(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 December 2024 (12.12.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/252358 A1

(51) International Patent Classification:
C08L 69/00 (2006.01)

(21) International Application Number:
PCT/IB2024/055604

(22) International Filing Date:
07 June 2024 (07.06.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

63/471,632	07 June 2023 (07.06.2023)	US
23182727.0	30 June 2023 (30.06.2023)	EP

(71) Applicant: **SHPP GLOBAL TECHNOLOGIES B.V.** [NL/NL]; Plasticslaan 1, 4612 PX Bergen op Zoom (NL).

(72) Inventors: **VAN DER MEE, Mark Adrianus Johannes**; Plasticslaan 1, 4612 PX Bergen op Zoom (NL). **VAN DE GRAMPEL, Robert Dirk**; Plasticslaan 1, 4612 PX Bergen op Zoom (NL). **VANDORMAEL, Bart**; Plasticslaan 1, 4612 PX Bergen op Zoom (NL). **VOLLENBERG, Peter**; 1 Lexan Lane, Mt. Vernon, Indiana 47620-9367 (US). **PREHN, JR., Frederick C.**; 1 Lexan Lane, Mt. Vernon, Indiana 47620-9367 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:
— *with international search report (Art. 21(3))*

WO 2024/252358 A1

(54) Title: GLASS-FILLED FLAME RETARDANT POLYCARBONATE COMPOSITIONS

(57) Abstract: A polycarbonate composition suitable for thin-wall applications comprises: a polycarbonate; a polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group; a non-halogenated flame retardant; glass fibers; glass fibers; optionally, a poly(carbonate-siloxane) present in an amount effective to provide 0.5-10 wt% siloxane repeating units, based on the total weight of the composition, and optionally, an additive composition wherein a sample of the composition has a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner. Advantageously, the polycarbonate compositions may minimize or eliminate fluorinated flame retardant salts such as Rimar salt and fluorinated anti-drip agents while achieving improved flame test performance.

GLASS-FILLED FLAME RETARDANT POLYCARBONATE COMPOSITIONS

BACKGROUND

[0001] This disclosure relates to polycarbonate compositions, and in particular to glass-filled flame-retardant polycarbonate compositions, methods of manufacture, and uses thereof in thin-wall articles.

[0002] Polycarbonates are useful in the manufacture of articles and components for a wide range of applications, from automotive parts to electronic appliances. Because of their broad use, particularly in electronics, it is desirable to provide glass-filled polycarbonate compositions with excellent physical, and thermal properties in an adequate processing window. Such properties may be particularly difficult to achieve in thin-wall applications. In addition, more stringent regulations are being put in place to reduce or eliminate the presence of halogens, in particular fluorine, in the final products.

[0003] There accordingly remains a need in the art for flame-retardant polycarbonate compositions suitable for thin-wall applications. It would be a further advantage if the compositions were essentially fluorine-free.

SUMMARY

[0004] The above-described and other deficiencies of the art are met by a polycarbonate composition including: polycarbonate; a polycarbonate including repeating units derived from a monomer including a pendant ester group; a non-halogenated flame retardant; glass fibers; optionally, a poly(carbonate-siloxane) present in an amount effective to provide 0.5-10 wt% siloxane repeating units, based on the total weight of the composition, and optionally, an additive composition, wherein a sample of the composition has a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner.

[0005] In another aspect, a method of manufacture includes combining the above-described components to form a polycarbonate composition.

[0006] In yet another aspect, an article includes the above-described polycarbonate composition.

[0007] In still another aspect, a method of manufacture of an article includes molding, extruding, or shaping the above-described polycarbonate composition into an article.

[0008] The above described and other features are exemplified by the following detailed description, examples, and claims.

DETAILED DESCRIPTION

[0009] Polycarbonates are thermoplastic resins with many desirable properties, but are inherently flammable. Current design trends are focused on thinner designs for purposes of slimness, weight reduction, and size reduction of the overall final product, as well as to for the purpose of more complex designs. However, polycarbonates tend to drip when exposed to a flame, and this behavior worsens as the wall thickness decreases. The UL 94 flammability test includes both short flame out times and no dripping of flaming particles as requirements for a V-0 or V-1 flame test rating. Conventional compositions often incorporate fluorine-based anti-drip agents either alone or in combination with a non-halogenated flame retardant in order to pass the UL94 flame test. Given that more stringent regulations are being put in place to reduce or eliminate the addition of halogenated materials, for example, per fluoroalkyl and polyfluoroalkyl substances (PFAS), to the compositions used to make final products, there is a need in the art for polycarbonate compositions that may achieve a V-0 or V-1 flame test rating for thin-walled molded samples and/or thin films, while also minimizing and/or eliminating the addition of PFAS into the polycarbonate compositions used to make the molded samples and/or thin films.

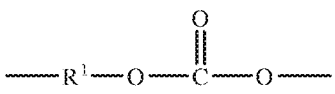
[00010] The inventors hereof have discovered that polycarbonate compositions including: a polycarbonate, a polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group; and optionally a poly(carbonate-siloxane); in combination with a non-halogenated flame retardant may provide the desired flame retardance while eliminating the need for halogenated additives, such as fluorinated flame retardants and anti-drip agents. Surprisingly, unlike conventional compositions, fluorinated anti-drip agents may be omitted in the present polycarbonate compositions, thus eliminating added fluorine while providing improved flammability. Advantageously, the polycarbonate compositions may have a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner and be considered "essentially fluorine-free." As used herein, the phrase "essentially fluorine-free" means that the amount of calculated intentionally added fluorine present in the composition is 1500 ppm or less, less than 1000 ppm, less than 500 ppm, less than 100 ppm, or less than 50 ppm. For example, if 0.5 wt% encapsulated polytetrafluoroethylene, (e.g., TSAN, which is 50 wt% PTFE and PFTE estimated to have 76 wt% fluorine content), the amount of calculated intentionally added fluorine would equal 1900 ppm. Further, the polycarbonate compositions of the present disclosure may have zero intentionally added fluorine.

[00011] In some aspects, the polycarbonate compositions may have a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner and be considered "essentially halogen-free" per IEC 61249-2-21 or UL 746H. As used herein, the phrase "essentially halogen-free" is as

defined by IEC 61249-2-21 or UL 746H. According to International Electrochemical Commission, Restriction Use of Halogen (IEC 61249-2-21), a composition should include 900 parts per million (ppm) or less of each of chlorine and bromine and also include 1500 ppm or less of total bromine, chlorine, and fluorine content. According to UL 746H, a composition should include 900 ppm or less of each of chlorine, bromine, and fluorine and 1500 ppm or less of the total chlorine, bromine, and fluorine content. The bromine, chlorine, and fluorine content in ppm may be calculated from the composition or measured by elemental analysis techniques. Conventional non-halogenated flame retardants may include or exclude halogens, but commonly employed anti-drip agents include PTFE-encapsulated styrene-acrylonitrile copolymers (e.g., TSAN) and thus include fluorine. Non-halogenated flame retardants that are not brominated, chlorinated, or fluorinated have been used in conventional polycarbonate compositions, but an anti-drip agent is usually present in combination with the non-halogenated flame retardant, causing the halogen content of the composition to exceed the 1500 ppm total halogen limit per IEC 61249-2-21 and UL 746H. Similarly, when non-halogenated flame retardants that are not brominated or chlorinated, but are fluorinated are used in combination with a fluorinated anti-drip agent, then the halogen content of the composition due to the presence of fluorine exceeds the 1500 ppm total halogen limit per IEC 61249-2-21 or UL 746H. Therefore, it would be a particular advantage if conventional anti-drip agents could be minimized or eliminated, so that the anti-drip agent does not contribute halogen content to the total halogen content of the compositions. Accordingly, a variety of non-halogenated flame retardants that include or exclude halogens may be used in polycarbonate compositions so that the compositions may be considered "essentially halogen-free" per IEC 61249-2-21 or UL 746H.

[00012] The polycarbonate compositions include a polycarbonate; a polycarbonate including repeating units derived from a monomer including a pendant ester group; glass fibers; optionally a poly(carbonate-siloxane) in an amount effective to provide 0.5-10 wt% siloxane; and a non-halogenated flame retardant. The individual components of the polycarbonate compositions are described in detail below.

[00013] "Polycarbonate" as used herein means a polymer having repeating structural carbonate units of formula (1)



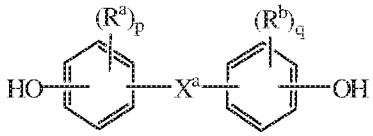
(1)

in which at least 60 percent of the total number of R^1 groups contain aromatic moieties and the balance thereof are aliphatic, alicyclic, or aromatic. In an aspect, each R^1 is a C_{6-30} aromatic

group, that is, contains at least one aromatic moiety. R^1 may be derived from an aromatic dihydroxy compound of the formula HO-R^1-OH, in particular of formula (2)

$$HO–A^1–Y^1–A^2–OH \quad (2)$$

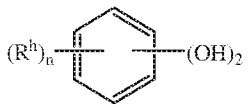
wherein each of A^1 and A^2 is a monocyclic divalent aromatic group and Y^1 is a single bond or a bridging group having one or more atoms that separate A^1 from A^2. In an aspect, one atom separates A^1 from A^2. Preferably, each R^1 may be derived from a bisphenol of formula (3)



(3)

wherein R^a and R^b are each independently a halogen, C_{1-12} alkoxy, or C_{1-12} alkyl, and p and q are each independently integers of 0 to 4. It will be understood that when p or q is less than 4, the valence of each carbon of the ring is filled by hydrogen. Also in formula (3), X^a is a bridging group connecting the two hydroxy-substituted aromatic groups, where the bridging group and the hydroxy substituent of each C_6 arylene group are disposed ortho, meta, or para (preferably para) to each other on the C_6 arylene group. In an aspect, the bridging group X^a is single bond, -O-, -S-, -S(O)-, -$S(O)_2$-, -C(O)-, or a C_{1-60} organic group. The organic bridging group may be cyclic or acyclic, aromatic or non-aromatic, and may further include heteroatoms such as halogens, oxygen, nitrogen, sulfur, silicon, or phosphorous. The C_{1-60} organic group may be disposed such that the C_6 arylene groups connected thereto are each connected to a common alkylidene carbon or to different carbons of the C_{1-60} organic bridging group. In an aspect, p and q is each 1, and R^a and R^b are each a C_{1-3} alkyl group, preferably methyl, disposed meta to the hydroxy group on each arylene group.

[00014] Other useful dihydroxy compounds of the formula HO-R^1-OH include aromatic dihydroxy compounds of formula (6)



(6)

wherein each R^h is independently a halogen atom, C_{1-10} hydrocarbyl group such as a C_{1-10} alkyl, a halogen-substituted C_{1-10} alkyl, a C_{6-10} aryl, or a halogen-substituted C_{6-10} aryl, and n is 0 to 4. The halogen is usually bromine.

[00015] Some illustrative examples of specific dihydroxy compounds include the following: 4,4'-dihydroxybiphenyl, 1,6-dihydroxynaphthalene, 2,6-dihydroxynaphthalene, bis(4-hydroxyphenyl)methane, bis(4-hydroxyphenyl)diphenylmethane, bis(4-hydroxyphenyl)-1-naphthylmethane, 1,2-bis(4-hydroxyphenyl)ethane, 1,1-bis(4-hydroxyphenyl)-1-phenylethane,

2-(4-hydroxyphenyl)-2-(3-hydroxyphenyl)propane, bis(4-hydroxyphenyl)phenylmethane, 2,2-bis(4-hydroxy-3-bromophenyl)propane, 1,1-bis (hydroxyphenyl)cyclopentane, 1,1-bis(4-hydroxyphenyl)cyclohexane, 1,1-bis(4-hydroxyphenyl)isobutene, 1,1-bis(4-hydroxyphenyl)cyclododecane, trans-2,3-bis(4-hydroxyphenyl)-2-butene, 2,2-bis(4-hydroxyphenyl)adamantane, alpha, alpha'-bis(4-hydroxyphenyl)toluene, bis(4-hydroxyphenyl)acetonitrile, 2,2-bis(3-methyl-4-hydroxyphenyl)propane, 2,2-bis(3-ethyl-4-hydroxyphenyl)propane, 2,2-bis(3-n-propyl-4-hydroxyphenyl)propane, 2,2-bis(3-isopropyl-4-hydroxyphenyl)propane, 2,2-bis(3-sec-butyl-4-hydroxyphenyl)propane, 2,2-bis(3-t-butyl-4-hydroxyphenyl)propane, 2,2-bis(3-cyclohexyl-4-hydroxyphenyl)propane, 2,2-bis(3-allyl-4-hydroxyphenyl)propane, 2,2-bis(3-methoxy-4-hydroxyphenyl)propane, 2,2-bis(4-hydroxyphenyl)hexafluoropropane, 1,1-dichloro-2,2-bis(4-hydroxyphenyl)ethylene, 1,1-dibromo-2,2-bis(4-hydroxyphenyl)ethylene, 1,1-dichloro-2,2-bis(5-phenoxy-4-hydroxyphenyl)ethylene, 4,4'-dihydroxybenzophenone, 3,3-bis(4-hydroxyphenyl)-2-butanone, 1,6-bis(4-hydroxyphenyl)-1,6-hexanedione, ethylene glycol bis(4-hydroxyphenyl)ether, bis(4-hydroxyphenyl)ether, bis(4-hydroxyphenyl)sulfide, bis(4-hydroxyphenyl)sulfoxide, bis(4-hydroxyphenyl)sulfone, 9,9-bis(4-hydroxyphenyl)fluorine, 2,7-dihydroxypyrene, 6,6'-dihydroxy-3,3,3',3'- tetramethylspiro(bis)indane ("spirobiindane bisphenol"), 3,3-bis(4-hydroxyphenyl)phthalimide, 2,6-dihydroxydibenzo-p-dioxin, 2,6-dihydroxythianthrene, 2,7-dihydroxyphenoxathin, 2,7-dihydroxy-9,10-dimethylphenazine, 3,6-dihydroxydibenzofuran, 3,6-dihydroxydibenzothiophene, and 2,7-dihydroxycarbazole, resorcinol, substituted resorcinol compounds such as 5-methyl resorcinol, 5-ethyl resorcinol, 5-propyl resorcinol, 5-butyl resorcinol, 5-t-butyl resorcinol, 5-phenyl resorcinol, 5-cumyl resorcinol, 2,4,5,6-tetrafluoro resorcinol, 2,4,5,6-tetrabromo resorcinol, or the like; catechol; hydroquinone; substituted hydroquinones such as 2-methyl hydroquinone, 2-ethyl hydroquinone, 2-propyl hydroquinone, 2-butyl hydroquinone, 2-t-butyl hydroquinone, 2-phenyl hydroquinone, 2-cumyl hydroquinone, 2,3,5,6-tetramethyl hydroquinone, 2,3,5,6-tetra-t-butyl hydroquinone, 2,3,5,6-tetrafluoro hydroquinone, 2,3,5,6-tetrabromo hydroquinone, or the like, or a combination thereof.

[00016] The polycarbonates may have an intrinsic viscosity, as determined in chloroform at 25°C, of 0.3 to 1.5 deciliters per gram (dl/gm), preferably 0.45 to 1.0 dl/gm. The polycarbonates may have a weight average molecular weight (Mw) of 10,000 to 200,000 g/mol, preferably 20,000 to 100,000 g/mol, as measured by gel permeation chromatography (GPC), using a crosslinked styrene-divinylbenzene column using polystyrene standards and calculated for polycarbonate. GPC samples are prepared at a concentration of 1 mg per ml, and are eluted at a flow rate of 1.5 ml per minute.

[00017] The polycarbonate of the polycarbonate compositions may have a glass transition temperature of less than 155 °C, determined according to ASTM E1640-13 with a 1°C/min heating rate.

[00018] The polycarbonate compositions may include a homopolycarbonate (wherein each R^1 in the polymer is the same). In an aspect, the homopolycarbonate in the polycarbonate composition is derived from a bisphenol of formula (2), preferably bisphenol A, in which each of A^1 and A^2 is p-phenylene and Y^1 is isopropylidene in formula (2).

[00019] In some aspects, the polycarbonate is a bisphenol A homopolycarbonate. The bisphenol A homopolycarbonate may have: a melt flow rate of 3-150, per 10 min at 300 °C and a 1.2 kg load according to ASTM D1238-04 and a Mw of 15,000-40,000, g/mole, preferably 20,000-30,000 g/mole, each as measured as described above. In some aspects, the polycarbonate includes a linear or branched bisphenol A homopolycarbonate. In some aspects, the polycarbonate includes a linear bisphenol A polycarbonate homopolymer having a weight average molecular weight of 26,000 to 40,000 grams per mole, preferably 27,000 to 35,000 grams per mole, as determined by gel permeation chromatography using polystyrene standards and calculated for polycarbonate; or a linear bisphenol A polycarbonate homopolymer having a weight average molecular weight of 15,000 to 25,000 grams per mole, preferably 17,000 to 25,000 grams per mole, as determined by gel permeation chromatography using polystyrene standards and calculated for polycarbonate; or a combination thereof.

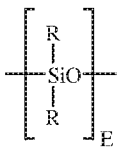
[00020] The polycarbonate of the polycarbonate composition may include post-consumer recycled polycarbonate ("PCR-PC"). PCR-PC is derived or recycled from polycarbonate as described herein. PCR-PC may be recovered from a source after consumption. In addition, PCR-PC may be recovered from post-consumer sources including, but not limited to, household appliance waste such as TV, air conditioner, washing machine, refrigerator, etc. Regardless of the source, the recovered polycarbonate component may be similar or even identical to the chemical composition of the corresponding original polycarbonate. In one example, the polycarbonate may be derived from an optical disc. In another example, the PCR-PC may be derived from a plastic bottle, such as a plastic beverage bottle. In contrast, virgin polycarbonate polymers refer to polycarbonate polymers produced directly from petrochemical feedstocks, such as natural gas or crude oil, which have never been used or processed before. One possible difference between the original polycarbonate component used in the composition of the invention and the PCR-PC is the presence of at least one impurity that is not present in the original material. For example, one or more additives conventionally used in the manufacture of impact modified thermoplastics may be present as impurities. Additional impurities may include

processing residues such as lubricants, mold release agents, antistatic agents, stabilizers, light stabilizers, flame retardants, metals (e.g., iron, aluminum, and copper). In addition, impurities may include polyurethane particles that cannot be completely removed during the recovery process. In some aspects, the level of impurities in the PCR-PC is less than about 5 wt%, or in other aspects less than about 3 wt%, or in other aspects less than about 2 wt%. If present, the impurities do not significantly affect the properties of the compositions described herein.

[00021] The polycarbonate(s) may be present, for example, from 10-95 wt%, 20-90 wt%, 30-90 wt%, 40-90 wt%, 50-90 wt%, 60-90 wt%, 60-70 wt%, 20-60 wt%, 20-50 wt%, or 20-40 wt%, based on the total weight of the polycarbonate composition. In some aspects, the polycarbonate(s) may be present, for example, from 60-95 wt%, 65-95 wt%, 70-95 wt%, 70-90 wt%, 75-95 wt%. 75-90 wt%, 80-95 wt%, 80-90 wt%, or 85-95 wt%, based on the total weight of the polycarbonate composition.

[00022] "Polycarbonates" include homopolycarbonates (wherein each R^1 in the polymer is the same) and copolymers including different R^1 moieties in the carbonate ("copolycarbonates"), and copolymers including carbonate units and other types of polymer units, such as ester units or siloxane units.

[00023] The polycarbonate compositions may include one or more poly(carbonate-siloxane)s, also referred to in the art as polycarbonate-polysiloxane copolymers. The polysiloxane blocks include repeating diorganosiloxane units as in formula (10)



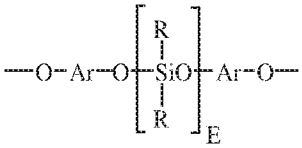
(10)

wherein each R is independently a C_{1-13} monovalent organic group. For example, R may be a C_{1-13} alkyl, C_{1-13} alkoxy, C_{2-13} alkenyl, C_{2-13} alkenyloxy, C_{3-6} cycloalkyl, C_{3-6} cycloalkoxy, C_{6-14} aryl, C_{6-10} aryloxy, C_{7-13} arylalkylene, C_{7-13} arylalkylenoxy, C_{7-13} alkylarylene, or C_{7-13} alkylaryleneoxy. The foregoing groups may be fully or partially halogenated with fluorine, chlorine, bromine, or iodine, or a combination thereof. In an aspect, where a transparent poly(carbonate-siloxane) is desired, R is unsubstituted by halogen. Combinations of the foregoing R groups may be used in the same copolymer.

[00024] The value of E in formula (10) may vary widely depending on the type and relative amount of each component in the polycarbonate composition, the desired properties of the composition, and like considerations. Generally, E has an average value of 2 to 1,000, preferably 2 to 500, 2 to 200, or 2 to 125, 5 to 80, or 10 to 70. In an aspect, E has an average

value of 10 to 80 or 10 to 40, and in still another aspect, E has an average value of 40 to 80, or 40 to 70. Where E is of a lower value, e.g., less than 40, it may be desirable to use a relatively larger amount of the poly(carbonate-siloxane) copolymer. Conversely, where E is of a higher value, e.g., greater than 40, a relatively lower amount of the poly(carbonate-siloxane) copolymer may be used. A combination of a first and a second (or more) poly(carbonate-siloxane) copolymers may be used, wherein the average value of E of the first copolymer is less than the average value of E of the second copolymer.

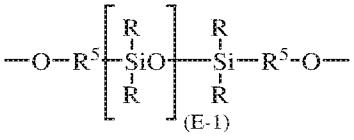
[00025] In an aspect, the polysiloxane blocks are of formula (11)



(11)

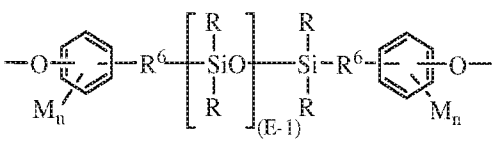
wherein E and R is each as defined if formula (10); each R may be the same or different, and is as defined above; and Ar may be the same or different, and is a substituted or unsubstituted C_{6-30} arylene, wherein the bonds are directly connected to an aromatic moiety. Ar groups in formula (11) may be derived from a C_{6-30} dihydroxyarylene compound, for example a dihydroxyarylene compound of formula (3) or (6). Dihydroxyarylene compounds are 1,1-bis(4-hydroxyphenyl) methane, 1,1-bis(4-hydroxyphenyl) ethane, 2,2-bis(4-hydroxyphenyl) propane, 2,2-bis(4-hydroxyphenyl) butane, 2,2-bis(4-hydroxyphenyl) octane, 1,1-bis(4-hydroxyphenyl) propane, 1,1-bis(4-hydroxyphenyl) n-butane, 2,2-bis(4-hydroxy-1-methylphenyl) propane, 1,1-bis(4-hydroxyphenyl) cyclohexane, bis(4-hydroxyphenyl sulfide), and 1,1-bis(4-hydroxy-t-butylphenyl) propane.

[00026] In another aspect, polysiloxane blocks are of formula (13)



(13)

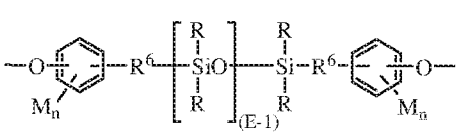
wherein R and E are as described above, and each R^5 is independently a divalent C_{1-30} organic group, and wherein the polymerized polysiloxane unit is the reaction residue of its corresponding dihydroxy compound. In a specific aspect, the polysiloxane blocks are of formula (14):

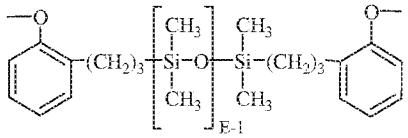


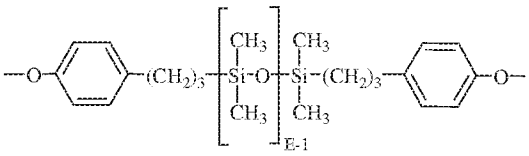
(14)

wherein R and E are as defined above. R^6 in formula (14) is a divalent C_{2-8} aliphatic group. Each M in formula (14) may be the same or different, and may be a halogen, cyano, nitro, C_{1-8} alkylthio, C_{1-8} alkyl, C_{1-8} alkoxy, C_{2-8} alkenyl, C_{2-8} alkenyloxy, C_{3-8} cycloalkyl, C_{3-8} cycloalkoxy, C_{6-10} aryl, C_{6-10} aryloxy, C_{7-12} aralkyl, C_{7-12} aralkoxy, C_{7-12} alkylaryl, or C_{7-12} alkylaryloxy, wherein each n is independently 0, 1, 2, 3, or 4.

[00027] In an aspect, M is bromo or chloro, an alkyl such as methyl, ethyl, or propyl, an alkoxy such as methoxy, ethoxy, or propoxy, or an aryl such as phenyl, chlorophenyl, or tolyl; R^6 is a dimethylene, trimethylene or tetramethylene; and R is a C_{1-8} alkyl, haloalkyl such as trifluoropropyl, cyanoalkyl, or aryl such as phenyl, chlorophenyl or tolyl. In another aspect, R is methyl, or a combination of methyl and trifluoropropyl, or a combination of methyl and phenyl. In still another aspect, R is methyl, M is methoxy, n is one, and R^6 is a divalent C_{1-3} aliphatic group. Specific polysiloxane blocks are of the formula


(14a),


(14b),


(14c),

or a combination thereof, wherein E has an average value of 2 to 200, 2 to 125, 5 to 125, 5 to 100, 5 to 50, 20 to 80, or 5 to 20.

[00028] Blocks of formula (14) may be derived from the corresponding dihydroxy polysiloxane, which in turn may be prepared effecting a platinum-catalyzed addition between the siloxane hydride and an aliphatically unsaturated monohydric phenol such as eugenol, 2-alkylphenol, 4-allyl-2-methylphenol, 4-allyl-2-phenylphenol, 4-allyl-2-bromophenol, 4-allyl-2-t-butoxyphenol, 4-phenyl-2-phenylphenol, 2-methyl-4-propylphenol, 2-allyl-4,6-dimethylphenol, 2-allyl-4-bromo-6-methylphenol, 2-allyl-6-methoxy-4-methylphenol and 2-allyl-4,6-dimethylphenol. The poly(carbonate-siloxane) copolymers may then be manufactured, for example, by the synthetic procedure of European Patent Application Publication No. 0 524 731 A1 of Hoover, page 5, Preparation 2.

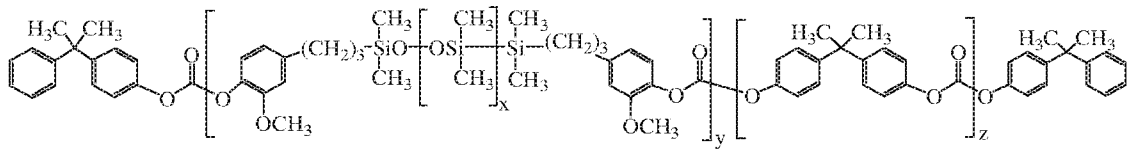
[00029] Transparent poly(carbonate-siloxane) copolymers include carbonate units (1) derived from bisphenol A, and repeating siloxane units (14a), (14b), (14c), or a combination thereof (preferably of formula 14a), wherein E has an average value of 4 to 50, 4 to 15, preferably 5 to 15, more preferably 6 to 15, and still more preferably 7 to 10. The transparent

copolymers may be manufactured using one or both of the tube reactor processes described in U.S. Patent Application No. 2004/0039145A1 or the process described in U.S. Patent No. 6,723,864 may be used to synthesize the poly(carbonate-siloxane) copolymers.

[00030] The poly(carbonate-siloxane) copolymers may include 50 to 99 wt% of carbonate units and 1 to 50 wt% siloxane units. Within this range, the poly(carbonate-siloxane) copolymer may include 70 to 98 wt%, more preferably 75 to 97 wt% of carbonate units and 2 to 30 wt%, more preferably 3 to 25 wt% siloxane units.

[00031] The poly(carbonate-siloxane) copolymers may include 50 to 99 wt% of carbonate units and 1 to 50 wt% siloxane units. Within this range, the poly(carbonate-siloxane) copolymer may include 70 to 98 wt%, more preferably 75 to 97 wt% of carbonate units and 2 to 45 wt%, more preferably 5 to 10 or 30 to 45 wt% siloxane units.

[00032] In an aspect, a blend is used, in particular a blend of a bisphenol A homopolycarbonate and a poly(carbonate-siloxane) block copolymer of bisphenol A blocks and eugenol capped polydimethylsiloxane blocks, of the formula



wherein x is 1 to 200, preferably 5 to 85, preferably 10 to 70, preferably 15 to 65, and more preferably 40 to 60; x is 1 to 500, or 10 to 200, and z is 1 to 1000, or 10 to 800. In an aspect, x is 1 to 200, y is 1 to 90 and z is 1 to 600, and in another aspect, x is 30 to 50, y is 10 to 30 and z is 45 to 600. The polysiloxane blocks may be randomly distributed or controlled distributed among the polycarbonate blocks.

[00033] Poly(carbonate-siloxane)s may have a weight average molecular weight of 2,000 to 100,000 g/mol, preferably 5,000 to 50,000 g/mol as measured by gel permeation chromatography using a crosslinked styrene-divinyl benzene column, at a sample concentration of 1 milligram per milliliter, using polystyrene standards and calculated for polycarbonate.

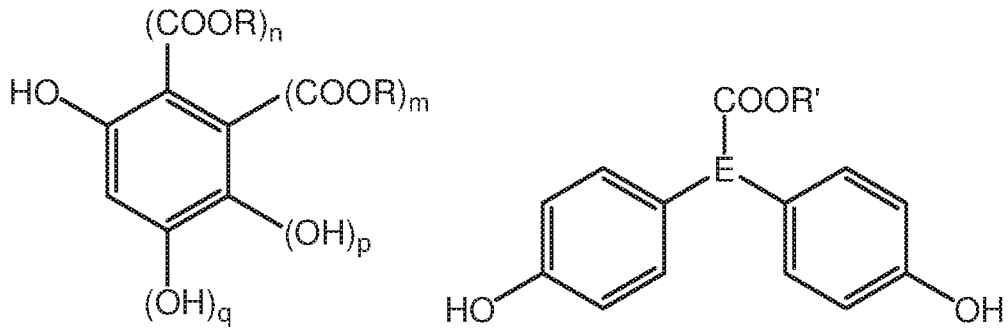
[00034] The poly(carbonate-siloxane)s may have a melt volume flow rate, measured at 300°C/1.2 kg, of 0.1 to 50 cubic centimeters per 10 minutes (cc/10 min), preferably 2 to 30 cc/10 min, according to ASTM D1238-04. Combinations of the poly(carbonate-siloxane)s of different flow properties may be used to achieve the overall desired flow property.

[00035] One or more poly(carbonate-siloxane) copolymers may be included in the polycarbonate compositions. The polycarbonate compositions may include a poly(carbonate-siloxane) copolymer having a siloxane repeating units of greater than 30 to 70 wt%, based on the total weight of the poly(carbonate-siloxane) copolymer. Within this range, the poly(carbonate-

siloxane) may have a siloxane repeating units of 35 to 70 wt%, or 35 to 65 wt%. As used herein, "siloxane repeating units" of a poly(carbonate-siloxane) refers to the content of siloxane units based on the total weight of the poly(carbonate-siloxane). The polycarbonate compositions may include a poly(carbonate-siloxane) copolymer having a siloxane repeating units of greater than 10 to 30 wt%, based on the total weight of the poly(carbonate-siloxane). Within this range, the poly(carbonate-siloxane) copolymer may have a siloxane repeating units of 15 to 25 wt%. The polycarbonate compositions may include a poly(carbonate-siloxane) copolymer having a siloxane repeating units of 10 wt% or less, based on the total weight of the poly(carbonate-siloxane). Within this range, the poly(carbonate-siloxane) copolymer may have a siloxane repeating units of 4 to 8 wt%. The polycarbonate compositions may include two or more of the foregoing.

[00036] When present, the poly(carbonate siloxane) copolymers may be present in an amount effective to provide 0.5-10 wt%, 0.5-8 wt%, 1-8 wt%, 2-8 wt%, or 4-8 wt% of siloxane repeating units, each based on the total composition. In an aspect, the polycarbonate compositions exclude poly(carbonate siloxane)s.

[00037] In addition to the polycarbonate and the optional poly(carbonate siloxane), the polycarbonate compositions include a polycarbonate including repeating units derived from a monomer including a pendant ester group. The polycarbonate having pendant ester groups includes a repeating unit derived from a bisphenol and a repeating unit derived from a monomer including the pendant ester group. The monomer including the pendant ester group has the structure of Formula (A) or Formula (B):



[00038] In Formula (A) and Formula (B), each occurrence of R and R' is independently C_2-C_{15} alkyl; each of m, n, p, and q is independently 0 or 1; m + n = 1; p + q = 1; and E is C_1-C_{15} alkyl. In some aspects, R is a linear or a branched C_2-C_{15} alkyl group, preferably a branched C_2-C_{15} alkyl group. In some aspects, R is ethyl, isopropyl, sec-butyl, tert-butyl, or isopentyl, preferably ethyl or isopropyl, more preferably isopropyl. The a polycarbonate including repeating units derived from a monomer including a pendant ester group may include repeating

units derived from Formula (A), repeating units of Formula (B), or a combination thereof. The pendant ester groups in the polycarbonate may be the same or different. The polycarbonate may be derived from Formula (A), Formula (B), or a combination thereof and the pendant ester groups may be the same. The polycarbonate may be derived from Formula (A), Formula (B), or a combination thereof and the pendant ester groups may be different. In some aspects, the a polycarbonate including repeating units derived from a monomer including a pendant ester group may include bisphenol A repeating units. In some aspects, the a polycarbonate including repeating units derived from a monomer including a pendant ester group may include bisphenol A repeating units and repeating units derived from a monomer of Formula (A), a monomer of Formula (B), or a combination thereof, wherein the pendant ester groups include ethyl esters, isopropyl esters, or a combination thereof. The polycarbonate(s) including repeating units derived from a monomer including a pendant ester group may include a polysiloxane block as described above. The polycarbonate including repeating units derived from a monomer including a pendant ester group may include 1-99 mol%, 1-90 mol%, 1-75 mol%, 1-60 mol%, 1-50 mol%, 1-40 mol%, 1-30 mol%, 1-25 mol%, 1-20 mol%, 1-15 mol%, 1-10 mol%, or 1-5 mol% of ester repeating units, each based on the total moles of monomers in the polycarbonate. The a polycarbonate including repeating units derived from a monomer including a pendant ester group may be present in the composition in an amount effective to provide 0.1-5 mol%, 0.1-4.5 mol%, 0.1-4.0 mol%, 0.1-3.5 mol%,0.1-3.0 mol%, 0.1-2.5 mol%, 0.1-2.0 mol%, 1.0-5.0 mol%, or 2.0-4.0 mol% ester repeating units, each based on the total monomers in the composition.

[00039] The polycarbonate including repeating units derived from a monomer including a pendant ester group may be oligomeric or polymeric, with a weight average molecular weight ranging from 1,000 to 150,000 g/mol, each measured by GPC using polystyrene standards and calculated for polycarbonate. Within this range, in some aspects, the polycarbonate including repeating units derived from a monomer including a pendant ester group may have a Mw of 5,000 to less than 26,000 g/mol, or 5,000-20,000 g/mol, 5,000-15,000 g/mol, or 10,000-15,000 g/mol. In some aspects, the polycarbonate including repeating units derived from a monomer including a pendant ester group may have a Mw of 26,000-50,000 g/mol or 26,000-45,000 g/mol. In some aspects, the polycarbonate including repeating units derived from a monomer including a pendant ester group may have a Mw of 50,000-150,000 g/mol, 75,000-150,000 g/mol, or 100,000-150,000 g/mol. As used herein, "using polystyrene standards and calculated for polycarbonate" refers to measurement of the retention time by GPC, fitting the retention time value to a curve for polystyrene and calculating the molecular weight for polycarbonate.

[00040] Polycarbonates may be manufactured by processes such as interfacial polymerization and melt polymerization. Although the reaction conditions for interfacial polymerization may vary, an exemplary process generally involves dissolving or dispersing a dihydroxy compound in aqueous NaOH or KOH, adding the resulting mixture to a water-immiscible solvent, and contacting the reactants with a carbonate precursor in the presence of a catalyst such as, for example, a tertiary amine or a phase transfer catalyst, under controlled pH conditions, e.g., 8 to 10. The water-immiscible solvent may be, for example, methylene chloride, 1,2-dichloroethane, chlorobenzene, toluene, and the like.

[00041] Exemplary carbonate precursors include a carbonyl halide such as carbonyl bromide or carbonyl chloride (phosgene) a bishaloformate of a dihydroxy compound (e.g., the bischloroformate of bisphenol A, hydroquinone ethylene glycol, neopentyl glycol, or the like), and diaryl carbonates. A combination thereof may also be used. The diaryl carbonate ester may be diphenyl carbonate, or an activated diphenyl carbonate having electron-withdrawing substituents on each aryl, such as bis(4-nitrophenyl)carbonate, bis(2-chlorophenyl)carbonate, bis(4-chlorophenyl)carbonate, bis(methyl salicyl)carbonate, bis(4-methylcarboxylphenyl) carbonate, bis(2-acetylphenyl) carboxylate, bis(4-acetylphenyl) carboxylate, or a combination thereof.

[00042] Among tertiary amines that may be used as catalysts in interfacial polymerization are aliphatic tertiary amines such as triethylamine and tributylamine, cycloaliphatic tertiary amines such as N,N-diethyl-cyclohexylamine, and aromatic tertiary amines such as N,N-dimethylaniline. Among the phase transfer catalysts that may be used are catalysts of the formula $(R^3)_4Q^+X$, wherein each R^3 is the same or different, and is a C_{1-10} alkyl; Q is a nitrogen or phosphorus atom; and X is a halogen atom or a C_{1-8} alkoxy or C_{6-18} aryloxy. Exemplary phase transfer catalysts include $(CH_3(CH_2)_3)_4NX$, $(CH_3(CH_2)_3)_4PX$, $(CH_3(CH_2)_5)_4NX$, $(CH_3(CH_2)_6)_4NX$, $(CH_3(CH_2)_4)_4NX$, $CH_3(CH_3(CH_2)_3)_3NX$, and $CH_3(CH_3(CH_2)_2)_3NX$, wherein X is Cl^-, Br^-, a C_{1-8} alkoxy or a C_{6-18} aryloxy. An effective amount of a phase transfer catalyst may be 0.1 to 10 wt%, or 0.5 to 2 wt%, each based on the weight of dihydroxy compound in the phosgenation mixture.

[00043] Alternatively, melt processes may be used to make the polycarbonates. Generally, in the melt polymerization process, polycarbonates may be prepared by co-reacting, in a molten state, a dihydroxy reactant and a diaryl carbonate ester in the presence of a transesterification catalyst. The reaction can be carried out in typical polymerization equipment, such as a continuously stirred reactor (CSTR), plug flow reactor, wire wetting fall polymerizers, free fall polymerizers, wiped film polymerizers, BANBURY mixers, single or twin screw

extruders, or a combination of the foregoing. Volatile monohydric phenol is removed from the molten reactants by distillation and the polymer is isolated as a molten residue. Melt polymerization can be conducted as a batch process or as a continuous process. In either case, the melt polymerization conditions used may include two or more distinct reaction stages, for example, a first reaction stage in which the starting dihydroxy aromatic compound and diaryl carbonate are converted into an oligomeric polycarbonate and a second reaction stage wherein the oligomeric polycarbonate formed in the first reaction stage is converted to high molecular weight polycarbonate. Such "staged" polymerization reaction conditions are especially suitable for use in continuous polymerization systems wherein the starting monomers are oligomerized in a first reaction vessel and the oligomeric polycarbonate formed therein is continuously transferred to one or more downstream reactors in which the oligomeric polycarbonate is converted to high molecular weight polycarbonate. Typically, in the oligomerization stage the oligomeric polycarbonate produced has a number average molecular weight of 1,000 to 7,500 g/mol. In one or more subsequent polymerization stages the number average molecular weight (Mn) of the polycarbonate is increased to between 8,000 and 25,000 g/mol (using polycarbonate standard). Typically, solvents are not used in the process, and the reactants dihydroxy aromatic compound and the diaryl carbonate are in a molten state. The reaction temperature may be 100°C to 350°C, preferably 180°C to 310°C. The pressure can be at atmospheric pressure, supra-atmospheric pressure, or a range of pressures from atmospheric pressure to 15 torr in the initial stages of the reaction, and at a reduced pressure at later stages, for example 0.2 to 15 torr. The reaction time is generally 0.1 hours to 10 hours.

[00044] Catalysts used in the melt transesterification polymerization production of polycarbonates may include alpha or beta catalysts. Beta catalysts are typically volatile and degrade at elevated temperatures. Beta catalysts are therefore preferred for use at early low-temperature polymerization stages. Alpha catalysts are typically more thermally stable and less volatile than beta catalysts.

[00045] The alpha catalyst may include a source of alkali or alkaline earth ions. The sources of these ions include alkali metal hydroxides such as lithium hydroxide, sodium hydroxide, and potassium hydroxide, as well as alkaline earth hydroxides such as magnesium hydroxide and calcium hydroxide. Other possible sources of alkali and alkaline earth metal ions include the corresponding salts of carboxylic acids (such as sodium acetate) and derivatives of ethylene diamine tetraacetic acid (EDTA) (such as EDTA tetrasodium salt, and EDTA magnesium disodium salt). Other alpha transesterification catalysts include alkali or alkaline earth metal salts of carbonate, such as Cs_2CO_3, $NaHCO_3$, and Na_2CO_3, and the like, non-volatile

inorganic acid such as NaH_2PO_3, NaH_2PO_4, Na_2HPO_3, KH_2PO_4, CsH_2PO_4, Cs_2HPO_4, and the like, or mixed salts of phosphoric acid, such as $NaKHPO_4$, $CsNaHPO_4$, $CsKHPO_4$, and the like. Combinations including at least one of any of the foregoing catalysts may be used.

[00046] Possible beta catalysts may include a quaternary ammonium compound, a quaternary phosphonium compound, or a combination thereof. The quaternary ammonium compound may be a compound of the structure $(R^4)_4N^+X^-$, wherein each R^4 is the same or different, and is a C_{1-20} alkyl, a C_{4-20} cycloalkyl, or a C_{4-20} aryl; and X^- is an organic or inorganic anion, for example a hydroxide, halide, carboxylate, sulfonate, sulfate, formate, carbonate, or bicarbonate. Examples of organic quaternary ammonium compounds include tetramethyl ammonium hydroxide, tetrabutyl ammonium hydroxide, tetramethyl ammonium acetate, tetramethyl ammonium formate, tetrabutyl ammonium acetate, and combination thereof. Tetramethyl ammonium hydroxide is often used. The quaternary phosphonium compound may be a compound of the structure $(R^5)_4P^+X^-$, wherein each R^5 is the same or different, and is a C_{1-20} alkyl, a C_{4-20} cycloalkyl, or a C_{4-20} aryl; and X^- is an organic or inorganic anion, for example a hydroxide, phenoxide, halide, carboxylate such as acetate or formate, sulfonate, sulfate, formate, carbonate, or bicarbonate. Where X^- is a polyvalent anion such as carbonate or sulfate it is understood that the positive and negative charges in the quaternary ammonium and phosphonium structures are properly balanced. For example, where R^4 or R^5 are each methyl and X^- is carbonate, it is understood that X^- represents $1/2(CO_3^{-2})$. Examples of organic quaternary phosphonium compounds include tetramethyl phosphonium hydroxide, tetramethyl phosphonium acetate, tetramethyl phosphonium formate, tetrabutyl phosphonium hydroxide, tetrabutyl phosphonium acetate (TBPA), tetraphenyl phosphonium acetate, tetraphenyl phosphonium phenoxide, and combination thereof. TBPA is often used.

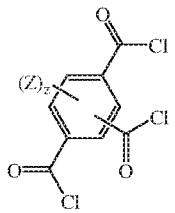
[00047] The amount of alpha and beta catalyst used may be based upon the total number of moles of dihydroxy compound used in the polymerization reaction. When referring to the ratio of beta catalyst, for example, a phosphonium salt, to all dihydroxy compounds used in the polymerization reaction, it is convenient to refer to moles of phosphonium salt per mole of the dihydroxy compound, meaning the number of moles of phosphonium salt divided by the sum of the moles of each individual dihydroxy compound present in the reaction mixture. The alpha catalyst may be used in an amount sufficient to provide 1×10^{-2} to 1×10^{-8} moles, preferably, 1×10^{-4} to 1×10^{-7} moles of metal per mole of the dihydroxy compounds used. The amount of beta catalyst (e.g., organic ammonium or phosphonium salts) may be 1×10^{-2} to 1×10^{-5}, preferably 1×10^{-3} to 1×10^{-4} moles per total mole of the dihydroxy compounds in the reaction mixture. Quenching of the transesterification catalysts and any reactive catalysts residues with an acidic

compound after polymerization is completed may also be useful in some melt polymerization processes. Removal of catalyst residues or quenching agent and other volatile residues from the melt polymerization reaction after polymerization is completed may also be useful in some melt polymerization processes.

[00048] Branched polycarbonate blocks may be prepared by adding a branching agent during polymerization. These branching agents include polyfunctional organic compounds containing at least three functional groups selected from hydroxyl, carboxyl, carboxylic anhydride, haloformyl, and mixtures of the foregoing functional groups. Specific examples include trimellitic acid, trimellitic anhydride, tris-phenol TC (1,3,5-tris((p-hydroxyphenyl)isopropyl)benzene), tris-phenol PA (4(4(1,1-bis(p-hydroxyphenyl)-ethyl) alpha, alpha-dimethyl benzyl)phenol), 4-chloroformyl phthalic anhydride, trimesic acid, and benzophenone tetracarboxylic acid. Combinations including linear polycarbonates and branched polycarbonates may be used.

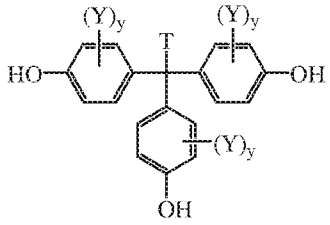
[00049] In some aspects, a particular type of branching agent is used to create branched polycarbonate materials. These branched polycarbonate materials have statistically more than two end groups. The branching agent is added in an amount (relative to the bisphenol monomer) that is sufficient to achieve the desired branching content, that is, more than two end groups. The molecular weight of the polymer may become very high upon addition of the branching agent, and to avoid excess viscosity during polymerization, an increased amount of a chain stopper agent may be used, relative to the amount used when the particular branching agent is not present. The amount of chain stopper used is generally above 5 mol% and less than 20 mol% compared to the bisphenol monomer.

[00050] Such branching agents include aromatic triacyl halides, for example triacyl chlorides of formula (20)



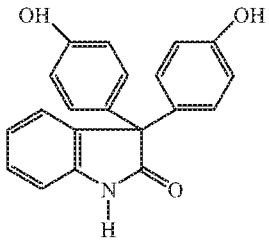
(20)

wherein Z is a halogen, C_{1-3} alkyl, C_{1-3} alkoxy, C_{7-12} arylalkylene, C_{7-12} alkylarylene, or nitro, and z is 0 to 3; a tri-substituted phenol of formula (21)



(21)

wherein T is a C_{1-20} alkyl, C_{1-20} alkoxy, C_{7-12} arylalkyl, or C_{7-12} alkylaryl, Y is a halogen, C_{1-3} alkyl, C_{1-3} alkoxy, C_{7-12} arylalkyl, C_{7-12} alkylaryl, or nitro, s is 0 to 4; or a compound of formula (22) (isatin-bis-phenol).



(22).

Examples of specific branching agents that are particularly effective in the compositions include trimellitic trichloride (TMTC), tris-p-hydroxyphenylethane (THPE), and isatin-bis-phenol.

[00051] The amount of the branching agents used in the manufacture of the polymer will depend on a number of considerations, for example the type of R^1 groups, the amount of chain stopper, e.g., cyanophenol, and the desired molecular weight of the polycarbonate. In general, the amount of branching agent is effective to provide 0.1 to 10 branching units per 100 R^1 units, preferably 0.5 to 8 branching units per 100 R^1 units, and more preferably 0.75 to 5 branching units per 100 R^1 units. For branching agents having formula (20), the branching agent is present in an amount to provide 0.1 to 10 triester branching units per 100 R^1 units, preferably 0.5 to 8, and more preferably 0.75 to 5 triester branching units per 100 R^1 units. For branching agents having formula (21), the branching agent is present in an amount effective to provide 0.1 to 10 triphenyl carbonate branching units per 100 R^1 units, preferably 0.5 to 8, and more preferably 2.5 to 3.5 triphenylcarbonate units per 100 R^1 units. In some aspects, a combination of two or more branching agents may be used. Alternatively, the branching agents may be added at a level of 0.05 to 2.0 wt.%.

[00052] In an aspect, the polycarbonate is a branched polycarbonate including units as described above; greater than or equal to 3 mole%, based on the total moles of the polycarbonate, of moieties derived from a branching agent; and end-capping groups derived from an end-capping agent having a pKa between 8.3 and 11. The branching agent may include trimellitic trichloride, 1,1,1-tris(4-hydroxyphenyl)ethane or a combination of trimellitic trichloride and 1,1,1-tris(4-hydroxyphenyl)ethane, and the end-capping agent is phenol or a

phenol containing a substituent of cyano group, aliphatic groups, olefinic groups, aromatic groups, halogens, ester groups, ether groups, or a combination thereof. In a specific aspect, the end-capping agent is phenol, p-t-butylphenol, p-methoxyphenol, p-cyanophenol, p-cumylphenol, or a combination thereof.

[00053] In some aspects, the polycarbonate compositions are substantially free of branched polycarbonates. When present, branched polycarbonates are present in an amount effective to provide less than or equal to 0.05 mol% branching, based on the total moles of carbonate repeating units in the polycarbonate composition. Within that range, the branched polycarbonates are present in an amount effective to provide less than or equal to 0.025 mol%, less than or equal to 0.02 mol%, less than or equal to 0.015 mol%, less than or equal to 0.01 mol%, less than or equal to 0.005 mol%, or less than or equal to 0.001 mol% branching, based on the total moles of carbonate repeating units in the composition. In some aspects, the polycarbonate compositions exclude branched polycarbonates.

[00054] An end-capping agent (also referred to as a chain stopper agent or chain terminating agent) may be included during polymerization to provide end groups. The end-capping agent (and thus end groups) are selected based on the desired properties of the polycarbonates. Exemplary end-capping agents are exemplified by monocyclic phenols such as phenol and C_{1-22} alkyl-substituted phenols such as p-cumyl-phenol, resorcinol monobenzoate, and p-and tertiary-butyl phenol, monoethers of diphenols, such as p-methoxyphenol, and alkyl-substituted phenols with branched chain alkyl substituents having 8 to 9 carbon atoms, 4-substituted-2-hydroxybenzophenones and their derivatives, aryl salicylates, monoesters of diphenols such as resorcinol monobenzoate, 2-(2-hydroxyaryl)-benzotriazoles and their derivatives, 2-(2-hydroxyaryl)-1,3,5-triazines and their derivatives, mono-carboxylic acid chlorides such as benzoyl chloride, C_{1-22} alkyl-substituted benzoyl chloride, toluoyl chloride, bromobenzoyl chloride, cinnamoyl chloride, and 4-nadimidobenzoyl chloride, polycyclic, mono-carboxylic acid chlorides such as trimellitic anhydride chloride, and naphthoyl chloride, functionalized chlorides of aliphatic monocarboxylic acids, such as acryloyl chloride and methacryoyl chloride, and mono-chloroformates such as phenyl chloroformate, alkyl-substituted phenyl chloroformates, p-cumyl phenyl chloroformate, and toluene chloroformate. Combinations of different end groups may be used.

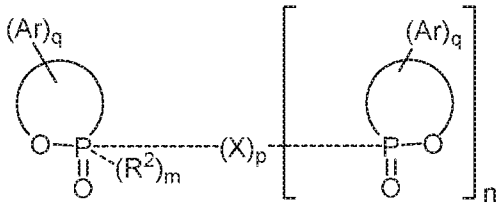
[00055] The polycarbonate compositions include a non-halogenated flame retardant. In an exemplary aspect, the polycarbonate compositions avoid the use of fluorinated flame retardants such as Rimar salt and brominated flame retardants such a brominated polycarbonate copolymers. Inorganic non-halogenated flame retardants may be used, for example salts of

aromatic sulfonates such as sodium benzene sulfonate, sodium toluene sulfonate (NATS), and the like, salts of aromatic sulfone sulfonates such as potassium diphenylsulfone sulfonate (KSS), and the like; salts formed by reacting for example an alkali metal or alkaline earth metal (e.g., lithium, sodium, potassium, magnesium, calcium and barium salts) and an inorganic acid complex salt, for example, an oxo-anion (e.g., alkali metal and alkaline-earth metal salts of carbonic acid, such as Na_2CO_3, K_2CO_3, $MgCO_3$, $CaCO_3$, and $BaCO_3$, KSS and NATS, alone or in combination with other non-halogenated flame retardants, are particularly useful. Exemplary amounts of an aromatic sulfone sulfonate salt may be 0.01 to 1.0 wt%, or 0.1 to 0.6 wt%, based on the total weight of the polycarbonate composition.

[00056] The polycarbonate compositions may include an organophosphorous flame retardant. In the aromatic organophosphorous compounds that have at least one organic aromatic group, the aromatic group may be a substituted or unsubstituted C_{3-30} group containing one or more of a monocyclic or polycyclic aromatic moiety (which may optionally contain with up to three heteroatoms (N, O, P, S, or Si)) and optionally further containing one or more nonaromatic moieties, for example alkyl, alkenyl, alkynyl, or cycloalkyl. The aromatic moiety of the aromatic group may be directly bonded to the phosphorous-containing group, or bonded via another moiety, for example an alkylene group. The aromatic moiety of the aromatic group may be directly bonded to the phosphorous-containing group, or bonded via another moiety, for example an alkylene group. In an aspect the aromatic group is the same as an aromatic group of the polycarbonate backbone, such as a bisphenol group (e.g., bisphenol A), a monoarylene group (e.g., a 1,3-phenylene or a 1,4-phenylene), or a combination including at least one of the foregoing.

[00057] The phosphorous-containing group may be a phosphate ($P(=O)(OR)_3$), phosphite ($P(OR)_3$), phosphonate ($RP(=O)(OR)_2$), phosphinate ($R_2P(=O)(OR)$), phosphine oxide ($R_3P(=O)$), or phosphine (R_3P), wherein each R in the foregoing phosphorous-containing groups may be the same or different, provided that at least one R is an aromatic group. A combination of different phosphorous-containing groups may be used. The aromatic group may be directly or indirectly bonded to the phosphorous, or to an oxygen of the phosphorous-containing group (i.e., an ester).

[00058] The organophosphorous flame retardant may include an oxaphosphorinoxide of the Formula (23) below.

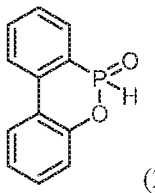


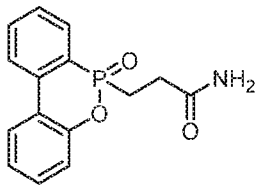
(23)

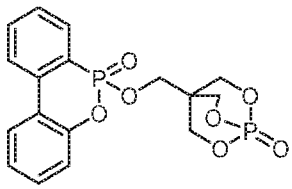
[00059] In Formula (23), the phosphorous atom and one oxygen atom are part of a cyclic structure, for example, a five or six membered ring and q is at least two. Each Ar is independently C_{6-18} aryl, preferably benzene, which is optionally substituted with a C_{1-18} hydrocarbyl group, or a C_{1-18} hydrocarbyloxy group (e.g., -O-hydrocarbyl). When n and p are each 0 and m is 1 ("mono-DOPO" type compounds), then R^2 is hydrogen, C_1-C_{18} alkyl, C_{3-10} cycloalkyl, (C_{1-6} alkyl)C_{3-10} cycloalkyl, C_{6-18} aryl, (C_{1-6} alkyl)C_{6-18} aryl, C_{3-12} heteroaryl, or (C_{1-6} alkyl)C_{3-12} heteroaryl. In the foregoing groups at least one hydrogen atom of these groups may be substituted with a group having an N, S, O, or F atom. As used herein, "(C_{1-6} alkyl)C_{3-10} cycloalkyl" refers to a cycloalkyl group attached to an alkylene group, "(C_{1-6} alkyl)C_{6-18} aryl" refers to an aryl group attached to an alkylene group, and "(C_{1-6} alkyl)C_{3-12} heteroaryl" refers to a heteroaryl group attached to an alkylene group. In any of the alkyl or cycloalkyl groups of R^2, any carbon-carbon single bond is optionally replaced by a carbon-carbon double or triple bond, and any methylene is optionally replaced by O, S, S(=O), C(=O), P(=O), or NR^{10}, wherein R^{10} is hydrogen or C_{1-6} alkyl, and any methylene is optionally substituted with a group having an N, S, O, or F atom.

[00060] In Formula (23), when n and p are each 1 or more and m is 0 ("Di-DOPO" type compounds), then X is C_1-C_{18} alkylidene, C_{3-10} cycloalkylidene, C_{6-18} arylene, C_{3-12} heteroarylene, a group derived from Formula (3), or a group represented by -L^1-X'-L^2-. The L^1 and L^2 linker groups are each independently a single bond, C_1-C_{18} alkylidene, or a C_{3-10} cycloalkylidene, where any carbon-carbon single bond is optionally replaced by a carbon-carbon double or triple bond, and any methylene is optionally replaced by O, S, S(=O), C(=O), P(=O), or NR^{10}, wherein R^{10} is hydrogen or C_{1-6} alkyl, and any methylene is optionally substituted with a group having an N, S, O, or F atom. X' is C_1-C_{18} alkylidene, C_{3-10} cycloalkylidene, C_{6-18} arylene, C_{3-12} heteroarylene, or a group derived from Formula (3).

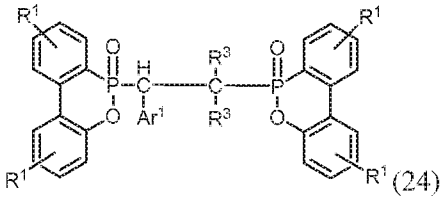
[00061] Specific examples of an oxaphosphorinoxide include 9,10-dihydro-9-oxo-10-phosphaphenanthrene-10-oxide (23a, "DOPO"), commercially available as from SANKO CO., LTD., under the trade name Sanko-HCA, 3-(6-oxidodibenzo[c,e][1,2]oxaphosphinin-6-yl)propanamide (23b, "AAM-DOPO"), and 6-[(1-oxido-2,6,7-trioxa-1-phosphabicyclo[2.2.2.]oct-4-yl)methoxy-6-oxide (23c, "DOPO-PEPA").


(23a)


(23b)


(23c)

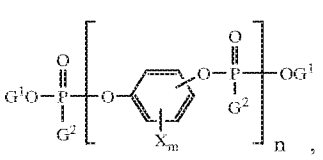
[00062] A specific formula for a Di-DOPO compound is Formula (24).

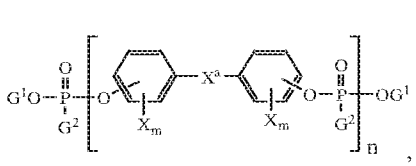

(24)

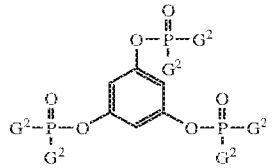
wherein Ar^1 is C_{3-18} heteroaryl or C_{6-18} aryl, each instance of R^3 is independently hydrogen, C_{1-18} alkyl, C_{3-18} heteroaryl or C_{6-18} aryl, each instance of R^1 is independently C_{1-18} alkyl, C_{3-18} heteroaryl or C_{6-18} aryl, and any hydrogen atom on an aryl or heteroaryl ring may be optionally substituted with a C_{1-18} alkyl group. An exemplary Di-DOPO compound is HTP-6123G, commercially available from GUIZHOU YUANYI MINING GROUP CO.

[00063] In an aspect, the aromatic organophosphorous compound is a monomeric phosphate. Representative monomeric aromatic phosphates are of the formula $(GO)_3P=O$, wherein each G is independently an alkyl, cycloalkyl, aryl, alkylarylene, or arylalkylene group having up to 30 carbon atoms, provided that at least one G is an aromatic group. Two of the G groups may be joined together to provide a cyclic group. In some aspects G corresponds to a monomer used to form the polycarbonate, e.g., resorcinol. Exemplary phosphates include phenyl bis(dodecyl) phosphate, phenyl bis(neopentyl) phosphate, phenyl bis(3,5,5'-trimethylhexyl) phosphate, ethyl diphenyl phosphate, 2-ethylhexyl di(p-tolyl) phosphate, bis(2-ethylhexyl) p-tolyl phosphate, tritolyl phosphate, bis(2-ethylhexyl) phenyl phosphate, tri(nonylphenyl) phosphate, bis(dodecyl) p-tolyl phosphate, dibutyl phenyl phosphate, 2-chloroethyl diphenyl phosphate, p-tolyl bis(2,5,5'-trimethylhexyl) phosphate, 2-ethylhexyl diphenyl phosphate, and the like. A specific aromatic phosphate is one in which each G is aromatic, for example, triphenyl phosphate, tricresyl phosphate, isopropylated triphenyl phosphate, and the like.

[00064] Di- or polyfunctional aromatic organophosphorous compounds are also useful, for example, compounds of the formulas


,

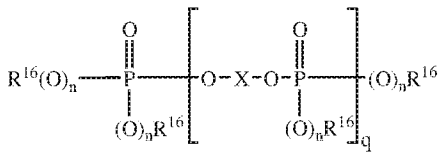

, and



wherein each G^1 is independently a C_{1-30} hydrocarbyl; each G^2 is independently a C_{1-30}

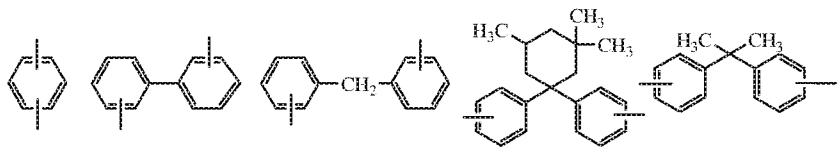
hydrocarbyl or hydrocarbyloxy; X^a is as defined in formula (3) or formula (4); each X is independently a bromine or chlorine; m is 0 to 4, and n is 1 to 30. In a specific aspect, X^a is a single bond, methylene, isopropylidene, or 3,3,5-trimethylcyclohexylidene.

[00065] Specific aromatic organophosphorous compounds are inclusive of acid esters of formula (9)



(9)

wherein each R^{16} is independently C_{1-8} alkyl, C_{5-6} cycloalkyl, C_{6-20} aryl, or C_{7-12} arylalkylene, each optionally substituted by C_{1-12} alkyl, specifically by C_{1-4} alkyl and X is a mono- or poly-nuclear aromatic C_{6-30} moiety or a linear or branched C_{2-30} aliphatic radical, which may be OH-substituted and may contain up to 8 ether bonds, provided that at least one R^{16} or X is an aromatic group; each n is independently 0 or 1; and q is from 0.5 to 30. In some aspects each R^{16} is independently C_{1-4} alkyl, naphthyl, phenyl(C_{1-4})alkylene, aryl groups optionally substituted by C_{1-4} alkyl; each X is a mono- or poly-nuclear aromatic C_{6-30} moiety, each n is 1; and q is from 0.5 to 30. In some aspects each R^{16} is aromatic, e.g., phenyl; each X is a mono- or poly-nuclear aromatic C_{6-30} moiety, including a moiety derived from formula (2); n is one; and q is from 0.8 to 15. In other aspects, each R^{16} is phenyl; X is cresyl, xylenyl, propylphenyl, or butylphenyl, one of the following divalent groups

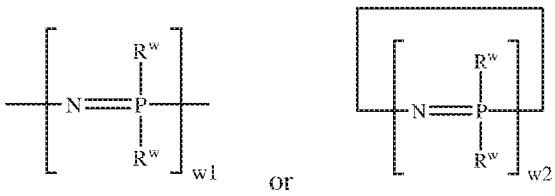


,

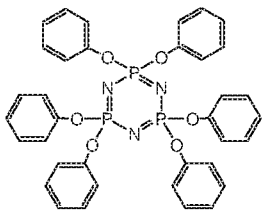
or a combination including one or more of the foregoing; n is 1; and q is from 1 to 5, or from 1 to 2. In some aspects at least one R^{16} or X corresponds to a monomer used to form the polycarbonate, e.g., bisphenol A, resorcinol, or the like. Aromatic organophosphorous compounds of this type include the bis(diphenyl) phosphate of hydroquinone, resorcinol bis(diphenyl phosphate) (RDP), and bisphenol A bis(diphenyl) phosphate (BPADP), and their oligomeric and polymeric counterparts.

[00066] The organophosphorous flame retardant containing a phosphorous-nitrogen bond may be a phosphazene, phosphonitrilic chloride, phosphorous ester amide, phosphoric acid amide, phosphonic acid amide, phosphinic acid amide, or tris(aziridinyl) phosphine oxide. These flame-retardant additives are commercially available. In an aspect, the organophosphorous flame

retardant containing a phosphorous-nitrogen bond is a phosphazene or cyclic phosphazene of the formulas



wherein w1 is 3 to 10,000; w2 is 3 to 25, or 3 to 7; and each R^w is independently a C_{1-12} alkyl, alkenyl, alkoxy, aryl, aryloxy, or polyoxyalkylene group. In the foregoing groups at least one hydrogen atom of these groups may be substituted with a group having an N, S, O, or F atom, or an amino group. For example, each R^w may be a substituted or unsubstituted phenoxy, an amino, or a polyoxyalkylene group. Any given R^w may further be a crosslink to another phosphazene group. Exemplary crosslinks include bisphenol groups, for example bisphenol A groups. Examples include phenoxy cyclotriphosphazene, octaphenoxy cyclotetraphosphazene decaphenoxy cyclopentaphosphazene, and the like. In an aspect, the phosphazene has a structure represented by the formula



[00067] Commercially available phenoxyphosphazenes having the aforementioned structures are LY202 manufactured and distributed by Lanyin Chemical Co., Ltd, FP-110 manufactured and distributed by Fushimi Pharmaceutical Co., Ltd, and SPB-100 manufactured and distributed by Otsuka Chemical Co., Ltd.

[00068] A cyclic siloxane, which also acts as a flame retardant, may also be used. Cyclic siloxanes have the general formula $[(R)_2SiO]_y$ wherein R is a monovalent hydrocarbon or fluorinated hydrocarbon having from 1 to 18 carbon atoms and y is a number from 3 to 12. A useful cyclic siloxane is octaphenylcyclotetrasiloxane. In some aspects, the polycarbonate composition excludes a cyclic siloxane.

[00069] When the non-halogenated flame retardant includes an organophosphorous flame retardant, the organophosphorous flame retardant may be present in an amount effective to provide 0.05-3 wt%, 0.05-2.5 wt%, 0.05-2.0 wt%, 0.05-1.8 wt%, 0.05-1.5 wt%, 0.05-1.0 wt%, 0.05-0.8 wt%, 0.05-0.6 wt%, or 0.05-0.5 wt% phosphorous, each based on the total weight of the composition.

[00070] The polycarbonate compositions minimize or eliminate conventional anti-drip agents, in particular fluorinated anti-drip agents. Anti-drip agents include, for example, a fibril forming or non-fibril forming fluoropolymer such as polytetrafluoroethylene (PTFE). The anti-drip agent can be encapsulated by a rigid copolymer, for example styrene–acrylonitrile copolymer (SAN). PTFE encapsulated in SAN is known as TSAN. An TSAN comprises 50 wt% PTFE and 50 wt% SAN, based on the total weight of the encapsulated fluoropolymer. The SAN can comprise, for example, 75 wt% styrene and 25 wt% acrylonitrile based on the total weight of the copolymer. In some aspects, the fluorinated anti-drip agent is present in an amount effective to provide 0.15 wt% or less fluorine to the total composition. In some aspects, a fluorinated anti-drip agent is excluded from the polycarbonate compositions.

[00071] The polycarbonate compositions include glass fibers. Glass fibers may include E, A, C, ECR, R, S, D, or NE glasses, or the like. The glass fibers made by bonding or non-bonding, or a combination thereof. The glass fibers may be continuous and chopped carbon fibers or glass fibers The glass fiber may be virgin glass fiber or may be derived from recycled sources. Recycled glass fiber may be post-consumer or post-industrial recycled glass fiber.

[00072] The glass fibers can be coated with a layer of metallic material to facilitate conductivity, or surface treated with silanes to improve adhesion and dispersion with the polymer matrix. In addition, the glass fibers can be provided in the form of monofilament or multifilament fibers and can be used individually or in combination with other types of fiber, through, for example, co-weaving or core/sheath, side-by-side, orange-type or matrix and fibril constructions, or by other methods known to one skilled in the art of fiber manufacture. Co-woven structures include glass fiber-carbon fiber, carbon fiber-aromatic polyimide (aramid) fiber, and aromatic polyimide fiberglass fiber or the like.

[00073] The glass fibers can be of any cross-sectional shape, for example round, square, ovoid, or irregular. The glass fibers can have an average largest diameter from 1 micrometer to 1 millimeter, or from 1-500 micrometers. The glass fibers can be supplied in the form of, for example, individual fibers, rovings, woven fibrous reinforcements, such as 0-90 degree fabrics or the like; non-woven fibrous reinforcements such as continuous strand mat, chopped strand mat, tissues, papers, felts, or the like; or three-dimensional reinforcements such as braids.

[00074] The glass fibers can be present from 5-45 wt%, 5-35 wt%, 5-30 wt%, 5-25 wt%, 5-20 wt%, 5-15 wt%, or 9-35 wt%, 9-30 wt%, 9-25 wt%, 9-20 wt%, 9-15 wt%, or from 9-12 wt%, each based on the total weight of the polycarbonate composition, which sums to 100 wt%.

[00075] The polycarbonate composition may include various additives ordinarily incorporated into polymer compositions of this type, with the proviso that the additive(s) are

selected so as to not significantly adversely affect the desired properties of the polycarbonate composition, in particular flame resistance, impact resistance and the melt volume rate. Such additives may be mixed at a suitable time during the mixing of the components for forming the composition. Additives include antioxidants, heat stabilizers, light stabilizers, ultraviolet (UV) light stabilizers, plasticizers, lubricants, mold release agents, antistatic agents, colorants such as such as titanium dioxide, carbon black, and organic dyes, surface effect additives, and radiation stabilizers. A combination of additives may be used, for example a combination of a heat stabilizer, mold release agent, and ultraviolet light stabilizer. In general, the additives are used in the amounts generally known to be effective. For example, the total amount of the additives (other than any impact modifier, filler, or reinforcing agents) may be 0.01 to 5 wt%, based on the total weight of the polycarbonate composition.

[00076] In some aspects, the polycarbonate compositions include a polycarbonate composition including a bisphenol A homopolycarbonate and a polycarbonate including bisphenol A carbonate units and repeating units derived from a monomer including a pendant ester group, based on the total weight of the polycarbonate composition; and an organophosphorous flame retardant present in amount effective to provide 0.05-1.0 wt% phosphorous.

[00077] In some aspects, the polycarbonate compositions include a polycarbonate composition including a bisphenol A homopolycarbonate and a polycarbonate including bisphenol A carbonate units and repeating units derived from a monomer including a pendant ester group, based on the total weight of the polycarbonate composition; and an organophosphorous flame retardant present in amount effective to provide 0.05-3.0 wt%, or 0.05-2.0 wt% phosphorous.

[00078] In some aspects, the polycarbonate compositions include a polycarbonate composition including a bisphenol A homopolycarbonate and a polycarbonate including bisphenol A carbonate units and repeating units derived from a monomer including a pendant ester group, based on the total weight of the polycarbonate composition; and 0.01 to 1.0 wt% of an aromatic sulfone sulfonate, preferably potassium diphenylsulfone sulfonate.

[00079] The polycarbonate compositions may have ultra-low halogen content. As used herein, "ultra-low chlorine and/or bromine content" refers to materials produced without the intentional addition of chlorine or bromine or chlorine or bromine containing materials. It is understood however that in facilities that process multiple products a certain amount of cross contamination may occur resulting in bromine or chlorine levels typically on the parts per million by weight scale. With this understanding it may be readily appreciated that "ultra-low

chlorine or bromine content" may be defined as having a bromine or chlorine content of less than or equal to 100 parts per million by weight (ppm), less than or equal to 75 ppm, or less than or equal to 50 ppm. In some aspects, "ultra-low chlorine and bromine content" means a total bromine and chlorine content of less than or equal to 100 parts per million by weight, or less than or equal to 75 ppm, or less than or equal to 50 ppm. When this definition is applied to the non-halogenated flame retardant it is based on the total weight of the non-halogenated flame retardant. When this definition is applied to the polycarbonate composition it is based on the total parts by weight of the polycarbonate composition.

[00080] In another aspect, the polycarbonate composition may have an ultra-low chlorine, bromine, or fluorine content. As used herein, "ultra-low chlorine, bromine, or fluorine content" is defined as having a bromine, chlorine, or fluorine content of less than or equal to 100 ppm, less than or equal to 75 ppm, or less than or equal to 50 ppm, based on the total parts by weight of the composition. Preferably, the polycarbonate composition has a combined bromine, chlorine, and fluorine content of less than or equal to 100 ppm, less than or equal to 75 ppm, or less than or equal to 50 ppm, based on the total parts by weight of the composition.

[00081] The polycarbonate compositions may be manufactured by various methods. For example, powdered polycarbonates, non-halogenated flame retardant, and/or optional components are first blended, optionally with fillers in a HENSCHEL-Mixer high speed mixer. Other low shear processes, including but not limited to hand mixing, may 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 may be incorporated into the composition by feeding directly into the extruder at the throat or downstream through a sidestuffer. Additives may also be compounded into a masterbatch with a desired polymeric polymer 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 so prepared may be one-fourth inch long or less as desired. Such pellets may be used for subsequent molding, shaping, or forming.

[00082] A sample of the polycarbonate composition may have a flame test rating of V-0, as measured according to UL-94 at a thickness of 1.5 millimeter or less, such as, for example, 1.2 millimeter, 1.0 millimeter, 0.8 millimeter, and 0.6 millimeter.

[00083] The polycarbonate compositions may have a melt volume rate (MVR) of 5 to 150 cc/10 min., preferably 7 to 125 cc/10 min, more preferably 9 to 110 cc/10 min, and still more preferably 10 to 100 cc/10 min., measured at 300°C and a load of 1.2 kilograms according to ASTM D1238-04 or ISO 1133. In some aspects, the polycarbonate compositions may have a

melt volume rate (MVR) of 10-25 or 10-20 cc/10 min, measured at 300°C and a load of 1.2 kilograms according to ASTM D1238-04 or ISO 1133.

[00084] Shaped, formed, or molded articles including the polycarbonate compositions are also provided. The polycarbonate compositions may be molded into useful shaped articles by a variety of methods, such as injection molding, extrusion, rotational molding, blow molding and thermoforming. Some examples of articles include computer and business machine housings such as housings for monitors, handheld electronic device housings such as housings for cell phones, electrical connectors, and components of lighting fixtures, ornaments, home appliances, roofs, greenhouses, sun rooms, swimming pool enclosures, and the like. In an aspect, the article is an extruded article, a molded article, pultruded article, a thermoformed article, a foamed article, a layer of a multi-layer article, a substrate for a coated article, or a substrate for a metallized article. In addition, the polycarbonate compositions may be used for such applications as a molded housing and other devices such as electrical circuit housing.

[00085] Thin films including the polycarbonate compositions are also provided.. The thin films can be prepare The thin film of the thermoplastic composition can be prepared by extrusion of the polycarbonate composition. The thin films may have improved thermal resistance.

[00086] This disclosure is further illustrated by the following examples, which are non-limiting.

EXAMPLES

[00087] The following components are used in the examples. Unless specifically indicated otherwise, the amount of each component is in wt%, based on the total weight of the composition.

[00088] The materials shown in Table 1 were used.

Table 1.

PC-1	Linear amorphous bisphenol A polycarbonate (BPA) homopolymer produced by interfacial polymerization (Mw 29,000-31,000 g/mol, using polystyrene standards)	SABIC
PC-2	Linear amorphous BPA homopolymer produced by interfacial polymerization (Mw 20,000-22,000, using polystyrene standards)	SABIC
PC-4	4/96 mol% amorphous IDHB-BPA copolymer produced by interfacial polymerization, Mw 29,000-31,000 g/mol, using polystyrene standards	SABIC
PC-5	4/96 mol% amorphous EDHB-BPA copolymer produced by interfacial polymerization, Mw 29,000-31,000 g/mol, using polystyrene standards	SABIC
PC-7	Branched, cyanophenol end-capped bisphenol A homopolycarbonate produced via interfacial polymerization, containing 3 mol% 1,1,1-tris(4-hydroxyphenyl)ethane (THPE) branching agent (Mw=29,000-31,000 g/mol, using polystyrene standards)	SABIC
PC-Si-1	Poly(bisphenol A – dimethylsiloxane) copolymer, produced via interfacial polymerization, 20 wt% siloxane, average siloxane block length = 45 units	SABIC

	(D45), Mw = 29,000 to 31,000 g/mol per d by GPC using polystyrene standards, para-cumylphenol (PCP) end-capped	
PC-Si-2	Poly(bisphenol A carbonate-dimethylsiloxane) copolymer having a siloxane repeating units of 40 wt%, average PDMS block length of 45 units, having a Mw of 37,000 to 38,000 grams per mole as determined by GPC using polystyrene standards and calculated for polycarbonate, produced by interfacial polymerization and endcapped with p-cumylphenol	SABIC
PPZ	Phenoxy phosphazene, 13.94 wt% phosphorous	Fushimi
KSS	Potassium diphenylsulfone sulfonate	Sloss Industries
PETS	Pentaerythrityl tetrastearate, >90% esterified	Faci
AO	Tris(di-t-butyl phenyl)phosphite, CAS Reg. No. 31570-04-4	Ciba
TSAN	Encapsulated Polytetrafluoroethylene, CAS Reg. No. 9002-84-0, with 47-53 wt% poly(tetrafluoroethylene)	SABIC
GF	Bonding Glass fibers	
UVA	2-(2Hydroxy-5-tert-octylphenyl) benzotriazole, commercially available as UVA 5411	CIBA

[00089] General Procedure for PC-4 and PC-5. In a pre-formulation tank, 7 L water, 23 L methylene chloride, 4200 g BPA, 40 mL TEA, 10 g sodium gluconate, and propan-2-yl 3,5-dihydroxybenzoate (IDHB) or ethyl 3,5-dihydroxybenzoate (EDHB) are added and well mixed. The resulting formulation is then transferred to the reactor, where phosgene is then added at 90g/min and the mixture is recirculated. To maintain a pH of 9-10, a 30% caustic solution is then added at a program-determined rate. During the course of the phosgenation, a solution of PCP in methylene chloride (184 g PCP / 800 g methylene) is added at 200 g/min. Phosgenation continues until a total of 2400 g of phosgene is delivered. Following completion of reaction, the reaction's MW is checked along with the presence of any excess phosgene. The reaction mixture is neutralized with dilute acid (to remove TEA and neutralize base) and the organic layer is separated from the aqueous layer after centrifugation. The organic layer is then washed with deionized water and separated again by centrifugation. The organic layer is then subjected to steam precipitation, and the resin is isolated as a wet powder and then dried in nitrogen dryer.

[00090] The testing samples were prepared as described below and the following test methods were used.

[00091] Typical compounding procedures are described as follows: The various formulations were prepared by direct dry-blending of the raw materials and pre-blended and then extruded using a twin-screw extruder. The composition was melt-kneaded, extruded, cooled through a water bath and pelletized. A typical extrusion profile is listed in Table 2.

Table 2.

Parameters	Unit	Typical values
Feed	°C	40
Zone 1 Temp	°C	200
Zone 2 Temp	°C	240
Zone 3 Temp	°C	260
Zone 4-9 Temp	°C	280

Screw Speed	Rpm	300
Throughput	kg/hr	~24
Torque	%	Max.

[00092] An Engel 45 molding machine was used to mold the test parts for standard physical property testing. The parameters are provided in Table 3.

Table 3.

Parameters	Unit	Conditions
Drying Temperature	°C	120
Drying Time	Hrs	2
Hopper temperature	°C	40
Nozzle Temperature	°C	275
Rear - Zone 1 Temperature	°C	260
Middle - Zone 2 Temperature	°C	270
Front - Zone 3 Temperature	°C	280

[00093] Sample preparation and testing methods are described in Table 4.

Table 4.

Property	Standard	Conditions	Specimen Type
MVR	ISO-1133	300 °C, 2.16 kg, 300 sec	Pellets
Notched Izod (NII)	ASTM D256	23 °C, -30 °C	Bar-63.5 mm x 12.7 mm x 3.2 mm
Flammability	UL 94	Vertical Burning	

[00094] Flammability tests were performed on samples at a thickness of 1.5 mm, 1.0 mm, and 0.8 mm in accordance with the Underwriter's Laboratory (UL) UL 94 standard. In some cases, a second set of 5 bars was tested to give an indication of the robustness of the rating. In this report the following definitions are used as shown in Table 5. Total flame-out-times for all 5 bars (FOT = t1 + t2) were determined. V-ratings were obtained for every set of 5 bars.

Table 5.

UL94 Rating	t_1 and/or t_2	5-bar FOT	burning drips
V-0	<10	<50	no
V1	<30	<250	no
V2	<30	<250	yes
N.R. (no rating)	>30	>250	

Prophetic Examples 1-34

[00095] Tables 6A-6B show the compositions and properties for the following comparative examples and examples with 10 wt% glass fibers. Comparative examples are indicated with an asterisk.

Table 6A.

	Unit	1*	2*	3	4	5	6	7*
PC-1	wt%	44.31	44.53	34.53	39.53	34.53	51.80	34.53
PC-2	wt%	44.31	44.53	34.53	39.53	34.53	17.27	34.53
PC-4	wt%			20				
PC-5	wt%				10	20	20	
PC-7	wt%							20
PC-Si-1	wt%							
GF	wt%	10	10	10	10	10	10	10
AO	wt%	0.09	0.09	0.09	0.09	0.09	0.09	0.09
PETS	wt%	0.1	0.1	0.1	0.1	0.1	0.1	0.1
UV	wt%	0.3	0.3	0.3	0.3	0.3	0.3	0.3
TSAN	wt%	0.45						
KSS	wt%	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Total	wt%	100	100	100	100	100	100	100
Ester	wt%	0	0	0.8	0.4	0.8	0.8	0
Added F	wt%	0.16	0	0	0	0	0	0

Table 6B.

	Unit	8*	9*	10	11	12	13	14	15
PC-1	wt%	43.03	43.26	33.26	38.26	33.26	34.01	25.76	29.51
PC-2	wt%	43.03	43.26	33.26	38.26	33.26	34.01	25.76	29.51
PC-4	wt%			20					
PC-5	wt%				10	20	20	20	20
PC-7	wt%								
PC-Si-1	wt%							15	
PC-Si-2	wt%								7.5
GF	wt%	10	10	10	10	10	10	10	10
AO	wt%	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
PETS	wt%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
UV	wt%	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
TSAN	wt%	0.45							
PPZ	wt%	3	3	3	3	3	1.5	3	3
Total	wt%	100	100	100	100	100	100	100	100
Ester	wt%	0	0	0.8	0.4	0.8	0.8	0.8	0.8
Added F	wt%	0.16	0	0	0	0	0	0	0
Added P	wt%	0.4	0.4	0.4	0.4	0.4	0.2	0.4	0.4

[00096] Table 7 shows the compositions and properties for the following comparative examples and examples including 30 wt% glass fibers. Comparative examples are indicated with an asterisk.

Table 7.

	Unit	18*	19*	20*	21*	22	23	24	25
PC-1	wt%	33.03	33.26	23.26	28.26	23.26	24.01	15.76	19.51
PC-2	wt%	33.03	33.26	23.26	28.26	23.26	24.01	15.76	19.51

PC-4	wt%			20					
PC-5	wt%				10	20	20	20	20
PC-7	wt%								
PC-Si-1	wt%							15	
PC-Si-2	wt%								7.5
GF	wt%	30	30	30	30	30	30	30	30
AO	wt%	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
PETS	wt%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
UV	wt%	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
TSAN	wt%	0.45							
PPZ	wt%	3	3	3	3	3	1.5	3	3
Total	wt%	100	100	100	100	100	100	100	100
Ester	wt%	0	0	0.8	0.4	0.8	0.8	0.8	0.8
Added F	wt%	0.16	0	0	0	0	0	0	0
Added P	wt%	0.4	0.4	0.4	0.4	0.4	0.2	0.4	0.4

[00097] This disclosure further encompasses the following aspects.

[00098] Aspect 1. A polycarbonate composition including: polycarbonate; a polycarbonate including repeating units derived from a monomer including a pendant ester group; a non-halogenated flame retardant; glass fibers; optionally, a poly(carbonate-siloxane) present in an amount effective to provide 0.5-10 wt% siloxane repeating units, based on the total weight of the composition, and optionally, an additive composition, wherein a sample of the composition has a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner.

[00099] Aspect 1a. A polycarbonate composition including: 60-95 wt% of a bisphenol A polycarbonate; a polycarbonate including repeating units derived from a monomer including a pendant ester group; a non-halogenated flame retardant, glass fibers; optionally, a poly(carbonate-siloxane) present in an amount effective to provide 0.5-10 wt% of siloxane repeating units, based on the total weight of the composition, and optionally, an additive composition, wherein a sample of the composition has a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner and wherein the polycarbonate is different from the polycarbonate including repeating units derived from a monomer including a pendant ester group.

[000100] Aspect 1b. The polycarbonate composition of Aspect 1 or 1a, wherein: the calculated added bromine and chlorine content of the polycarbonate composition are each about 900 ppm or less and the calculated total added halogen content of the polycarbonate composition is about 1500 ppm or less; or the calculated added bromine, chlorine, and fluorine content of the polycarbonate composition are each about 900 ppm or less and the calculated total added bromine, chlorine, and fluorine content of the polycarbonate composition is about 1500 ppm or less.

[000101] Aspect 1c: The polycarbonate composition of any of the preceding aspects, wherein the polycarbonate composition excludes an anti-drip agent.

[000102] Aspect 1d: The polycarbonate composition of any of the preceding aspects, wherein the polycarbonate composition is substantially free of a branched polycarbonate.

[000103] Aspect 2: A polycarbonate composition including: a polycarbonate composition comprising: a polycarbonate; a polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group; a non-halogenated flame retardant; glass fibers; optionally, a poly(carbonate-siloxane) present in an amount effective to provide 0.5-10 wt% siloxane repeating units, based on the total weight of the composition, and optionally, an additive composition, wherein: the polycarbonate is different from the polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group; a sample of the composition has a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner, and the calculated added bromine and chlorine content of the polycarbonate composition are each about 900 ppm or less and the calculated total added halogen content of the polycarbonate composition is about 1500 ppm or less; or the calculated added bromine, chlorine, and fluorine content of the polycarbonate composition are each about 900 ppm or less and the calculated total added bromine, chlorine, and fluorine content of the polycarbonate composition is about 1500 ppm or less.

[000104] Aspect 2a. The polycarbonate composition of any one of the preceding aspects, wherein the polycarbonate comprises a glass transition temperature of less than 155 °C, determined according to ASTM E1640-13 with a 1°C/min heating rate.

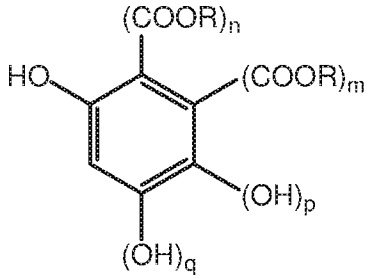
[000105] Aspect 2b. The polycarbonate composition of any one of the preceding aspects, wherein the polycarbonate is a linear bisphenol A polycarbonate homopolymer.

[000106] Aspect 2c: The polycarbonate composition of any one of the preceding aspects, wherein the polycarbonate composition excludes an anti-drip agent.

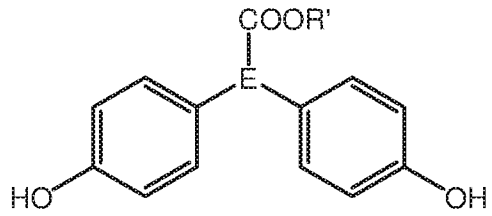
[000107] Aspect 2d: The polycarbonate composition of any one of the preceding aspects, wherein the polycarbonate composition comprises a branched polycarbonate in an amount effective to provide 0.05 mol% or less, 0.025 mol% or less, or 0.01 mol% or less branching, based on the total moles of carbonate repeating units in the polycarbonate composition.

[000108] Aspect 2e: The polycarbonate composition of any one of the preceding aspects comprising a melt flow rate (MVR) of 10-25 cc/10 min, or 10-20 cc/10 min, at 300 °C and a 1.2 kg load according to ASTM D1238-04.

[000109] Aspect 3. The polycarbonate composition of any one of the preceding aspects, wherein the monomer including a ester pendant group has the structure of Formula (A) or Formula (B)



Formula (A)



Formula (B)

wherein each occurrence of R and R' is independently C_2-C_{15} alkyl; each of m, n, p, and q is independently 0 or 1; m + n = 1; and p + q = 1 and E is C_1-C_{15} alkyl, and wherein the monomers including the pendant ester groups may be the same or different.

[000110] Aspect 4. The polycarbonate composition of Aspect 3, wherein R is a linear C_2-C_{15} alkyl group, preferably an ethyl group, or R is a branched C_2-C_{15} alkyl group, preferably an isopropyl group.

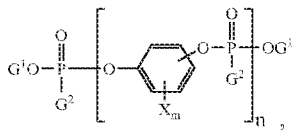
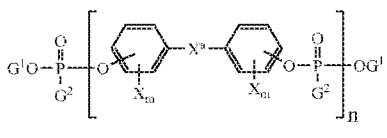
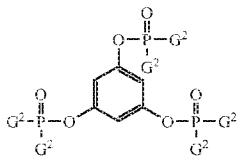
[000111] Aspect 5a. The polycarbonate composition of any one of the preceding aspects, wherein the polycarbonate including repeating units derived from a monomer including a pendant ester group is present in an amount effective to provide 0.1-5.0 mol% repeating units derived from a monomer having a pendant ester group, based on the total moles of the composition.

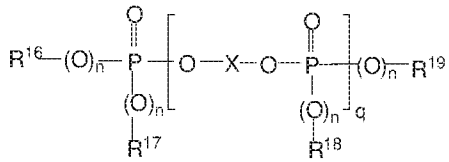
[000112] Aspect 5b. The polycarbonate composition of any one of the preceding aspects comprising 5-45 wt% glass fibers, preferably 5-30 wt% glass fibers.

[000113] Aspect 6. The polycarbonate composition of any one of the preceding aspects, wherein the non-halogenated flame retardant comprises an aromatic sulfonate, an aromatic sulfone sulfonate, an organophosphorous flame retardant, or a combination thereof.

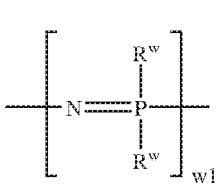
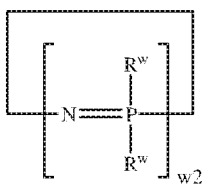
[000114] Aspect 7. The polycarbonate composition of any one of the preceding aspects, wherein the non-halogenated flame retardant includes an organophosphorous flame retardant including a monomeric or oligomeric phosphate ($P(=O)(OR)_3$), phosphite ($P(OR)_3$), phosphonate ($RP(=O)(OR)_2$), phosphinate ($R_2P(=O)(OR)$), phosphine oxide ($R_3P(=O)$), or phosphine (R_3P), wherein each R in the may be the same or different, provided that at least one R is an aromatic group; a monomeric or oligomeric compound having at least one phosphorous-nitrogen bond; or a combination thereof.

[000115] Aspect 8. The polycarbonate composition of any one of the preceding aspects, wherein the non-halogenated flame retardant includes an organophosphorous flame retardant including:

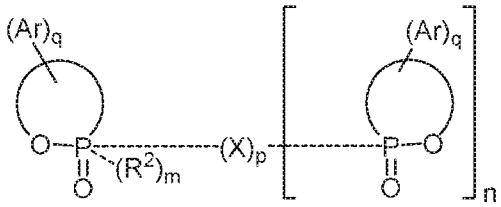

, 
, 
, or a combination thereof, wherein each occurrence of G^1 is independently a C_{1-30} hydrocarbyl; each occurrence of G^2 is independently a C_{1-30} hydrocarbyl or hydrocarbyloxy; each X is independently a bromine or chlorine; m is 0 to 4, and n is 1 to 30;


wherein R^{16}, R^{17}, R^{18}, and R^{19} are each independently C_{1-8} alkyl, C_{5-6} cycloalkyl, C_{6-20} aryl, or C_{7-12} arylalkylene, each optionally substituted by C_{1-12} alkyl, preferably by C_{1-4} alkyl and X is a mono- or poly-nuclear aromatic C_{6-30} moiety or a linear or branched C_{2-30} aliphatic radical, each optionally OH-substituted and optionally including up to 8 ether bonds, provided that at least one of R^{16}, R^{17}, R^{18}, R^{19}, and X is an aromatic group;
or a combination thereof.

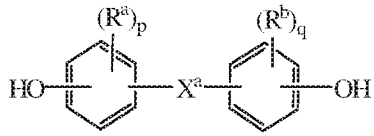
[000116] Aspect 9. The polycarbonate composition of any one of the preceding aspects, wherein the wherein the non-halogenated flame retardant includes an organophosphorous flame retardant including phosphonitrilic chloride, phosphorous ester amide, phosphoric acid amide, phosphonic acid amide, phosphinic acid amide, or tris(aziridinyl) phosphine oxide; or a phosphazene or cyclic phosphazene of the formulas


or 
wherein w1 is 3 to 10,000; w2 is 3 to 25, or 3 to 7; and each R^w is independently a C_{1-12} alkyl, alkenyl, alkoxy, aryl, aryloxy, or polyoxyalkylene group, optionally wherein at least one hydrogen atom is replaced with an N, S, O, or F atom, or an amino group.

[000117] Aspect 10. The polycarbonate composition of any one of the preceding claims, wherein the wherein the non-halogenated flame retardant comprises an organophosphorous flame retardant of Formula (23)



wherein q is at least 2, each occurrence of Ar is independently C_{6-18} aryl, preferably benzene, optionally substituted with a C_{1-18} hydrocarbyl group, or a C_{1-18} hydrocarbyloxy group, and n and p are each 0, m is 1, R^2 is hydrogen, C_1-C_{18} alkyl, C_{3-10} cycloalkyl, (C_{1-6} alkyl)C_{3-10} cycloalkyl, C_{6-18} aryl, (C_{1-6} alkyl)C_{6-18} aryl, C_{3-12} heteroaryl, or (C_{1-6} alkyl)C_{3-12} heteroaryl, any carbon-carbon single bond is optionally replaced by a carbon-carbon double or triple bond, and any methylene is optionally replaced by O, S, S(=O), C(=O), P(=O), or NR^{10}, wherein R^{10} is hydrogen or C_{1-6} alkyl, and any methylene is optionally substituted with a group having an N, S, O, or F atom; or n and p are each at least 1, m is 0, and X is C_1-C_{18} alkylidene, C_{3-10} cycloalkylidene, C_{6-18} arylene, C_{3-12} heteroarylene, or a group derived from Formula (3)



(3), wherein R^a and R^b are each independently a halogen, C_{1-12} alkoxy, or C_{1-12} alkyl, and p and q are each independently integers of 0 to 4, X^a is single bond, -O-, -S-, -S(O)-, -$S(O)_2$-, -C(O)-, or a C_{1-60} organic group; or a -L^1-X'-L^2- group, wherein L^1 and L^2 are each independently a single bond, C_1-C_{18} alkylidene, or a C_{3-10} cycloalkylidene, where any carbon-carbon single bond is optionally replaced by a carbon-carbon double or triple bond, and any methylene is optionally replaced by O, S, S(=O), C(=O), P(=O), or NR^{10}, wherein R^{10} is hydrogen or C_{1-6} alkyl, and any methylene is optionally substituted with a group having an N, S, O, or F atom; X' is C_1-C_{18} alkylidene, C_{3-10} cycloalkylidene, C_{6-18} arylene, C_{3-12} heteroarylene, or a group derived from Formula (3).

[000118] Aspect 11. The polycarbonate composition of any one of the preceding aspects wherein the polycarbonate composition comprises 0.15 wt% or less of an anti-drip agent comprising fluorine, preferably wherein the polycarbonate composition excludes an anti-drip agent comprising fluorine.

[000119] Aspect 12. The polycarbonate composition of any one of the preceding aspects wherein the polycarbonate composition comprises an organophosphorous flame retardant present in amount effective to provide 0.05-2.1wt%, or 0.05 to less than 2.1 wt% phosphorous.

[000120] Aspect 13. The polycarbonate composition of any one of the preceding aspects wherein the polycarbonate composition comprises 0.01 to 1.0 wt% of an aromatic sulfone sulfonate, preferably potassium diphenylsulfone sulfonate.

[000121] Aspect 14. An article including the polycarbonate composition of any one of the preceding aspects, preferably wherein the article is a housing for monitors, a thin film, a housing for a handheld electronic device, preferably a housing for a cell phone or a personal health care device, a housing for a consumer electronic device, preferably a battery housing, a covers, or a display panel, a housing for an electrical component, preferably an electric vehicle charger, a smart meter cover, a smart meter box, or a lighting component; an electrical connector; a component of a lighting fixture; an ornament; a home appliance; a roof; a greenhouse enclosure, a sun room enclosure, and a swimming pool enclosure.

[000122] Aspect 15. A method for forming the article according to aspect 14, including molding, casting, or extruding the composition to provide the article.

[000123] The compositions, methods, and articles may alternatively include, consist of, or consist essentially of, any appropriate materials, steps, or components herein disclosed. The compositions, methods, and articles may additionally, or alternatively, be formulated so as to be devoid, or substantially free, of any materials (or species), steps, or components, that are otherwise not necessary to the achievement of the function or objectives of the compositions, methods, and articles.

[000124] All ranges disclosed herein are inclusive of the endpoints, and the endpoints are independently combinable with each other (e.g., ranges of "up to 25 wt%, or, more specifically, 5 wt% to 20 wt%", is inclusive of the endpoints and all intermediate values of the ranges of "5 wt% to 25 wt%," etc.). "Combinations" is inclusive of blends, mixtures, alloys, reaction products, and the like. The terms "first," "second," and the like, do not denote any order, quantity, or importance, but rather are used to distinguish one element from another. The terms "a" and "an" and "the" do not denote a limitation of quantity and are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. "Or" means "and/or" unless clearly stated otherwise. Reference throughout the specification to "some embodiments", "an embodiment", and so forth, means that a particular element described in connection with the embodiment is included in at least one embodiment described herein, and may or may not be present in other embodiments. In addition, it is to be understood that the described elements may be combined in any suitable manner in the various embodiments. A "combination thereof" is open and includes any combination including at least

one of the listed components or properties optionally together with a like or equivalent component or property not listed

[000125] Unless specified to the contrary herein, all test standards are the most recent standard in effect as of the filing date of this application, or, if priority is claimed, the filing date of the earliest priority application in which the test standard appears.

[000126] Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which this application belongs. All cited patents, patent applications, and other references are incorporated herein by reference in their entirety. However, if a term in the present application contradicts or conflicts with a term in the incorporated reference, the term from the present application takes precedence over the conflicting term from the incorporated reference.

[000127] Compounds are described using standard nomenclature. For example, any position not substituted by any indicated group is understood to have its valency filled by a bond as indicated, or a hydrogen atom. A dash ("-") that is not between two letters or symbols is used to indicate a point of attachment for a substituent. For example, -CHO is attached through carbon of the carbonyl group.

[000128] As used herein, the term "hydrocarbyl", whether used by itself, or as a prefix, suffix, or fragment of another term, refers to a residue that contains only carbon and hydrogen unless it is specifically identified as "substituted hydrocarbyl". The hydrocarbyl residue may be aliphatic or aromatic, straight-chain, cyclic, bicyclic, branched, saturated, or unsaturated. It may also contain combinations of aliphatic, aromatic, straight chain, cyclic, bicyclic, branched, saturated, and unsaturated hydrocarbon moieties. When the hydrocarbyl residue is described as substituted, it may contain heteroatoms in addition to carbon and hydrogen.

[000129] The term "alkyl" means a branched or straight chain, unsaturated aliphatic hydrocarbon group, e.g., methyl, ethyl, n-propyl, i-propyl, n-butyl, s-butyl, t-butyl, n-pentyl, s-pentyl, and n- and s-hexyl. "Alkenyl" means a straight or branched chain, monovalent hydrocarbon group having at least one carbon-carbon double bond (e.g., ethenyl (-HC=CH_2)). "Alkoxy" means an alkyl group that is linked via an oxygen (i.e., alkyl-O-), for example methoxy, ethoxy, and sec-butyloxy groups. "Alkylene" means a straight or branched chain, saturated, divalent aliphatic hydrocarbon group (e.g., methylene (-CH_2-) or, propylene (-$(CH_2)_3$-)). "Cycloalkylene" means a divalent cyclic alkylene group, -C_nH_{2n-x}, wherein x is the number of hydrogens replaced by cyclization(s). "Cycloalkenyl" means a monovalent group having one or more rings and one or more carbon-carbon double bonds in the ring, wherein all ring members are carbon (e.g., cyclopentyl and cyclohexyl). "Aryl" means an aromatic hydrocarbon group

containing the specified number of carbon atoms, such as phenyl, tropone, indanyl, or naphthyl. "Arylene" means a divalent aryl group. "Alkylarylene" means an arylene group substituted with an alkyl group. "Arylalkylene" means an alkylene group substituted with an aryl group (e.g., benzyl). The prefix "halo" means a group or compound including one more of a fluoro, chloro, bromo, or iodo substituent. A combination of different halo groups (e.g., bromo and fluoro), or only chloro groups may be present. The prefix "hetero" means that the compound or group includes at least one ring member that is a heteroatom (e.g., 1, 2, or 3 heteroatom(s)), wherein the heteroatom(s) is each independently N, O, S, Si, or P. "Substituted" means that the compound or group is substituted with at least one (e.g., 1, 2, 3, or 4) substituents that may each independently be a C_{1-9} alkoxy, a C_{1-9} haloalkoxy, a nitro ($-NO_2$), a cyano (-CN), a C_{1-6} alkyl sulfonyl ($-S(=O)_2$-alkyl), a C_{6-12} aryl sulfonyl ($-S(=O)_2$-aryl)a thiol (-SH), a thiocyano (-SCN), a tosyl ($CH_3C_6H_4SO_2$-), a C_{3-12} cycloalkyl, a C_{2-12} alkenyl, a C_{5-12} cycloalkenyl, a C_{6-12} aryl, a C_{7-13} arylalkylene, a C_{4-12} heterocycloalkyl, and a C_{3-12} heteroaryl instead of hydrogen, provided that the substituted atom's normal valence is not exceeded. The number of carbon atoms indicated in a group is exclusive of any substituents. For example $-CH_2CH_2CN$ is a C_2 alkyl group substituted with a nitrile.

[000130] While particular embodiments have been described, alternatives, modifications, variations, improvements, and substantial equivalents that are or may be presently unforeseen may arise to applicants or others skilled in the art. Accordingly, the appended claims as filed and as they may be amended are intended to embrace all such alternatives, modifications variations, improvements, and substantial equivalents.

CLAIMS

What is claimed is:

1. A polycarbonate composition comprising:

a polycarbonate;

a polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group;

a non-halogenated flame retardant;

glass fibers;

optionally, a poly(carbonate-siloxane) present in an amount effective to provide 0.5-10 wt% siloxane repeating units, based on the total weight of the composition, and

optionally, an additive composition,

wherein:

the polycarbonate is different from the polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group, and

a sample of the composition has a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner.

2. A polycarbonate composition comprising:

a polycarbonate;

a polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group;

a non-halogenated flame retardant;

glass fibers;

optionally, a poly(carbonate-siloxane) present in an amount effective to provide 0.5-10 wt% siloxane repeating units, based on the total weight of the composition, and

optionally, an additive composition,

wherein:

the polycarbonate is different from the polycarbonate comprising repeating units derived from a monomer comprising a pendant ester group;

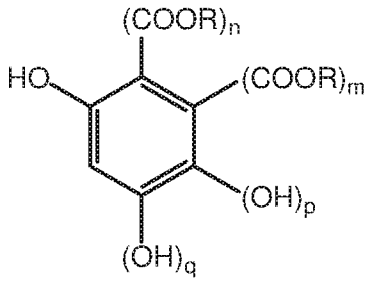
a sample of the composition has a UL-94 flame test rating of V-0 at a thickness of 1.5 mm or thinner, and

the calculated added bromine and chlorine content of the polycarbonate composition are each about 900 ppm or less and the calculated total added halogen content of the polycarbonate composition is about 1500 ppm or less; or

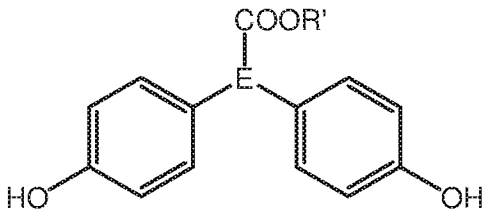
the calculated added bromine, chlorine, and fluorine content of the polycarbonate composition are each about 900 ppm or less and the calculated total added bromine, chlorine, and fluorine content of the polycarbonate composition is about 1500 ppm or less.

3. The polycarbonate composition of claim 1 or claim 2, wherein the composition comprises 60-95 wt% of a bisphenol A polycarbonate.

4. The polycarbonate composition of any one of the preceding claims, wherein the monomer having a pendant ester group has the structure of Formula (A) or Formula (B)



Formula (A)



Formula (B)

wherein each occurrence of R and R' is independently C_2-C_{15} alkyl; each of m, n, p, and q is independently 0 or 1; m + n = 1; and p + q = 1, and E is C_1-C_{15} alkyl, and wherein the repeating units derived from a monomer comprising a pendant ester group may be the same or different.

5. The polycarbonate composition of Claim 4, wherein R is a linear C_2-C_{15} alkyl group, preferably an ethyl group, or R is a branched C_2-C_{15} alkyl group, preferably an isopropyl group.

6. The polycarbonate composition of any one of the preceding claims comprising 5-45 wt%, preferably 5-35 wt% glass fibers.

7. The polycarbonate composition of any one of the preceding claims, wherein the non-halogenated flame retardant comprises an aromatic sulfonate, an aromatic sulfone sulfonate, an organophosphorous flame retardant, or a combination thereof.

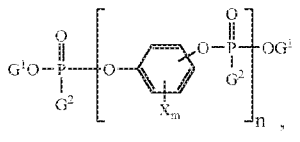
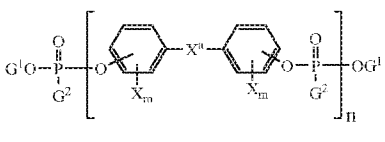
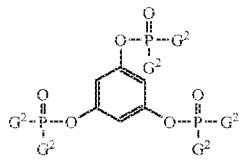
8. The polycarbonate composition of any one of the preceding claims, wherein the non-halogenated flame retardant comprises an organophosphorous flame retardant comprising

a monomeric or oligomeric phosphate ($P(=O)(OR)_3$), phosphite ($P(OR)_3$), phosphonate ($RP(=O)(OR)_2$), phosphinate ($R_2P(=O)(OR)$), phosphine oxide ($R_3P(=O)$), or phosphine (R_3P), wherein each R in the may be the same or different, provided that at least one R is an aromatic group;

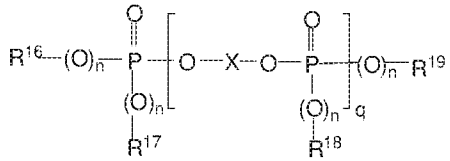
a monomeric or oligomeric compound having at least one phosphorous-nitrogen bond;

or a combination thereof.

9. The polycarbonate composition of any one of the preceding claims, wherein the non-halogenated flame retardant comprises an organophosphorous flame retardant comprising




, or a combination thereof,

wherein each occurrence of G^1 is independently a C_{1-30} hydrocarbyl; each occurrence of G^2 is independently a C_{1-30} hydrocarbyl or hydrocarbyloxy; each X is independently a bromine or chlorine; m is 0 to 4, and n is 1 to 30;



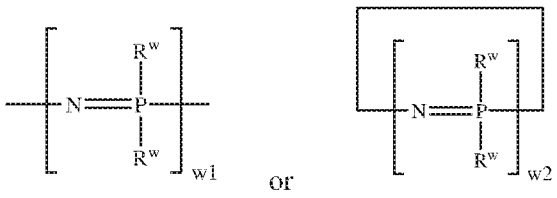
wherein R^{16}, R^{17}, R^{18}, and R^{19} are each independently C_{1-8} alkyl, C_{5-6} cycloalkyl, C_{6-20} aryl, or C_{7-12} arylalkylene, each optionally substituted by C_{1-12} alkyl, preferably by C_{1-4} alkyl and X is a mono- or poly-nuclear aromatic C_{6-30} moiety or a linear or branched C_{2-30} aliphatic radical, each optionally OH-substituted and optionally comprising up to 8 ether bonds, provided that at least one of R^{16}, R^{17}, R^{18}, R^{19}, and X is an aromatic group;

or a combination thereof.

10. The polycarbonate composition of any one of the preceding claims, wherein the wherein the non-halogenated flame retardant comprises an organophosphorous flame retardant comprising

phosphonitrilic chloride, phosphorous ester amide, phosphoric acid amide, phosphonic acid amide, phosphinic acid amide, or tris(aziridinyl) phosphine oxide; or

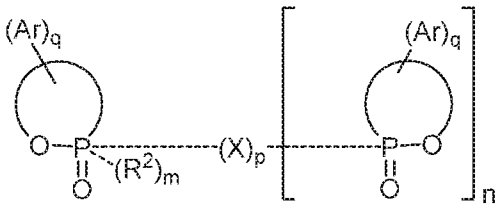
a phosphazene or cyclic phosphazene of the formulas



or

wherein w1 is 3 to 10,000; w2 is 3 to 25, or 3 to 7; and each R^w is independently a C_{1-12} alkyl, alkenyl, alkoxy, aryl, aryloxy, or polyoxyalkylene group, optionally wherein at least one hydrogen atom is replaced with an N, S, O, or F atom, or an amino group.

11. The polycarbonate composition of any one of the preceding claims, wherein the wherein the non-halogenated flame retardant comprises an organophosphorous flame retardant of Formula (23)

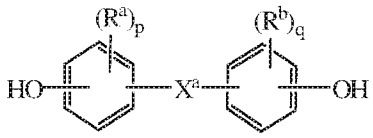


wherein q is at least 2, each occurrence of Ar is independently C_{6-18} aryl, preferably benzene, optionally substituted with a C_{1-18} hydrocarbyl group, or a C_{1-18} hydrocarbyloxy group, and

n and p are each 0, m is 1, R^2 is hydrogen, C_1-C_{18} alkyl, C_{3-10} cycloalkyl, (C_{1-6} alkyl)C_{3-10} cycloalkyl, C_{6-18} aryl, (C_{1-6} alkyl)C_{6-18} aryl, C_{3-12} heteroaryl, or (C_{1-6} alkyl)C_{3-12} heteroaryl, any carbon-carbon single bond is optionally replaced by a carbon-carbon double or triple bond, and any methylene is optionally replaced by O, S, S(=O), C(=O), P(=O), or NR^{10}, wherein R^{10} is hydrogen or C_{1-6} alkyl, and any methylene is optionally substituted with a group having an N, S, O, or F atom; or

n and p are each at least 1, m is 0, and X is C_1-C_{18} alkylidene, C_{3-10} cycloalkylidene, C_{6-18} arylene, C_{3-12} heteroarylene, or

a group derived from Formula (3)



(3),

wherein R^a and R^b are each independently a halogen, C_{1-12} alkoxy, or C_{1-12} alkyl, and p and q are each independently integers of 0 to 4, X^a is single bond, -O-, -S-, -S(O)-, -$S(O)_2$-, -C(O)-, or a C_{1-60} organic group; or

a -L^1-X'-L^2- group,

wherein L^1 and L^2 are each independently a single bond, C_1-C_{18} alkylidene, or a C_{3-10} cycloalkylidene, where any carbon-carbon single bond is optionally replaced by a carbon-carbon double or triple bond, and any methylene is optionally replaced by O, S, S(=O), C(=O), P(=O), or NR^{10}, wherein R^{10} is hydrogen or C_{1-6} alkyl, and any methylene is optionally substituted with one or more substituents independently chosen from halogen, hydroxyl, cyano, and amino. X' is C_1-C_{18} alkylidene, C_{3-10} cycloalkylidene, C_{6-18} arylene, C_{3-12} heteroarylene, or a group derived from Formula (3).

12. The polycarbonate composition of any one of the preceding claims, wherein the polycarbonate composition comprises 0.15 wt% or less of an anti-drip agent comprising fluorine, preferably wherein the polycarbonate composition excludes an anti-drip agent comprising fluorine.

13. The polycarbonate composition of any one of the preceding claims, wherein the polycarbonate composition comprises 0.01 to 1.0 wt% of an aromatic sulfone sulfonate, preferably potassium diphenylsulfone sulfonate.

14. An article comprising the polycarbonate composition of any one of the preceding claims, preferably wherein the article is a housing for monitors, a housing for a handheld electronic device, a thin film preferably a housing for a cell phone or a personal health care device, a housing for a consumer electronic device, preferably a battery housing, a covers, or a display panel, a housing for an electrical component, preferably an electric vehicle charger, a smart meter cover, a smart meter box, or a lighting component; an electrical connector; a component of a lighting fixture; an ornament; a home appliance; a roof; a greenhouse enclosure, a sun room enclosure, and a swimming pool enclosure.

15. A method for forming the article according to claim 14, comprising molding, casting, or extruding the composition to provide the article.

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/055604

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 C09J

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, 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.
Y	EP 3 798 265 A1 (SHPP GLOBAL TECH BV [NL]) 31 March 2021 (2021-03-31) paragraph [0009]; claim 1	1-15
Y	WO 2022/130211 A1 (SHPP GLOBAL TECH BV [NL]) 23 June 2022 (2022-06-23) paragraphs [0001], [0002]; claims 1,2,5,9	1-15
Y	US 10 597 530 B2 (SABIC GLOBAL TECHNOLOGIES BV [NL]) 24 March 2020 (2020-03-24) column 1, background section; claims 1,3,11,14	1-15
A	US 2013/317145 A1 (AN NARONG [CN] ET AL) 28 November 2013 (2013-11-28) paragraphs [0002], [0125], [0155]	1-15

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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
12 July 2024	09/09/2024

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	Goulis, Panagiotis

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2024/055604

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3798265 A1	31-03-2021	CN 112574545 A	30-03-2021
		EP 3798265 A1	31-03-2021
		US 2021095118 A1	01-04-2021
WO 2022130211 A1	23-06-2022	CN 116615503 A	18-08-2023
		EP 4263708 A1	25-10-2023
		US 2024010832 A1	11-01-2024
		WO 2022130211 A1	23-06-2022
US 10597530 B2	24-03-2020	CN 107849229 A	27-03-2018
		EP 3320018 A1	16-05-2018
		US 2018223097 A1	09-08-2018
		WO 2017007562 A1	12-01-2017
US 2013317145 A1	28-11-2013	CN 104334638 A	04-02-2015
		CN 104350098 A	11-02-2015
		CN 104364313 A	18-02-2015
		CN 104395402 A	04-03-2015
		CN 104395403 A	04-03-2015
		CN 104428354 A	18-03-2015
		CN 104583316 A	29-04-2015
		CN 104704059 A	10-06-2015
		CN 107434907 A	05-12-2017
		EP 2855570 A1	08-04-2015
		EP 2855575 A2	08-04-2015
		EP 2855581 A1	08-04-2015
		EP 2855585 A1	08-04-2015
		EP 2855586 A1	08-04-2015
		EP 2855587 A1	08-04-2015
		EP 2855588 A1	08-04-2015
		EP 2855593 A2	08-04-2015
		EP 3202851 A1	09-08-2017
		KR 20150013758 A	05-02-2015
		KR 20150013814 A	05-02-2015
		KR 20150013897 A	05-02-2015
		KR 20150023341 A	05-03-2015
		KR 20150023453 A	05-03-2015
		KR 20150023463 A	05-03-2015
		US 2013313493 A1	28-11-2013
		US 2013317141 A1	28-11-2013
		US 2013317143 A1	28-11-2013
		US 2013317144 A1	28-11-2013
		US 2013317145 A1	28-11-2013
		US 2013317146 A1	28-11-2013
		US 2013317147 A1	28-11-2013
		US 2013317148 A1	28-11-2013
		WO 2013175445 A2	28-11-2013
		WO 2013175450 A2	28-11-2013
		WO 2013175451 A1	28-11-2013
		WO 2013175453 A1	28-11-2013
		WO 2013175455 A1	28-11-2013
		WO 2013175456 A1	28-11-2013
		WO 2013177497 A1	28-11-2013
		WO 2013177558 A1	28-11-2013