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(54) Title: POLYCARBONATE COMPOSITION

(57) Abstract: The present invention relates to a polycarbonate composition comprising the following components, relative to the total weight of the composition: A) 10 - 60 wt. % of a copolycarbonate, B) 25 - 75 wt. % of a homopolycarbonate, C) 3 - 13 wt. % of a phosphorous flame retardant, D) 4 - 9 wt. % of an impact modifier, and E) 2- 14 wt. % of a polyester poly (1,4- butylene terephthalate), poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate), poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester, and a combination thereof. The present invention also relates to a shaped article made from the composition. The polycarbonate composition according to the present invention has a good combination of comparative tracking index, high heat resistance, good impact resistance and flame retardancy.

POLYCARBONATE COMPOSITION

TECHNICAL FIELD

The present invention relates to a polycarbonate (PC) composition. In particular, the present invention relates to a polycarbonate composition with high level of comparative tracking index, good flame retardancy, high heat resistance, and good impact resistance, and a shaped article made from the same.

BACKGROUND ART

Polycarbonate is widely used for a variety of applications, such as automotive, electric and electronic fields due to excellent optical, mechanical and heat resistant properties as well as excellent thermal processing ability thereof.

Copolycarbonates, as special types of polycarbonates, are widely used in electrical and electronic sectors, as housing material of lights, and in applications where particular thermal and mechanical properties are required, for example blow dryers, applications in the automotive sector, plastic covers, diffuser screens or waveguide elements and lamp covers or lamp bezels.

It is known that the heat distortion resistance of polycarbonate can be improved by introducing a specific building block based on 1,1-bis(4-hydroxyphenyl)-3,3,5-trimethylcyclohexane (Bisphenol TMC) into polycarbonate backbone. The copolycarbonate obtained thereby is also-called high-Tg polycarbonate. Furthermore, the flowability of such kind of copolycarbonates is not high due to its relatively higher glass transition temperature (Tg).

Recently, there is a trend to miniaturize electronic and electrical devices in the field of electric and electronic applications. This prompted the adoption of more complicated and compacted design of electrical devices including plastic housings or parts. Therefore, safety-related properties of plastic materials, such as comparative tracking index (CTI) and flame retardancy, were required in the field of electronics and electrical applications.

For instance, a high level of flame retardancy (e.g., V0 rating at 1.5mm as determined according to UL94-2015) and high CTI rank (e.g., CTI= 600 V as determined according to IEC60112:2011) are required for plastic materials. However, it has been well known that the comparative tracking index for standard polycarbonate resin is only around 250 V or even below.

Furthermore, introducing flame retardant agents into standard bisphenol A based polycarbonate was commonly believed to be harmful to the CTI performance of finished blends, the more the flame retardant, the lower the CTI will be, more details can be found in S. Sullalti et al., “Effect of phosphorus based flame retardants on UL94 and Comparative Tracking Index properties of poly(butylene terephthalate)”, *Polymer Degradation and Stability, 2012*.

In some applications such as electrical vehicle battery package, in addition to high comparative tracking index and good flame retardancy, good heat resistance and good impact resistance are also desired.

US4900784A discloses a polymer mixture which consists of a polybutylene terephthalate, a brominated polystyrene, an aromatic polycarbonate and an agent to improve the impact strength, which shows a combination of good flame-retardancy and a high level of comparative tracking index.

There are no polymer compositions with high level of comparative tracking index, good flame retardancy, high heat resistance, and good impact resistance reported.

Thus, there is still a need for a polycarbonate composition with a good combination of comparative tracking index, flame retardancy, heat resistance, and impact resistance.

SUMMARY OF THE INVENTION

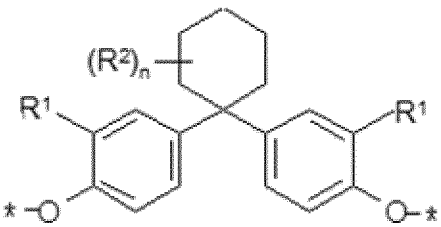
One objective of the present application is thus to provide a polycarbonate composition which has a good combination of comparative tracking index, flame retardancy, heat resistance, and impact resistance.

Another object of the present application is to provide an article which has a good combination of comparative tracking index, high heat resistance, good impact resistance and flame retardancy.

In a first aspect, the present invention provides a polycarbonate composition comprising the following components, relative to the total weight of the composition:

A) 10 - 60 wt. % of a copolycarbonate comprising

i) units of formula (1)



(1)

wherein

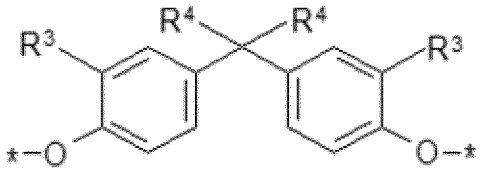
* indicates the position where formula (1) is connected to the polymer chain,

R^1, each independently, is hydrogen or C_1-C_4 alkyl,

R^2, each independently, is C_1-C_4 alkyl,

n is 0, 1, 2 or 3, and

ii) units of formula (2):



(2)

wherein

* indicates the position where formula (2) is connected to the polymer chain,

R^3, each independently, is hydrogen, linear or branched C_1-C_{10} alkyl, and

R^4, each independently, is linear or branched C_1-C_{10} alkyl,

B) 25 - 75 wt. % of a homopolycarbonate containing units of formula (2) as defined above,

C) 7 - 13 wt. % of a phosphorous flame retardant,

D) 4 - 9 wt. % of an impact modifier, and

E) 2-14 wt.% a polyester selected from poly(1,4-butylene terephthalate), poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate), poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester, and a combination thereof,

wherein the content by weight of the units of formula (1) in the polycarbonate composition is 8-31 wt. %.

As used herein, the content by weight of the units of formula (1) in the polycarbonate composition ($C_{1/C/W}$) is calculated as follows:

$$C_{1/C/W} = \frac{C_{1/CO/M} \times M_{w1}}{(C_{1/CO/M} \times M_{w1'} + C_{2/CO/M} \times M_{w2})} \times C_{co/c/w}$$

Wherein

$C_{1/C/W}$ stands for the content by weight of the units of formula (1) in the polycarbonate composition;

$C_{1/CO/M}$ stands for the content by mole of the units of formula (1) in the copolycarbonate;

M_{w1} stands for the molecular weight of the unit of formula (1), which is expressed in grams per mole;

$M_{w1'}$ stands for the total molecular weight of the unit of formula (1) and -C=O-, which is expressed in grams per mole;

$C_{2/CO/M}$ stands for the content by mole of the units of formula (2) in the copolycarbonate;

M_{w2} stands for the molecular weight of the unit of formula (2), which is expressed in grams per mole; and

$C_{co/c/w}$ stands for the content by weight of the copolycarbonate in the polycarbonate composition.

Comparative tracking index (CTI) means a numerical value of the maximum voltage at which five test specimens in test period withstand 50 drops of specified

electrolyte liquid without tracking failure and without a persistent flame occurring, as determined according to IEC60112:2011.

The inventors have discovered unexpectedly that the composition according to the present invention has a comparative tracking index up to 600V as determined according to IEC60112:2011, a flame-retardancy level of V0 as determined according to UL94-2015, good heat resistance with a Vicat temperature not lower than 100 °C as determined according to ISO 306: 2013, and an impact strength more than 10 kJ/m^2 as determined according to ISO 180/A:2000.

In a second aspect, the present invention provides a shaped article made from a polycarbonate composition according to the first aspect of the present invention.

In a third aspect, the present invention provides a process for preparing the shaped article mentioned above, comprising injection moulding, extrusion moulding, blow moulding or thermoforming the polycarbonate composition according to the first aspect of the present invention.

Other subjects and characteristics, aspects and advantages of the present invention will emerge even more clearly on reading the description and the examples that follow.

DETAILED DESCRIPTION OF THE INVENTION

In that which follows and unless otherwise indicated, the limits of a range of values are included within this range, in particular in the expressions "between...and..." and "from ... to ...".

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the present invention pertains. When the definition of a term in the present description conflicts with the meaning as commonly understood by those skilled in the art the present invention belongs to, the definition described herein shall apply.

Throughout the instant application, the term “comprising” is to be interpreted as encompassing all specifically mentioned features as well optional, additional, unspecified ones. As used herein, the use of the term “comprising” also discloses the embodiment wherein no features other than the specifically mentioned features are present (*i.e.* “consisting of”).

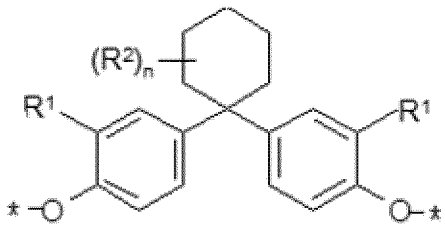
Unless otherwise specified, all numerical values expressing amount of ingredients and the like which are used in the description and claims are to be understood as being modified by the term “about”.

Component A

According to the first aspect, the polycarbonate composition according to the present invention comprises a copolycarbonate.

In the present application, the copolycarbonate refers to the polycarbonate comprising

i) units of formula (1)



(1)

wherein

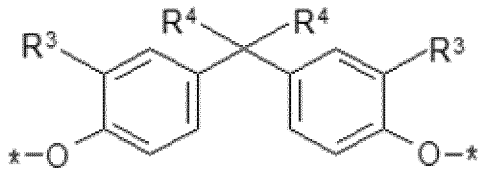
* indicates the position where formula (1) is connected to the polymer chain,

R^1, each independently, is hydrogen or C_1-C_4 alkyl,

R^2, each independently, is C_1-C_4 alkyl,

n is 0, 1, 2 or 3, and

ii) units of formula (2):



(2)

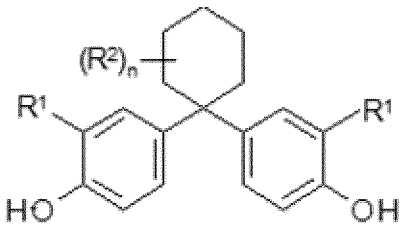
wherein

* indicates the position where formula (2) is connected to the polymer chain,

R^3, each independently, is H, linear or branched C_1-C_{10} alkyl, preferably, H, linear or branched C_1-C_4 alkyl, and

R^4, each independently, is linear or branched C_1-C_{10} alkyl, preferably linear or branched C_1-C_4 alkyl.

The units of formula (1) can be derived from a diphenol of formula (1'):



(1')

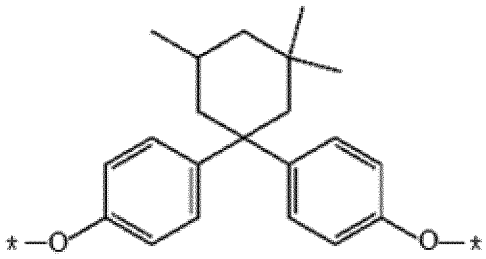
wherein

R^1, each independently, represents hydrogen or C_1-C_4-alkyl,

R^2, each independently, represents C_1-C_4-alkyl,

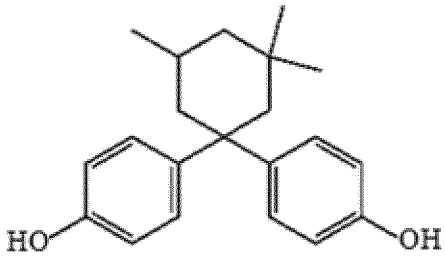
n represents 0, 1, 2 or 3.

Preferably, the unit of formula (1) has the following formula (1a),



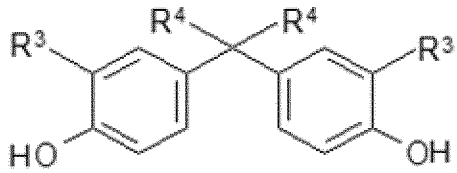
(1a)

wherein * indicates the position where formula (1a) is connected to the polymer chain, i.e., the unit of formula (1) is derived from bis(4-hydroxyphenyl)-3,3,5-trimethylcyclohexane (BPTMC) having the formula (1'a):



(1'a).

The units of formula (2) can be derived from a diphenol of formula (2'):



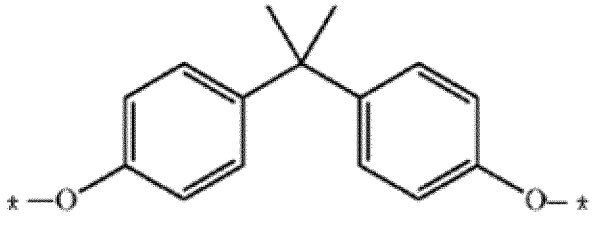
(2')

wherein

R^3, each independently, represents H, linear or branched C_1-C_{10} alkyl,

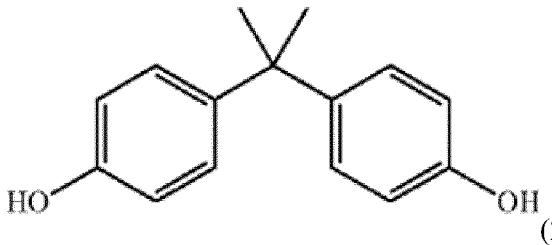
R^4, each independently, represents linear or branched C_1-C_{10} alkyl.

Preferably, the unit of formula (2) has the following formula (2a),



(2a)

wherein * indicates the position where formula (2a) is connected to the polymer chain, i.e., the unit of formula (2) is derived from bisphenol A, i.e. the diphenol of formula (2'a).



(2'a).

Preferably, the copolycarbonate comprises units derived from bis(4-hydroxyphenyl)-3,3,5-trimethylcyclohexane (BPTMC) and bisphenol A.

Preferably, the units of formula (1) in the copolycarbonate are derived from a diphenol of formula (1') and the units of formula (2) in the copolycarbonate are derived from a diphenol of formula (2').

Preferably, the units of formula (1) in the copolycarbonate are derived from bis(4-hydroxyphenyl)-3,3,5-trimethylcyclohexane (BPTMC) and the units of formula (2) in the copolycarbonate are derived from bisphenol A.

The diphenols of formula (1') and formula (2') are known and can be prepared by processes known from literatures (for example H. J. Buysch et al., Ullmann's Encyclopedia of Industrial Chemistry, VCH, New York 1991, 5th Ed., Vol. 19, p. 348).

Preferably, the mole content of the units of the formula (1) in the copolycarbonate is 20-80 mol %, the mole content of the units of the formula (2) in the copolycarbonate is 80 - 20 mol %, based on the total mole number of units of formula (1) and formula (2).

More preferably, the mole content of the units of the formula (1) in the copolycarbonate is 30-75 mol %, the mole content of the units of the formula (2) in the copolycarbonate is 70 - 25 mol %, based on the total mole number of units of formula (1) and formula (2).

The copolycarbonate used in the composition according to the present invention is commercially available or can be produced by a process known in the art.

For example, the copolycarbonate used in the composition according to the present invention can be produced by an interfacial process. In particular, the diphenols of the formula (1') and (2') and optional branching agents are dissolved in aqueous alkaline solution and reacted with a carbonate source, such as phosgene, optionally dissolved in a solvent, in a two-phase mixture comprising an aqueous alkaline solution, an organic solvent and a catalyst, preferably an amine compound. The reaction procedure can also be conducted in a multistep process.

Such processes for the preparation of copolycarbonate are known in principle as two-phase interfacial processes, for example from H. Schnell, Chemistry and Physics of Polycarbonates, Polymer Reviews, Vol. 9, Interscience Publishers, New York 1964, page 33 et seq., and on Polymer Reviews, Vol. 10, "Condensation Polymers by Interfacial and Solution Methods", Paul W. Morgan, Interscience Publishers, New York 1965, Chapter VIII, page 325, and the underlying conditions are therefore familiar to the person skilled in the art.

The concentration of the diphenols in the aqueous alkaline solution is from 2 wt. % to 25 wt. %, preferably from 2 wt. % to 20 wt. %, more preferably from 2 wt. % to 18 wt. % and even more preferably from 3 wt. % to 15 wt. %. The aqueous alkaline solution consists of water in which hydroxides of alkali metals or alkaline earth metals are dissolved. Sodium and potassium hydroxides are preferred.

The concentration of the amine compound is from 0.1 mol % to 10 mol %, preferably 0.2 mol % to 8 mol %, particularly preferably 0.3 mol % to 6 mol % and more particularly preferably 0.4 mol % to 5 mol %, relative to the mole amount of diphenol used.

The carbonate source is phosgene, diphosgene or triphosgene, preferably phosgene. Where phosgene is used, a solvent may optionally be dispensed with and the phosgene may be passed directly into the reaction mixture.

Tertiary amines, such as triethylamine or N-alkylpiperidines, may be used as a catalyst. Suitable catalysts are trialkylamines and 4-(dimethylamino)pyridine. Triethylamine, tripropylamine, triisopropylamine, tributylamine, trisobutylamine, N-methylpiperidine, N-ethylpiperidine and N-propylpiperidine are particularly suitable.

Halogenated hydrocarbons, such as methylene chloride, chlorobenzene, dichlorobenzene, trichlorobenzene or mixtures thereof, or aromatic hydrocarbons, such as, toluene or xylenes, are suitable as an organic solvent. The reaction temperature may be from -5 °C. to 100 °C, preferably from 0 °C to 80 °C, particularly preferably from 10 °C to 70 °C. and very particularly preferably from 10 °C. to 60 °C. The preparation of the copolycarbonates by the melt transesterification process, in which the diphenols are reacted with diaryl carbonates, generally diphenyl carbonate, in the presence of catalysts, such as alkali metal salts, ammonium or phosphonium compounds, in the melt, is also possible.

The melt transesterification process is described, for example, in Encyclopedia of Polymer Science, Vol. 10 (1969), Chemistry and Physics of Polycarbonates, Polymer Reviews, H. Schnell, Vol. 9, John Wiley and Sons, Inc. (1964), and DE-C 1031 512.

In the transesterification process the aromatic dihydroxy compounds already described in the case of the phase boundary process are transesterified with carbonic acid diesters with the aid of suitable catalysts and optionally further additives in the melt.

The reaction of the aromatic dihydroxy compound and of the carbonic acid diester to give the copolycarbonate can be carried out batchwise or preferably continuously, for example in stirred vessels, thin-film evaporators, falling-film evaporators, stirred vessel cascades, extruders, kneaders, simple disc reactors and high-viscosity disc reactors.

Preferably, the copolycarbonate is selected from block copolycarbonates and random copolycarbonates. More preferably, the copolycarbonate is selected from random copolycarbonates.

Advantageously, the copolycarbonate has a weight average molecular weight (Mw) ranging from 16000 g/mol to 40000 g/mol, preferably from 17000 g/mol to 32000 g/mol, as determined by Gel Permeation Chromatography (GPC) in methylene chloride at 25°C using a polycarbonate standard with an UV-IR detector.

As an example for commercial products of the copolycarbonate suitable for the composition according to the present invention, mention can be made of the products sold under the name APEC® by the company Covestro Polymer (China), which are polycarbonate copolymers made from the copolymerization of carbonyl chloride with bisphenol A (BPA) and 3,3,5-trimethy1-1,1-bis(4-hydroxyphenyl) cyclohexane (BPTMC).

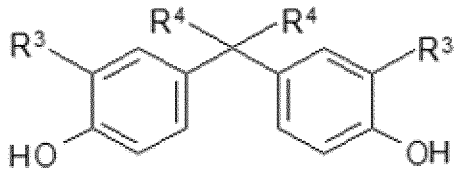
Advantageously, the copolycarbonate is present in an amount ranging from 10 wt. % to 60 wt. %, more preferably from 12 wt. % to 45 wt. %, even more preferably from 15 wt. % to 45 wt. %, relative to the total weight of the composition according to the present invention.

Component B

According to the first aspect, the polycarbonate composition according to the present invention comprises a homopolycarbonate comprising units of formula (2).

In the present application, the homopolycarbonate refers to the polycarbonate comprising units of formula (2) as defined above.

The unit of formula (2) is derived from a diphenol of formula (2'):



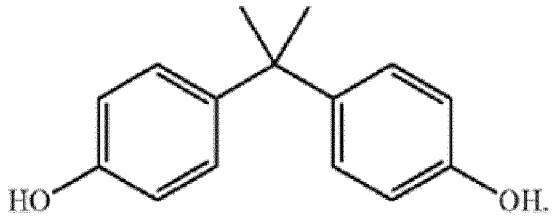
(2')

wherein

R^3, each independently, represents H, linear or branched C_1-C_{10} alkyl, preferably linear or branched C_1-C_6-alkyl, more preferably linear or branched C_1-C_4 alkyl, even more preferably H or methyl, and

R^4, each independently, represents linear or branched C_1-C_{10} alkyl, preferably linear or branched C_1-C_6 alkyl, more preferably linear or branched C_1-C_4-alkyl, even more preferably methyl.

Preferably, the unit of formula (2) is derived from the diphenol of formula (2'a), i.e. bisphenol A.



(2'a)

The homopolycarbonate used in the composition according to the present invention is commercially available or can be produced by a process known in the art.

For example, the homopolycarbonate can be produced by referring to the preparation process described with respect to component A.

Advantageously, the homopolycarbonate has a weight average molecular weight (Mw) ranging from 20,000 g/mol to 32,000 g/mol, preferably from 20,000 g/mol to 30,000 g/mol, as determined by Gel Permeation Chromatography (GPC) in methylene chloride at 25°C using a polycarbonate standard with an UV-IR detector.

As commercial products of homopolycarbonates suitable for use in the composition according to the present invention, mention can be made of Makrolon® FS2000, Makrolon® 2400, Makrolon® 2600, and Makrolon® 2800 sold by the company Covestro Polymer (China).

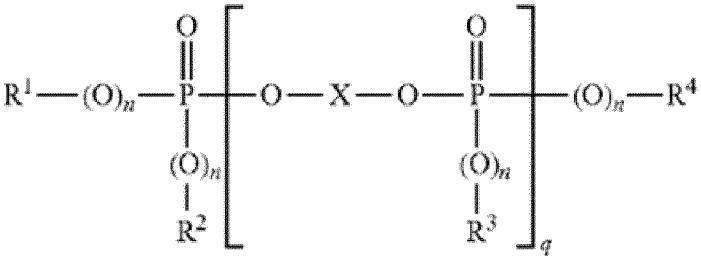
Advantageously, the homopolycarbonate is present in the polycarbonate composition according to the present invention in an amount ranging from 25 wt. % to 75wt. %, preferably from 26 wt. % to 65 wt. %, more preferably from 26 wt. % to 60 wt. %, relative to the total weight of the composition.

Component C

According to the first aspect, the polycarbonate composition according to the present invention comprises a phosphorous flame retardant.

Preferably, the phosphorus flame retardant suitable for use in the composition according to the present invention are selected from monomeric and oligomeric phosphoric and phosphonic acid esters, and mixtures thereof.

Preferred monomeric and oligomeric phosphoric and phosphonic acid esters are phosphorus compounds of formula (3).



(3)

wherein

R^1, R^2, R^3 and R^4, independently of one another, each denotes optionally halogenated C1-C8 alkyl, C5-C6 cycloalkyl, C6-C20 aryl or C7-C12 aralkyl each optionally substituted by alkyl, preferably C1-C4 alkyl, and/or halogen, preferably chlorine, bromine,

n independently of one another, denotes 0 or 1,

q denotes a number ranging from 0 to 30, and

X denotes a mononuclear or polynuclear aromatic residue with 6 to 30 carbon atoms or a linear or branched aliphatic residue with 2 to 30 carbon atoms, which can be OH-substituted and can contain up to eight ether bonds.

Preferably, R^1, R^2, R^3 and R^4, independently of one another, each denotes C1-C4 alkyl, phenyl, naphthyl, or phenyl C1-C4 alkyl, wherein the aromatic groups R^1, R^2, R^3 and R^4 can themselves be substituted with halogen and/or alkyl groups, preferably chlorine, bromine and/or C1-C4 alkyl. Particularly preferred aryl residues are cresyl, phenyl, xylenyl, propylphenyl or butylphenyl and the corresponding brominated and chlorinated derivatives thereof.

Preferably, X in formula (3) denotes a mononuclear or polynuclear aromatic residue with 6 to 30 carbon atoms.

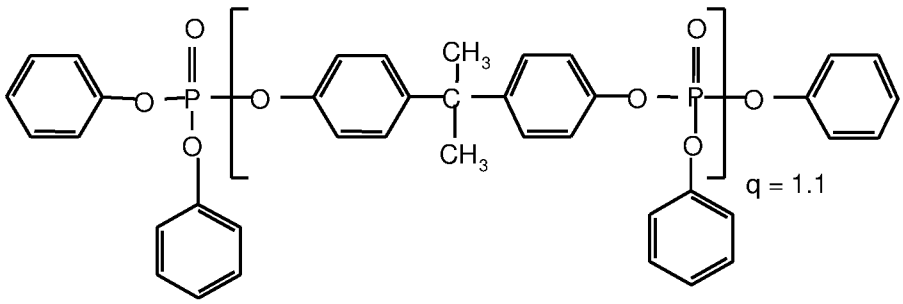
More preferably, X, is derived from resorcinol, hydroquinone, bisphenol A or diphenylphenol. Particularly preferably, X is derived from bisphenol A.

Preferably, n is equal to 1.

Preferably, q denotes a number from 0 to 20, particularly from 0 to 10, and in the case that a mixture of phosphorus compounds of the general formula (3) are used, a average value from 0.8 to 5.0, preferably 1.0 to 3.0, more preferably 1.05 to 2.00, and particularly preferably from 1.08 to 1.60.

Phosphorus compounds of formula (3) are in particular tributyl phosphate, triphenyl phosphate, tricresyl phosphate, diphenyl cresyl phosphate, diphenyl octyl phosphate, diphe-nyl-2-ethylcresyl phosphate, tri(isopropylphenyl)phosphate, resorcinol bridged oligophosphate and bisphenol A bridged oligophosphate. The use of oligomeric phosphoric acid esters of formula (3) derived from bisphenol A is particularly preferred.

Most preferred phosphorus compounds of formula (3) is bisphenol A based oligophosphate according to formula (4), i.e., bisphenol-A bis(diphenyl phosphate):



(4)

The phosphorus compounds of formula (3) are known (cf. e.g. EP-A 0 363 608, EP-A 0 640 655) or can be produced by known methods in an analogous manner (e.g. Ullmanns Enzyklopadie der technischen Chemie, vol. 18, pp. 301 ff. 1979; Houben-Weyl, Methoden der organischen Chemie, vol. 12/1, p. 43; Beilstein vol. 6, p. 177).

Advantageously, the phosphorus flame-retardant is present in the composition according to the present invention in an amount ranging from 7 wt. % to 13 wt. %, more preferably 8 wt. % to 11 wt. %, relative to the total weight of the composition.

Component D

According to the first aspect, the polycarbonate composition of the present invention comprise an impact modifier.

There is no particular limitation on the impact modifier.

Impact modifiers commonly used in polycarbonate composition can be used in the polycarbonate composition according to the present invention.

Preferably, the impact modifier is selected from rubber-modified vinyl (co)polymers comprising,

D1) 5 to 95 wt. %, preferably 8 to 90 wt. %, in particular 20 to 85 wt. %, of at least one vinyl monomer on

D2) 95 to 5 wt. %, preferably 92 to 10 wt. %, in particular 80 to 15 wt. %, of one or more graft bases having glass transition temperatures of < 10 °C, preferably < 0 °C, particularly preferably < -20 °C,

The wt. % is calculated based on the weight of the rubber-modified vinyl (co)polymer.

The glass transition temperature was determined by means of dynamic differential calorimetry (DSC) in accordance with the standard DIN EN 61006 at a heating rate of 10 K/min with definition of the T_g as the midpoint temperature (tangent method).

The at least one vinyl monomer D1 are preferably mixtures of

D1.1) 50 to 99 wt. %, preferably 65 to 85 wt. %, in particular 75 to 80 wt. %., of vinylaromatics and/or vinylaromatics substituted on the nucleus (such as styrene, α-methylstyrene, *p*-methylstyrene) and/or methacrylic acid (C_1-C_8)-alkyl esters (such as methyl methacrylate, ethyl methacrylate) and

D1.2) 1 to 50 wt. %, preferably 15 to 35 wt. %, in particular 20 to 25 wt. %, of vinyl cyanides (unsaturated nitriles, such as acrylonitrile and methacrylonitrile) and/or (meth)acrylic acid (C_1-C_8)-alkyl esters, such as methyl methacrylate, *n*-butyl acrylate, *t*-butyl acrylate, and/or derivatives (such as anhydrides and imides) of unsaturated carboxylic acids, for example maleic anhydride and *N*-phenyl-maleimide,

The wt. % is calculated based on the weight of the vinyl monomer D1.

Preferred monomer D1.1 is chosen from styrene, α-methylstyrene and methyl methacrylate. Preferred monomer D1.2 is chosen from acrylonitrile, maleic anhydride and methyl methacrylate. More preferably, monomer D1.1 is styrene and monomer D1.2 is selected from acrylonitrile and methyl methacrylate.

As examples of the graft base D2, mention can be made of, diene rubbers, and acrylate, and ethylene/vinyl acetate rubbers.

Preferred graft base D2 is chosen from diene rubbers, for example based on butadiene and isoprene, or mixtures of diene rubbers or copolymers of diene rubbers or mixtures thereof with further copolymerizable monomers (e.g. according to D1.1 and D1.2), with the provison that the glass transition temperature of component D2 is below < 10 °C, preferably < 0 °C, particularly preferably < -20 °C.

Particularly preferred graft base D2 is selected from pure polybutadiene rubber or acrylate composite rubbers.

Particularly preferred rubber-modified vinyl (co)polymers are for example, ABS (Acrylonitrile-Butadiene-Styrene), MBS (Methyl methacrylate-Butadiene-Styrene).

The rubber-modified vinyl (co)polymers can be prepared by free radical polymerization, e.g. by emulsion, suspension, solution or bulk polymerization, preferably by emulsion or bulk polymerization, in particular by emulsion polymerization.

As examples of commercial products of rubber-modified vinyl (co)polymers can be used in the present invention, mention can be made of:

- ABS 8391 available from SINOPEC Shanghai Gaoqiao Company having a polybutadiene rubber content of 10 - 15 wt. % based on the ABS polymer,
- ABS HRG powder P60 available from the company INEOS Styrolution, produced by emulsion polymerisation of 42 - 45 wt. %, based on the ABS polymer, of a mixture of 27 wt. % acrylonitrile and 73 wt. % styrene in the presence of 55-58 wt. %, based on the ABS polymer, of a crosslinked polybutadiene rubber (the average particle diameter d_{50} is 0.3 µm);
- Kane Ace M732 available from Japan Kaneka Chemical Co. Ltd.

Advantageously, the impact modifier is present in the polycarbonate composition according to the present invention in amount ranging from 4 wt. % to 9 wt. %, relative to the total weight of the polycarbonate composition.

Component E

According to the first aspect, the polycarbonate composition of the present invention comprise a polyester, selected from poly(1,4-butylene terephthalate), poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate), poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester, and a combination thereof.

Poly(1,4-butylene terephthalate)

Poly(1,4-butylene terephthalate), also called as (PBT), is obtained by polycondensing terephthalic acid with a glycol component containing an alkylene glycol having 4 carbon atoms (1,4-butanediol).

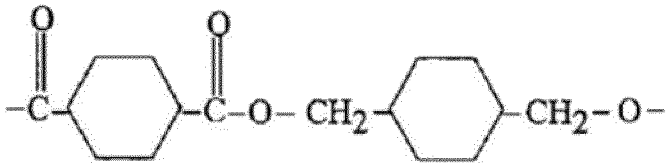
The intrinsic viscosity of the polybutylene terephthalate resin is not particularly limited.

Advantageously, the intrinsic viscosity (IV) of the polybutylene terephthalate resin is from 0.60 dL/g to 1.2 dL/g, preferably from 0.65 dL/g to 0.9 dL/g. The intrinsic viscosity (IV) of the polybutylene terephthalate resin can be measured, for example, in o-chlorophenol at a temperature of 35 °C.

It is possible to adjust intrinsic viscosity by blending polybutylene terephthalate resins each having a different intrinsic viscosity. For example, a polybutylene terephthalate resin having an intrinsic viscosity of 0.9 dL/g can be prepared by blending a polybutylene terephthalate resin having an intrinsic viscosity of 1.0 dL/g and a polybutylene terephthalate resin having an intrinsic viscosity of 0.7 dL/g.

Poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate)

Poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate), also called as PCCD or poly(1,4-cyclohexenedimethanol-1,4-dicarboxylate), has recurring units of the formula:

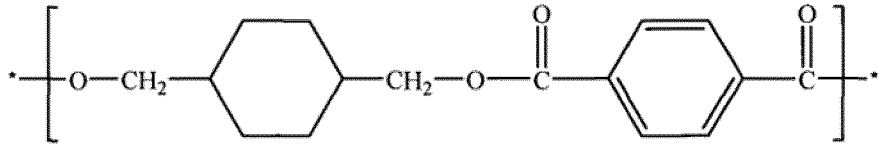


PCCD employed can be a standard PCCD available from Eastman Chemical. It has a molecular weight of 41,000 to 60,000 g/mol as determined by GPC with $CHCl_3$ as solvent at 23 °C.

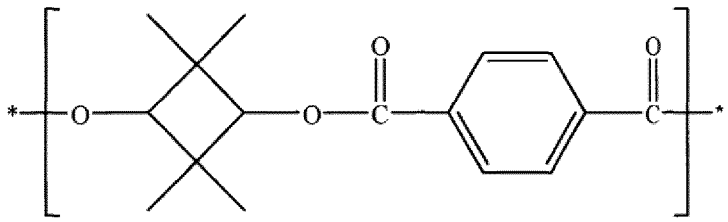
Advantageously, PCCD has an inherent viscosity of from 0.8 dL/g to 1.1 dL/g, preferably of 0.82 dL/g to 1.0 dL/g, as measured in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.5g/100ml at 25 °C.

Poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester

Poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester is an amorphous copolyester comprising 1,4-cyclohexanedimethylene terephthalate repeating units having the structure



and 2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate repeating units having the structure



wherein * indicates the position where the unit is connected to the polymer chain.

Poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester can be obtained by polymerization of 2,2,4,4-tetramethyl-1,3-cyclobutanediol (TMCBD), terephthalic acid (or dimethyl terephthalate) and 1,4-cyclohexanediol.

According to the different positions of hydroxyl groups, the monomer TMCBD has *cis* and *trans* isomers. The C4 ring of the *cis*-TMCBD is non-planar and the crystals have a dihedral angle of 17.5°, while the *trans*-TMCBD has a dihedral angle of 0° and has a symmetrical structure; the C4 ring is very stable.

Preferably, the copolyester comprises 10 wt.-% to 90 wt.-% of the cyclohexanedimethylene terephthalate repeating units and 10 wt.-% to 90 wt.-% of the 2,2,4,4-tetramethylcyclobutylene terephthalate repeating units, based on the weight of the copolyester.

Advantageously, the copolyester has a melt volume rate (MVR) of 5 to 30 g/mol, preferably of 8 to 25 g/mol, and more preferably of 10 to 20 g/mol, as measured in accordance with ISO 1133-1: 2011 at 260°C under a loading of 5kg.

Advantageously, the polyester is present in the polycarbonate composition according

to the present invention in an amount ranging from 2 wt.% to 14 wt.%, preferably from 2 wt.% to 13 wt.%, relative to the total weight of the polycarbonate composition.

Additives

In addition to components A-E mentioned above, the polycarbonate compositions according to the present invention can optionally comprise one or more additives conventionally used in polycarbonate compositions. Such additives are, for example, fillers, carbon black, UV stabilizers, IR stabilizers, heat stabilizers, antistatic agents, pigments, colorants, lubricants, demoulding agents (such as pentaerythrityl tetrastearate), antioxidants, flow improvers agents, anti-dripping agents (such as poly(tetrafluoroethylene)), etc.

Such additives are described, for example, in WO 99/55772, pages 15-25, and in "Plastics Additives", R. Gachter and H. Muller, Hanser Publishers 1983).

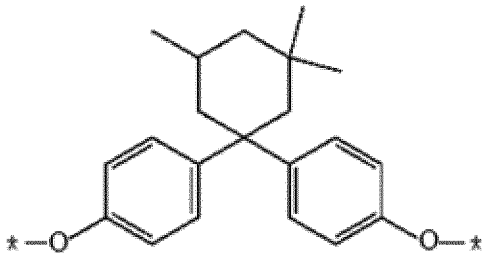
The person skilled in the art can select the type of the additives so as not to adversely affect the desired properties of the polycarbonate composition according to the present invention.

The total amount of the additives preferably is up to 4 wt. %, preferably up 1.8 wt. %, relative to the total weight of the polycarbonate composition according to the present invention.

Preferably, the polycarbonate composition according to the present invention comprises the following components, relative to the total weight of the composition:

A) 15 - 45 wt. % of a copolycarbonate comprising

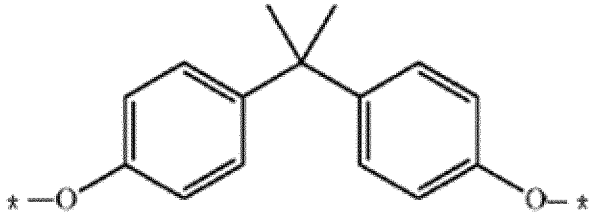
i) units of formula (1a)



(1a)

wherein * indicates the position where formula (1a) is connected to the polymer chain, and

ii) units of formula (2a):



(2a)

wherein * indicates the position where formula (2a) is connected to the polymer chain,

B) 26 - 60 wt. % of a homopolycarbonate comprising units of formula (2a) as defined above,

C) 8 - 11 wt. % of bisphenol-A bis(diphenyl phosphate),

D) 4 - 9 wt. % of an impact modifier selected from acrylonitrile-butadiene-styrene or methyl methacrylate-butadiene-styrene, and

E) 2- 13 wt. % of a polyester selected from poly(1,4-butylene terephthalate), poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate), poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester, and a combination thereof,

wherein the content by weight of the unit of formula (1a) in the polycarbonate composition is from 8 wt. % to 31 wt. %.

Preparation of the polycarbonate composition

The polycarbonate composition according to the present invention can be in the form of, for example, pellets.

The polycarbonate composition according to the present invention demonstrates a good processing behaviour and can be prepared by a variety of methods involving intimate admixing of the materials desired in the composition.

For example, the materials desired in the composition are first blended in a high speed mixer. Low shear processes, including but not limited to hand mixing, can also accomplish this blending. The blend is then fed into the throat of a twin-screw extruder via a hopper. Alternatively, at least one of the components can be incorporated into the composition by feeding it directly into the extruder at the throat and/or downstream through a side stuffer. Additives can also be compounded into a masterbatch with a desired polymeric resin and fed into the extruder. The extruder is generally operated at a temperature higher than that necessary to cause the composition to flow. The extrudate is immediately quenched in a water bath and pelletized. The pellets can be one-fourth inch long or less as described. Such pellets can be used for subsequent molding, shaping or forming.

Melt blending methods are preferred due to the availability of melt blending equipment in commercial polymer processing facilities.

Illustrative examples of equipment used in such melt processing methods include co-rotating and counter-rotating extruders, single screw extruders, co-kneaders, and various other types of extrusion equipment.

The temperature of the melt in the processing is preferably minimized in order to avoid excessive degradation of the polymers. It is often desirable to maintain the melt temperature between 230 °C and 350 °C in the molten resin composition, although higher temperatures can be used provided that the residence time of the resin in the processing equipment is kept short.

In some cases, the melting composition exits from a processing equipment such as an extruder through small exit holes in a die. The resulting strands of the molten resin are

cooled by passing the strands through a water bath. The cooled strands can be chopped into small pellets for packaging and further handling.

Shaped articles

The polycarbonate compositions according to the present invention can be used, for example for the production of various types of shaped articles.

In the second aspect, the present invention also provides a shaped article made from a polycarbonate composition according to the first aspect of the present invention.

As examples of such shaped articles mention can be made of, for example, films; profiles; housing parts, e.g. for domestic appliances or for office machines such as monitors, flat screens, notebooks, printers and copiers; sheets; tubes; electrical conduits; windows, doors and other profiles for the building sector (interior and exterior applications); electrical and electronic parts such as keypads, screen display covers, switches, plugs and sockets; lenses, and body parts or interior trim for commercial vehicles.

Preparation of shaped articles

The polycarbonate compositions according to the present invention can be processed into shaped articles by a variety of means such as injection moulding, extrusion moulding, blow moulding or thermoforming to form shaped articles.

In the third aspect, the present invention provides a process for preparing the shaped article made from a composition according to the first aspect of the present invention, comprising injection moulding, extrusion moulding, blow moulding or thermoforming the polycarbonate composition according to the present invention.

Examples

The present invention will be illustrated in detail below with reference to the examples below. The examples are only for the purpose of illustration, rather than limiting the scope of the present invention.

Materials used

Component A

CoPC-1: commercially available from the company Covestro Polymer (China), a copolycarbonate based on 70 mol % of 3,3,5-trimethy1-1,1-bis(4-hydroxyphenyl)cyclohexane (bisphenol TMC) units and 30 mol % of bisphenol A units, based on the total amount of bisphenol units, with a MVR of 7 cm^3/10 min, as measured at 330 °C, 1.2 kg according to ISO 1133: (2011), and a weight average molecular weight of about 30000 g/mol, as determined by means of Gel Permeation Chromatography (GPC) in methylene chloride at 25 °C using a polycarbonate standard.

CoPC-2: commercially available from the company Covestro Polymer (China), a copolycarbonate based on 44 mol % of 3,3,5-trimethy1-1,1-bis(4-hydroxyphenyl)cyclohexane (bisphenol TMC) units and 56 mol % of bisphenol A units, based on the total amount of bisphenol units, with a MVR of 16 cm^3/10 min, as measured at 330 °C, 1.2 kg according to ISO 1133: 2011, and a weight average molecular weight of about 27000 g/mol, as determined by means of Gel Permeation Chromatography (GPC) in methylene chloride at 25 °C using a polycarbonate standard.

Component B

PC-1: commercially available from the company Covestro Polymer (China), a linear polycarbonate based on bisphenol A have a weight average molecular weight of 26000 g/mol, as determined by means of Gel Permeation Chromatography (GPC) in methylene chloride at 25 °C using a polycarbonate standard.

PC-2: commercially available from the company Covestro Polymer (China), a linear polycarbonate based on bisphenol A having a weight average molecular weight (Mw) of 28000 g/mol, as determined by means of Gel Permeation Chromatography (GPC) in methylene chloride at 25 °C using a polycarbonate standard.

PC-3: commercially available from the company Covestro Polymer (China), a linear polycarbonate based on bisphenol A having a weight average molecular weight (Mw) of 20000 g/mol, as determined by means of Gel Permeation Chromatography (GPC) in methylene chloride at 25 °C using a polycarbonate standard.

Component C

BDP: bisphenol-A bis(diphenyl phosphate), available from the company Zhejiang Wansheng Science China.

Component D

ABS: available under the trade name P60 from INEOS Styrolution GmbH, a core-shell impact modifier prepared by emulsion polymerization of 58 wt. %, based on the ABS polymer, of a mixture of 24 wt. % of acrylonitrile and 76 wt. % of styrene in the presence of 42 wt. %, based on the ABS polymer, of a linear polybutadiene rubber.

MBS: available under the trade name Kane Ace M732 from Japan Kaneka Chemical Co. Ltd, methyl methacrylate-butadiene-styrene with a core/shell structure.

Component E

PET: polyethylene terephthalate, having an intrinsic viscosity of 0.652-0.676 dl/g, available as RT6020 from Invista CO.

PBT: polybutylene terephthalate, having an intrinsic viscosity of 1.2 dl/g, available as 1100-211 S from ChangChun Plastic.

PCCD: a copolymer of 1,4-cyclohexanedimethanol (CHDM) and 1,4-dimethylcyclohexane dicarboxylate (DMCD), PCCD has an inherent viscosity of 0.92 dL/g, as measured in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.5g/100ml at 25 °C. available as NEOSTAR COPOLYESTER 24303 from Eastman Chemical Company.

Tritan: poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester, a copolymer of dimethyl terephthalate (DMT), 1,4-cyclohexanedimethanol (CHDM), and 2,2,4,4-tetramethyl-1,3-cyclobutanediol (TMCBD), with a melt volume flow rate of about 14.5 cm^3/10 min in accordance with ISO 1133-1: 2011 at 260 °C and 5 kg load, available as TRITAN™ Copolyester TX1001 from Eastman Chemical Company.

Other additives

ADS5000: masterbatch of poly(tetrafluoroethylene) sold under the trade name ADS5000 from the company Chemical Innovation Co., Ltd. Thailand.

FACI L348 (PETS): Pentaerythritol tetrastearate powder, a mold release agent.

Irganox® B900: a mixture of 80% Irgafos® 168 and 20% Irganox® 1076 sold from the company BASF, wherein Irgafos®168 is (tris (2,4-di-tert-butylphenyl)phosphite), Irganox® 1076 is (2,6-di-tert-butyl-4-(octadecanoxy-carbonylethyl)-phenol.

Phosphorous acid: H_3PO_3, available from the company Sigma-Aldrich Chemie GmbH.

Test methods

The physical properties of specimens in the examples were tested as follows.

Comparative tracking index

The comparative tracking index (CTI) was determined according to IEC60112-2020-solution A.

Vicat softening temperature

The Vicat softening temperature (T_{Vicat}) was determined on test specimens of dimension of 80mm×10mm×4mm according to ISO 306: 2013 with a ram load of 50 N and a heating rate of 120 °C/h with a Coesfeld Eco 2920 instrument from Coesfeld Materialtest.

Melt volume flow rate (MVR)

The melt volume flow rate (MVR) was determined according to ISO 1133: 2011 at 260 °C and a loading of 5 kg with a Zwick 4106 instrument from Roell.

Izod notched impact strength

Izod notched impact strength was measured on specimens with dimensions of 80 mm ×10 mm ×3 mm according to ISO180/A:2000 (23°C, 4 mm, 5.5J).

Flame retardancy

The flame retardancy was evaluated on 127 mm x 12.7 mm x 1.5 mm bars according to UL94-2015 after the bars were conditioned at 23 °C for 48 hours.

Comparative Examples (CE) 1-10

The materials listed in Table 1 were compounded on a twin-screw extruder (ZSK-26) (from Coperion, Werner and Pfleiderer) at a speed of rotation of 225 rpm, a throughput of 20 kg/h, and a machine temperature of 300°C-330 °C and granulated.

The granules were processed into corresponding testing specimens on an injection moulding machine (from Arburg) with a melting temperature of 300-330 °C and a mold temperature of 60-80 °C.

The physical properties (including comparative tracking index (CTI), melt volume flow rate (MVR), Vicat softening temperature, Izod notched impact strength, flame retardancy) of the compositions obtained were tested and the results were summarized in Table 1.

Table 1

	CE1	CE2	CE3	CE4	CE5	CE6	CE7	CE8	CE9	CE10
PC-1(M.2600)	76.5	56	46	67.9	67.9	66.5	61.5	67.9	68.48	71.48
CoPC-1	-	20	30	-	-	-	-	-	-	-
PET	-	-	-	15	15	-	-	-	-	-
PBT	-	-	-	-	-	-	-	15	13	10
PCCD	-	-	-	-	-	15	15	-	-	-
BDP	10.5	16	16	9.00	9.00	10.5	10.5	9.00	10.50	10.50
ABS	7	7	7	6.5	-	6.5	-	-	6.5	6.5
SAN	4.7	4.7	4.7	-	-	-	-	-	-	-
MBS	-	-	-	-	6.5	-	6.5	6.5	-	-
ADS5000	0.8	0.8	0.8	1	1	1	1	1	1	1
FACI L348 (PETS)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Irganox® B900	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Phosphorous acid	-	-	-	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BPTMC content* (wt%)	0	14	21	0	0	0	0	0	0	0
CTI (V)	300	300	325	600	600	600	600	600	300	300
Vicat softening temperature (°C)	NA	NA	NA	111	110	97.9	94.9	99.3	96.8	112
MVR (g/10min)	15.5	16.1	17.3	28.3	31.1	41.2	33	24.9	35.8	35.6
Izod notched impact strength (kJ/m^2)	NA	NA	NA	7.1	6.1	49	52	52	17	30
Flame retardancy	V0	V0	V0	V0	V0	V0	V0	V0	V0	V0

NA: not tested.

*BPTMC content means BPTMC unit content in the polycarbonate composition.

As used herein, the content by weight of BPTMC unit ($C_{BPTMC/C/W}$) in a polycarbonate composition is calculated as follows:

$$C_{BPTMC/C/W} = \frac{C_{BPTMC/CO/M} \times M_{wBPTMC}}{(C_{BPTMC/CO/M} \times M_{wBPTMC'} + C_{BPA/CO/M} \times M_{wBPA})} \times C_{co/c/w}$$

wherein

$C_{BPTMC/C/W}$ stands for the content by weight of BPTMC unit in the polycarbonate composition;

$C_{BPTMC/CO/M}$ stands for the content by mole of BPTMC unit in a copolycarbonate;

M_{wBPTMC} stands for the molecular weight of BPTMC unit, which is expressed in grams per mole;

$M_{wBPTMC'}$ stands for the total molecular weight of BPTMC unit and -C=O-, which is expressed in grams per mole;

$C_{BPA/CO/M}$ stands for the content by mole of BPA unit in the copolycarbonate;

M_{wBPA} stands for the molecular weight of BPA unit, which is expressed in grams per mole; and

$C_{co/c/w}$ stands for the content by weight of the copolycarbonate in a polycarbonate composition.

Taking comparative example 2 as an example, the molar content of BPTMC unit is 70 mol% and the molar content of BPA unit is 30 mol% in CoPC-1, the molecular weight of BPTMC unit is 308 g/mol, the total molecular weight of BPTMC unit and -C=O- is 336 g/mol, the molecular weight of BPA unit (including -C=O-) is 254 g/mol, CoPC-1 is present in an amount of 20 wt. % in the polycarbonate composition, thus the content by weight of BPTMC unit in invention example 1 is:

$$\frac{70\ \text{mol\%} \times 308\ \text{g/mol}}{(70\ \text{mol\%} \times 336\ \text{g/mol} + 30\ \text{mol\%} \times 254\ \text{g/mol})} \times 20\ \text{wt. \%} = 14\ \text{wt. \%}$$

Composition of comparative example 1 not comprising a copolycarbonate and a polyester as defined in claim 1 does not have a high comparative tracking index.

Each composition of comparative examples 2 and 3 not comprising a polyester as defined in claim 1 does not have a high comparative tracking index.

Each composition of comparative examples 4 and 5 not comprising a copolycarbonate as defined in claim 1 does not have a high impact strength.

Each composition of comparative examples 6-9 not comprising a copolycarbonate as defined in claim 1 does not have a high Vicat softening temperature. In addition, composition of comparative example 9 does not have a high comparative tracking index.

Composition of comparative example 10 not comprising a copolycarbonate as defined in claim 1 does not have a high comparative tracking index.

Invention Examples (IE) 1-3 and Comparative Examples (CE) 11-14

Similarly, the materials listed in Table 2 were compounded, the physical properties of the compositions obtained were tested and the results were summarized in Table 2.

Table 2

	CE11	CE12	CE13	CE14	IE1	IE2	IE3
PC-1(M.2600)	52.98	46.13	-	46.13	46.13	44.63	44.63
PC-2(M.2800)	-	-	46.13	-	-	-	-
PC-3(FS2000P)	5	5	5	5	5	5	5
CoPC-1	15	-	-	-	-	-	-
CoPC-2	-	21.85	21.85	21.85	21.85	21.85	21.85
PET	10.00	10.00	10.00	10.00	-	-	-
PBT	-	-	-	-	10.00	-	-
Tritan	-	-	-	-	-	10.00	-
PCCD	-	-	-	-	-	-	10.00
BDP	9.00	9.00	9.00	9.00	9.00	10.50	10.50
ABS	6.5	6.5	6.5	-	6.5	6.5	6.5
MBS	-	-	-	6.5	-	-	-
ADS5000	1	1	1	1	1	1	1
FACI L348 (PETS)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Irganox® B900	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Phosphorous acid	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BPTMC content* (wt%)	10.3%	10.3%	10.3%	10.3%	10.3%	10.3%	10.3%
CTI (V)	600	600	600	600	600	600	600
Vicat softening temperature (°C)	118	118	117	119	108	118	113
MVR (g/10min)	21.0	22.1	20.0	23.9	23.6	19.5	25.5
Izod notched impact strength (kJ/m^2)	8.7C	9.2C	9.0C	6.8C	42P	45P	41P
Flame retardancy	V0	V0	V0	V0	V0	V0	V0

*BPTMC content means BPTMC unit content in the polycarbonate composition.

Each composition of comparative examples 11-14 comprising PET rather than a polyester as defined in claim 1 does not have a high impact strength.

Composition of invention examples 1-3 according to the present invention have a good combination of comparative tracking index, Vicat softening temperature, Izod notched impact strength, and flame-retardancy.

Invention Examples (IE) 4-14

Similarly, the materials listed in Table 3 were compounded, the physical properties of the compositions obtained were tested and the results were summarized in Table 3.

Table 3

	IE4	IE5	IE6	IE7	IE8	IE9	IE10	IE11	IE12	IE13	IE14
PC-1(M.2600)	57.63	54.63	51.63	46.63	54.63	51.63	46.63	54.63	51.63	46.63	59.48
CoPC-1	21.85	21.85	21.85	-	21.85	21.85	-	21.85	21.85	-	12.00
CoPC-2	-	-	-	21.85	-	-	21.85	-	-	21.85	-
PBT	2.00	5.00	8.00	13.00	-	-	-	-	-	-	10.00
Tritan	-	-	-	-	5.00	8.00	13.00	-	-	-	-
PCCD	-	-	-	-	-	-	-	5.00	8.00	13.00	-
BDP	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
ABS	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
ADS5000	1	1	1	1	1	1	1	1	1	1	1
FACI L348 (PETS)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
IRGANOX B 900	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Phosphorous acid	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BPTMC content* (wt%)	15.3	15.3	15.3	9.6	15.3	15.3	9.6	15.3	15.3	9.6	8.4
CTI (V)	600	600	600	600	600	600	600	600	600	600	600
Vicat softening temperature (°C)	115	103	108	101	117	116	110	115	112	106	101
MVR (g/10min)	20.9	24.5	22.8	29.4	19.4	18.9	21.0	20.9	23.8	28.2	29.7
Izod notched impact strength (kJ/m^2)	29	47	26	15	32	30	39	31	29	37	37
Flame retardancy	V0	V0	V0	V0	V0	V0	V0	V0	V0	V0	V0

*BPTMC content means BPTMC unit content in the polycarbonate composition.

Composition of invention examples 4-14 according to the present invention have a good combination of comparative tracking index, Vicat softening temperature, Izod notched impact strength, and flame-retardancy.

Invention Examples (IE) 15-20 and Comparative Examples (CE) 15-17

Similarly, the materials listed in Table 4 were compounded, the physical properties of the compositions obtained were tested and the results were summarized in Table 4.

Compositions of invention examples 15-20 according to the present invention have a good combination of comparative tracking index, Vicat softening temperature, Izod notched impact strength, and flame-retardancy.

Composition of comparative example 15 comprising more than 14 wt.% of BDP(bisphenol-A bis(diphenyl phosphate)) copolycarbonate does not have a high Vicat softening temperature.

Composition of comparative example 16 comprising lower than 4 wt.% of ABS does not have a high impact strength.

Composition of comparative example 17 comprising more than 9 wt.% of ABS does not pass the flame retardancy test.

Table 4

	IE15	IE16	IE17	IE18	CE15	CE16	IE19	IE20	CE17
PC-1(M.2600)	53.48	41.48	26.48	52.13	45.13	54.13	48.13	54.13	46.13
CoPC-1	18.00	30.00	45.00	21.85	21.85	21.85	21.85	21.85	21.85
PBT	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10	10.00
BDP	10.50	10.50	10.50	8	15.00	10.50	10.50	7	10.50
ABS	6.5	6.5	6.5	6.5	6.5	2	8	5.5	10
ADS5000	1	1	1	1	1	1	1	1	1
FACI L348 (PETS)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
IRGANOX B 900	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Phosphorous acid	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BPTMC content* (wt%)	12.1	20.1	30.2	14.6	14.6	14.6	14.6	14.6	14.6
CTI (V)	600	600	600	600	600	600	600	600	600
Izod notched impact (kJ/m^2)	36	30	24	14	14	2.4	30	51	53
Vicat softening temperature (°C)	102	104	108	111	94.2	104	112	113	101
Flame retardancy	V0	V0	V0	V0	V0	V0	V0	V0	Fail*

*BPTMC content means BPTMC unit content in the polycarbonate composition.

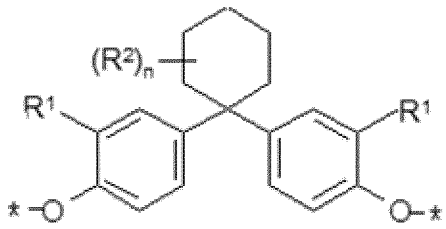
Fail* means V2 is not passed.

Claims

1. A polycarbonate composition comprising the following components, relative to the total weight of the composition:

A) 10 - 60 wt. % of a copolycarbonate comprising

i) units of formula (1)



(1)

wherein

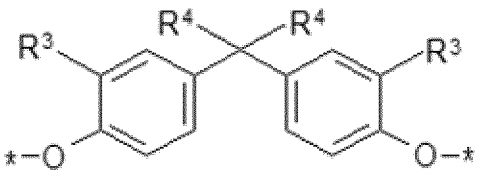
* indicates the position where formula (1) is connected to the polymer chain,

R^1, each independently, is hydrogen or C_1-C_4 alkyl,

R^2, each independently, is C_1-C_4 alkyl,

n is 0, 1, 2 or 3, and

ii) units of formula (2):



(2)

Wherein

* indicates the position where formula (2) is connected to the polymer chain,

R^3, each independently, is hydrogen, linear or branched C_1-C_{10} alkyl, and

R^4, each independently, is linear or branched C_1-C_{10} alkyl,

B) 25 - 75 wt. % of a homopolycarbonate comprising units of formula (2) as defined above,

C) 7- 13 wt. % of a phosphorous flame retardant,

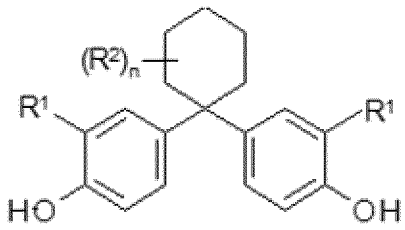
D) 4 - 9 wt. % of an impact modifier, and

E) 2- 14 wt. % of a polyester selected from poly(1,4-butylene terephthalate), poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate), poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester, and a combination thereof,

wherein the content by weight of the unit of formula (1) in the polycarbonate composition is 8-31 wt. %.

2. Composition according to Claim 1, wherein the units of formula (1) in copolycarbonate are derived from a diphenol of formula (1') and the units of formula (2) in

copolycarbonate are derived from a diphenol of formula (2'):



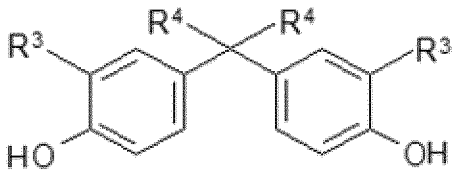
(1')

wherein

R^1, each independently, represents hydrogen or C_1-C_4-alkyl,

R^2, each independently, represents C_1-C_4-alkyl,

n represents 0, 1, 2 or 3;



(2')

wherein

R^3, each independently, represents H, linear or branched C_1-C_{10} alkyl,

R^4, each independently, represents linear or branched C_1-C_{10} alkyl.

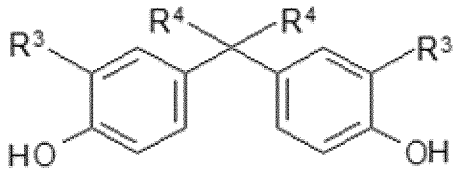
3. Composition according to Claim 2, wherein the units of formula (1) in the copolycarbonate are derived from bis(4-hydroxyphenyl)-3,3,5-trimethylcyclohexane (BPTMC) and the units of formula (2) in the copolycarbonate are derived from bisphenol A.

4. Composition according to any of Claims 1 to 3, wherein the mole content of the units of the formula (1) in the copolycarbonate is 20-80 mol %, preferably 30-75 mol %, the mole content of the units of the formula (2) in the copolycarbonate is 80 - 20 mol %, preferably 70 - 25 mol %, based on the total mole number of units of formula (1) and formula (2).

5. Composition according to any of Claims 1 to 4, wherein the copolycarbonate is selected from block copolycarbonates and random copolycarbonates.

6. Composition according to any of Claims 1 to 5, wherein the copolycarbonate has a weight average molecular weight (Mw) ranging from 16000 g/mol to 40000 g/mol, preferably from 17000 g/mol to 32000 g/mol, as determined by Gel Permeation Chromatography (GPC) in methylene chloride at 25°C using a polycarbonate standard.

7. Composition according to any of Claims 1 to 6, wherein the unit of formula (2) in the homopolycarbonate is derived from a diphenol of formula (2'):



(2')

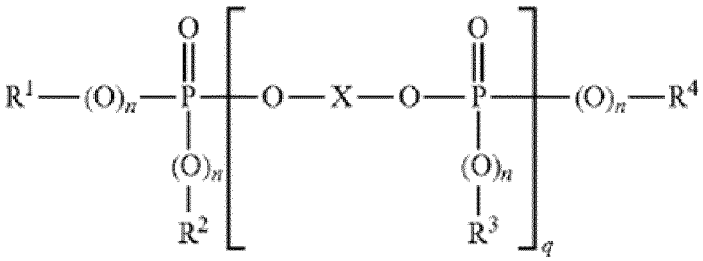
wherein

R^3, each independently, represents H, linear or branched C_1-C_4 alkyl, and

R^4, each independently, represents linear or branched C_1-C_4 alkyl.

8. Composition according to any of Claims 1 to 7, wherein the unit of formula (2) is derived from bisphenol A.

9. Composition according to any of claims 1 to 8, wherein the phosphorous flame retardant is selected from phosphorus compounds of formula (3)



(3)

wherein

R^1, R^2, R^3 and R^4, independently of one another, each denotes optionally halogenated C1 to C8 alkyl, C5 to C6 cycloalkyl, C6 to C20 aryl or C7 to C12 aralkyl each optionally substituted by alkyl, preferably C1 to C4 alkyl, and/or halogen, preferably chlorine, bromine,

n independently of one another, denotes 0 or 1,

q denotes a number ranging from 0 to 30 and

X denotes a mononuclear or polynuclear aromatic residue with 6 to 30 carbon atoms or a linear or branched aliphatic residue with 2 to 30 carbon atoms, which can be OH-substituted and can contain up to eight ether bonds,

preferably, the phosphorous flame retardant is bisphenol-A bis(diphenyl phosphate).

10. Composition according to any of Claims 1 to 9, wherein the impact modifier is selected from rubber-modified vinyl (co)polymer comprising

D1) 5 to 95 wt. %, preferably 8 to 90 wt. %, in particular 20 to 85 wt. %, of at least one vinyl monomer on

D2) 95 to 5 wt. %, preferably 92 to 10 wt. %, in particular 80 to 15 wt. %, of one or more graft bases having glass transition temperatures of < 10 °C, preferably < 0 °C, particularly preferably < -20 °C,

the wt. % is calculated based on the weight of the rubber-modified vinyl (co)polymer.

11. Composition according to Claim 10, wherein

the at least one vinyl monomer D1 is a mixture of

D1.1) 50 to 99 wt. %, preferably 65 to 85 wt. %, in particular 75 to 80 wt. %., of vinylaromatics and/or vinylaromatics substituted on the nucleus and/or methacrylic acid (C_1-C_8)-alkyl esters, and

D1.2) 1 to 50 wt. %, preferably 15 to 35 wt. %, in particular 20 to 25 wt. %, of vinyl cyanides and/or (meth)acrylic acid (C_1-C_8)-alkyl esters,

the wt. % is calculated based on the weight of the vinyl monomer D1;

and/or

the graft base D2 is chosen from diene rubbers, and acrylate, and ethylene/vinyl acetate rubbers.

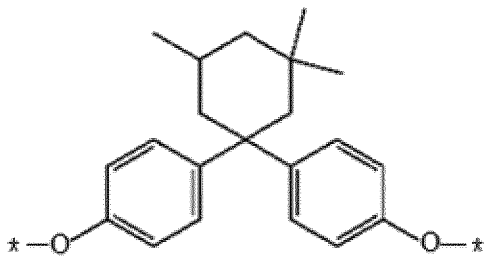
12. Composition according to Claim 11, wherein monomer D1.1 is styrene, monomer D1.2 is selected from acrylonitrile and methyl methacrylate, graft base D2 is selected from pure polybutadiene rubber or acrylate rubbers.

13. Composition according to any of Claims 1 to 9, wherein the impact modifier is selected from ABS, methyl methacrylate-butadiene-styrene (MBS), and a combination thereof.

14. Composition according to Claim 1, comprising the following components, relative to the total weight of the composition:

A) 15 - 45 wt. % of a copolycarbonate comprising

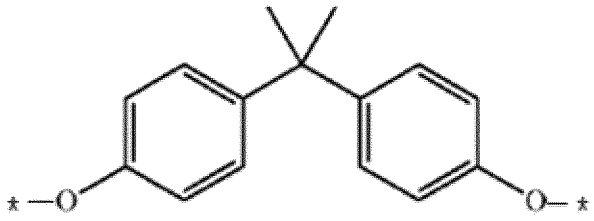
i) units of formula (1a)



(1a)

wherein * indicates the position where formula (1a) is connected to the polymer chain, and

ii) units of formula (2a):



(2a)

wherein * indicates the position where formula (2a) is connected to the polymer chain,

B) 26 - 60 wt. % of a homopolycarbonate comprising units of formula (2a) as defined above,

C) 8 - 11 wt. % of bisphenol-A bis(diphenyl phosphate),

D) 4 - 9 wt. % of an impact modifier selected from acrylonitrile-butadiene-styrene or methyl methacrylate-butadiene-styrene, and

E) 2- 13 wt. % of a polyester selected from poly(1,4-butylene terephthalate), poly(1,4-cyclohexylenedimethylene 1,4-cyclohexanedicarboxylate), poly(2,2,4,4-tetramethyl-1,3-cyclobutylene terephthalate) copolyester, and a combination thereof,

wherein the content by weight of the unit of formula (1a) in the polycarbonate composition is from 8 wt. % to 31 wt. %.

15. A shaped article made from the composition according to any of Claims 1 to 14.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/056843

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L69/00
ADD.

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)
C08L

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 practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 111 117 192 A (ORINKO ADVANCED PLASTICS CO LTD) 8 May 2020 (2020-05-08) paragraphs [0003] - [0009]	1-15
A	WO 2008/002734 A2 (GEN ELECTRIC [US]; LENS JAN-PLEUN [NL] ET AL.) 3 January 2008 (2008-01-03) claims 1,3; examples first full paragraph; page 45 page 57, last paragraph - page 59, line 4 page 36, line 20 - page 37, line 30	1-15
A	US 2015/232661 A1 (WANG HUANBING [CN] ET AL) 20 August 2015 (2015-08-20) example 6	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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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
6 June 2023	15/06/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Schlicke, Benedikt

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2023/056843

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 3107964 A1	28-12-2016
		KR 20160124740 A	28-10-2016
		US 2015232661 A1	20-08-2015
		WO 2015125050 A1	27-08-2015