stearate, zinc stearate, magnesium behenate, magnesium stearate, sodium ricinoleate and potassium palmitate, antimony pyrocatecholate or zinc pyrocatecholate.

11. Nucleating agents, for example inorganic substances, such as talcum, metal oxides, such as titanium dioxide or magnesium oxide, phosphates, carbonates or sulfates of, preferably, alkaline earth metals; organic compounds, such as mono- or polycarboxylic acids and the salts thereof, e.g. 4-tert-butylbenzoic acid, adipic acid, diphenylacetic acid, sodium succinate or sodium benzoate; polymeric compounds, such as ionic copolymers (ionomers). Especially preferred are 1,3:2,4-bis(3',4'-dimethylbenzylidene)sorbitol, 1,3:2,4-di(paramethyldibenzylidene)sorbitol, and 1,3:2,4-di(benzylidene)sorbitol.

12. Fillers and reinforcing agents, for example calcium carbonate, silicates, glass fibres, glass beads, asbestos, talc, kaolin, mica, barium sulfate, metal oxides and hydroxides, carbon black, graphite, wood flour and flours or fibers of other natural products, synthetic fibers.

13. Other additives, for example plasticisers, lubricants, emulsifiers, pigments, rheology additives, catalysts, flow-control agents, optical brighteners, flameproofing agents, antistatic agents and blowing agents.

14. Benzofuranones and indolinones, for example those disclosed in U.S. 4,325,863; U.S. 4,338,244; U.S. 5,175,312; U.S. 5,216,052; U.S. 5,252,643; DE-A-4316611;

DE-A-4316622; DE-A-4316876; EP-A-0589839, EP-A-0591102; EP-A-1291384 or 3-[4-(2-acetoxyethoxy)phenyl]-5,7-di-tert-butylbenzofuran-2-one, 5,7-di-tert-butyl-3-[4-(2-stearoyloxyethoxy)phenyl]benzofuran-2-one, 3,3'-bis[5,7-di-tert-butyl-3-(4-[2-hydroxyethoxy]phenyl)benzofuran-2-one], 5,7-di-tert-butyl-3-(4-ethoxyphenyl)benzofuran-2-one, 3-(4-acetoxy-3,5-dimethylphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(3,5-dimethyl-4-pivaloyloxyphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(3,4-dimethylphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(2,3-dimethylphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(2-acetyl-5-isooctylphenyl)-5-isooctylbenzofuran-2-one.

The costabilizers are added, for example, in concentrations of 0.01 to 10%, relative to the total weight of the polyester to be stabilized.

Preferred further additives are aldehyde scavengers. These are for example polyvinyl alcohols, (meth)acrylamides homo- or copolymers, hydroxylamines, nitrones, amine oxides, poly[glyceryl(meth)acrylates], aminic antioxidants, benzofuran-2-ones, phosphites, phosphonites or phosphonates or mixtures thereof. Aldehydes of special interest are formaldehyde, acetaldehyde or propionaldehyde.

A preferred subject of the present invention is also the use of a chain extenders as outlined above for improving the thermal and light stability of polyesters.

Polyesters with such improved properties are especially useful for the preparation of articles such as for example fibers, films, pipes, profiles, bottles, tank or containers.

A preferred embodiment of the present invention relates therefore also to an article containing a polyester with improved thermal and light stability which comprises a chain extender.

The examples which follow illustrate the invention in more detail. Parts and percentages are by weight.

Example 1: Stabilization of polyester fibers.

In order to evaluate the light and thermal performance of PET yarns containing a chain extender, the following procedure is used:

A PET powder [RT 21 (Kosa)] is dried in a vacuum oven for eight hours at 120°C. Appropriate amounts of the chain extenders are added to the dried PET powder. The formulations are mixed in a turbo mixer and extruded in a twin-screw extruder (Berstorff ZE25 33D). The polymer string is then granulated. The obtained granulates are dried for one hour at 190°C followed by one hour at 100°C in a vacuum drying oven. The granules are then processed through a fiber extruder Spinboy II to produce yarns of 40 filaments of 4.5 Denier each. The fibers are then further tested in a Weather-O-Meter (WOM) [light stability] according to ISO 4892-2. The yarns were separately tested for their heat stability in an air-circulating oven at 120°C (heat stability). The results are summarized in Table 1.

Table 1:

| Examples | Chain extender | Light Stability<br>Time (hours) to 50 % Retained Tensile Strength upon Weathering | Heat Stability<br>% Retained Tensile Strength after 200 days at 120°C |
|---|---|---|---|
| 1a[a)] | none | 50 | 71 |
| 1b[b)] | 0.25 % Irgamod RA 20[c)] | 125 | 80 |
| 1c[b)] | 0.50 % Irgamod RA 20[c)] | 165 | 80 |
| 1d[b)] | 1.00 % Irgamod RA 20[c)] | 205 | 91 |

a) Comparison example.

b) Example according to the invention.

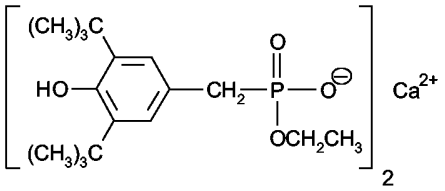
c) Irgamod RA 20 (RTM) (Ciba Specialty Chemicals Inc.) is a mixture (by weight) of

75.5 % of polyester (Tarilin from Nan Ya)

20.5 % of pyromellitic dianhydride

2 % of pentaerythritol and

2 % of a compound of the formula Ia (Irgamod 195, Ciba Specialty Chemicals Inc.)




(Ia)

What is claimed is:

**1.** A process for improving the thermal and light stability of polyesters which comprises adding to the polyesters a chain extender.

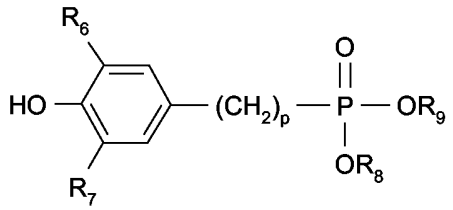
**2.** A process according to claim 1, wherein the polyester is a polyester fiber.

**3.** A process according to claim 1, wherein the polyester is polyethylene terephthalate or polyethylene naphthalate.

**4.** A process according to claim 1, wherein the chain extender is a compound selected from the group consisting of anhydrides, epoxides, oxazolines, oxazolones, oxazines, isocyanates, acyllactams, maleimides, alcohols and hindered phenolic aromatic phosphates or mixtures thereof.

**5.** A process according to claim 1, wherein the chain extender is a compound selected from the group consisting of anhydrides, alcohols and hindered phenolic aromatic phosphates or mixtures thereof.

**6.** A process according to claim 5, wherein the hindered phenolic aromatic phosphate is a compound of the formula I




(I)

wherein

$R_6$ is isopropyl, tert-butyl, cyclohexyl or cyclohexyl which is substituted by 1-3 $C_1$-$C_4$alkyl groups,

$R_7$ is hydrogen, $C_1$-$C_4$alkyl, cyclohexyl or cyclohexyl which is substituted by 1-3 $C_1$-$C_4$alkyl groups,

$R_8$ is $C_1$-$C_{20}$alkyl, unsubstituted or $C_1$-$C_4$alkyl-substituted phenyl or naphthyl,

$R_9$ is hydrogen, $C_1$-$C_{20}$alkyl, unsubstituted or $C_1$-$C_4$alkyl-substituted phenyl or naphthyl; or is

$$\frac{M^{r+}}{r} \quad ;$$

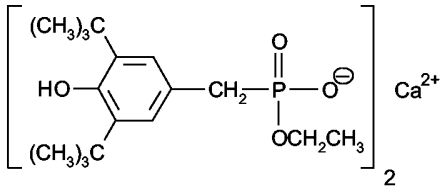
$M^{r+}$ is an r-valent metal cation,

p is 1, 2, 3, 4, 5 or 6, and

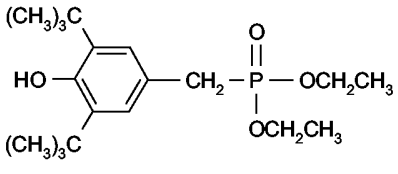
r is 1, 2 or 3.

**7.** A process according to claim 1, wherein the chain extender is a compound selected from the group consisting of pyromellitic dianhydride, pentaerythritol, a compound of the formula Ia and Ib

(Ia)



(Ib)



or mixtures thereof.

**8.** A process according to claim 1, wherein the chain extender is present in an amount of 0.01 to 10 % based on the weight of the polyester.

**9.** A process according to claim 1, comprising in addition, besides the chain extender, further additives.

**10.** A process according to claim 9, comprising as further additives aldehyde scavengers.

**11.** An article containing a polyester with improved thermal and light stability which comprises a chain extender.

**12.** Use of a chain extender for improving the thermal and light stability of polyesters.

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/062180

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08K5/5333 C08K5/1539 C08K5/053 C08K5/00 C08G63/20
C08G63/91 C08J3/22 D01F1/10 D01F6/62

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08K C08G C08J D01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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| X | US 5 670 584 A (AL GHATTA ET AL)<br>23 September 1997 (1997-09-23)<br>column 2, lines 38-51; claims 1,2<br>column 3, lines 15-27; example 1 | 1-12 |
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 21 July 2006 | 28/07/2006 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL – 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Dury, O |

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# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/062180

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| X | US 6 469 078 B1 (SIMON DIRK ET AL)<br>22 October 2002 (2002-10-22)<br>cited in the application<br>column 1, lines 1-8,45-61; claims 1-14<br>column 7, line 20 - column 18, line 64<br>tables 1,2 | 1-12 |
| X | US 5 693 681 A (PFAENDNER ET AL)<br>2 December 1997 (1997-12-02)<br>column 1, lines 1-65; claims 1-11<br>column 4, line 66 - column 7, line 56<br>column 16, lines 55-61<br>examples 1-18; tables 1-4 | 1-12 |

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Information on patent family members

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