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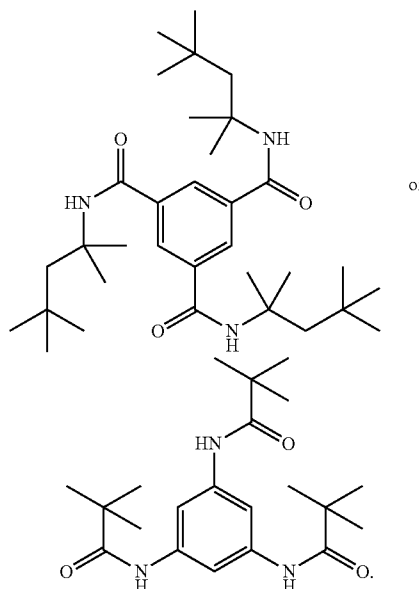
(19) **United States**(12) **Patent Application Publication**
Chin et al.(10) **Pub. No.: US 2011/0230109 A1**(43) **Pub. Date: Sep. 22, 2011**(54) **ELECTRET MATERIALS**(76) Inventors: **Hui Chin**, Katonah, NY (US);
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Klaus Stoll, Binzen (DE)(21) Appl. No.: **13/151,732**(22) Filed: **Jun. 2, 2011****Related U.S. Application Data**

(63) Continuation of application No. 12/079,605, filed on Mar. 27, 2008.

(60) Provisional application No. 60/928,610, filed on May 10, 2007, provisional application No. 60/922,024, filed on Apr. 5, 2007.

Publication Classification(51) **Int. Cl.****C08K 5/20** (2006.01)
C08L 23/12 (2006.01)
C08K 5/5357 (2006.01)
C08K 5/17 (2006.01)
D04H 13/00 (2006.01)(52) **U.S. Cl.** **442/327; 524/227; 524/229; 524/132**(57) **ABSTRACT**

Disclosed are electret materials with outstanding thermal and charge stability. The electret materials comprise a melt blend of a thermoplastic polymer and one or more compounds selected from the aromatic trisamides. The aromatic trisamides are for example of the formula



The melt blends are subjected to an electret treatment, for example a corona treatment. The electret materials are for example nonwoven polyolefin webs and are employed as filter materials, wipes, absorbent materials, filter masks, acoustic materials, printing substrates, measuring devices or contactless switches. The present electret materials may also comprise a further additive selected from the hindered amine light stabilizers and the hydroxyphenylalkylphosphonic esters or monoesters.

ELECTRET MATERIALS

[0001] This application claims benefit of U.S. app. Ser. No. 12/079,605, filed Mar. 27, 2008, pending, which claims benefit of U.S. provisional application Nos. 60/928,610, filed May 10, 2007 and 60/922,024, filed Apr. 5, 2007, the contents of which are incorporated herein by reference.

[0002] The present invention is aimed at electret materials having excellent thermal stability and charge stability. The electret materials are for example polyolefin fibers or films and are suitably employed as filter materials, wipes, absorbent materials, filter masks, acoustic materials, printing substrates, measuring devices or contactless switches.

BACKGROUND

[0003] U.S. Pat. No. 5,057,710 teaches electret materials comprising hindered amines, nitrogen containing hindered phenols or metal-containing hindered phenols.

[0004] U.S. Pat. No. 5,556,618 discloses antibacterial electret materials.

[0005] U.S. Pat. No. 6,123,752 teaches high efficiency filter medium containing a performance enhancing additive.

[0006] U.S. Pat. No. 6,743,464 teaches a method of making electrets through vapor condensation.

[0007] U.S. Pat. No. 6,969,484 discloses a method of making electret.

[0008] U.S. patent app. No. 60/791,047, filed Apr. 11, 2006, teaches electret materials comprising certain additives.

[0009] U.S. published app. No. 2005/0203226 and WO 2004/072168 teach trisamide nucleating agents.

[0010] Mohmeyer, et al., in *Polymer*, 48(2007), 1612-1619, discusses electret materials.

SUMMARY

[0011] Disclosed is an electret material with enhanced thermal and charge stability, which material has been subjected to an electret treatment, comprising

[0012] a thermoplastic polymer and

[0013] incorporated therein, an effective stabilizing amount of one or more aromatic trisamide compounds.

[0014] Also disclosed is a method for preparing an electret material with enhanced thermal and charge stability, which method comprises

[0015] melt blending a thermoplastic polymer with an effective stabilizing amount of one or more aromatic trisamide compounds and

[0016] subjecting the blend to an electret treatment.

DETAILED DISCLOSURE

[0017] The thermoplastic polymer is a non-conductive polymer that has the capability of possessing a non-transitory or long-lived trapped charge. The polymer is for example a polyolefin, a halogenated vinyl polymer (e.g. polyvinyl chloride), polystyrene, polycarbonate, a polyester (e.g. polyethylene terephthalate), a polyamide or a fluoropolymer (e.g. polytetrafluoroethylene).

[0018] The thermoplastic polymers are for example propylene homopolymers, propylene copolymers and polypropylene blends. Propylene copolymers may contain various proportions up to 90%, preferably up to 50%, of comonomers. Examples of comonomers are: olefins such as 1-olefins, e.g. ethylene, 1-butene, 1-pentene, 1-hexene, 1-heptene or 1-octene, isobutylene, cycloolefins, e.g. cyclopentene, cyclohexene, norbornene or ethylenenorborne, dienes such as butadiene, isoprene, 1,4-hexadiene, cyclopentadiene, dicyclopentadiene or norbornadiene; also acrylic acid derivatives and unsaturated carboxylic anhydrides such as maleic anhydride.

[0019] Polypropylene blends which can be used are mixtures of polypropylene with polyolefins. Examples are blends of polypropylene with polyethylene selected from the group consisting of high density polyethylene (HDPE), high molecular weight high density polyethylene (HMW HDPE), ultra high molecular weight high density polyethylene (UHMW HDPE), medium density polyethylene (MDPE), low density polyethylene (LDPE), linear low density polyethylene (LLDPE), branched low density polyethylene (BLDPE) and ethylene-propylene-diene terpolymers (EPDM) containing small proportions of diene.

[0020] The polymer is especially a polyolefin, for example polypropylene, poly(4-methyl-1-pentene) or linear low density polyethylene, or blends or copolymers thereof. The polymer may be a blend of a polyolefin and a polymer that contains polar groups, for example a polyester or a polyamide.

[0021] Polypropylene includes for instance reactor (such as metallocene) and visbroken (e.g. peroxides, hydroxylamine esters, thermally broken, etc.) grades.

[0022] The electret material comprising the thermoplastic material is in the form of a nonwoven web, a film, or a woven fabric. The electret material is in particular a nonwoven fibrous web.

[0023] The thermoplastic polymer may also be for example polyurethane or a polyester such as polylactic acid. The polyurethane may for example be in the form of a foam.

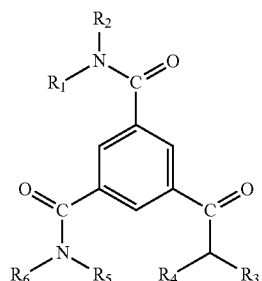
[0024] In addition to thermoplastic fibers, the electret material may be a natural fiber such as cotton.

[0025] The electret treatment may be any known treatment. Electret treatments are taught for example in U.S. Pat. Nos. 5,057,710, 5,556,618, 6,123,752, 6,743,464, 6,969,484, 6,284,339, 5,256,176 and 6,926,961, the disclosures of which are hereby incorporated by reference. The electret treatment is for example hydro-charging, tribo-electric charging or corona treatment. The electret treatment is especially a corona treatment.

[0026] An electret material according to this invention is a thermoplastic material that has been subjected to an electret treatment.

[0027] The aromatic trisamide compounds are taught for example in U.S. published app. No. 2005/0203226 and U.S. app. No. 10/544,508, published as WO 2004/072168, the contents of which are hereby incorporated by reference.

[0028] The aromatic trisamides are for instance of formula I



(I)

wherein

[0029] R₁, R₂, R₃, R₄, R₅ and R₆, independently of one another, are hydrogen,

[0030] C₁-C₂₀alkyl,

[0031] C₂-C₂₀alkyl substituted by C₁-C₁₀alkylamino, di(C₁-C₁₀alkyl)amino, C₁-C₁₀alkyloxy or hydroxy;

[0032] C₃-C₂₀alkenyl,

[0033] C₅-C₁₂cycloalkyl,

[0034] C₅-C₁₂cycloalkyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

[0035] cyclohexylmethyl;

[0036] cyclohexylmethyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

[0037] C₅-C₉cycloalkenyl,

[0038] C₅-C₉cycloalkenyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

[0039] phenyl substituted by 1, 2 or 3 radicals selected from the group consisting of C₁-C₁₀alkyl,

[0040] C₁-C₁₀alkyloxy, hydroxy, halogen, trihalogenmethyl, trihalogenmethoxy, benzoyl, phenylamino, acylamino and phenylazo;

[0041] C₇-C₉phenylalkyl,

[0042] C₇-C₉phenylalkyl which is substituted on the phenyl by 1, 2 or 3 radicals selected from the group

[0043] consisting of C₁-C₁₀alkyl, C₁-C₁₀alkoxy and hydroxy;

[0044] naphthyl,

[0045] naphthyl substituted by C₁-C₁₀alkyl;

[0046] adamantyl, or

[0047] a 5 to 6 membered heterocyclic group.

[0048] Examples of C₁-C₂₀alkyl are methyl, ethyl, propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, 2-ethylbutyl, n-pentyl, isopentyl, 1-methylpentyl, 1,3-dimethylbutyl, n-hexyl, 1-methyl-hexyl, n-heptyl, isoheptyl, 1,1,3,3-tetramethylbutyl, 1-methylheptyl, 3-methylheptyl, n-octyl, 2-ethylhexyl, 1,1,3-trimethylhexyl, 1,1,3,3-tetramethylpentyl, nonyl, decyl, undecyl, 1-methyl-undecyl, dodecyl, 1,1,3,3,5,5-hexamethylhexyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl and eicosyl. Preferred examples are butyl, octyl and octadecyl.

[0049] Examples of C₂-C₂₀alkyl substituted by C₁-C₁₀alkylamino, di(C₁-C₁₀alkyl)amino, C₁-C₁₀alkyloxy or hydroxy are 3-methylaminopropyl, 2-dimethylaminoethyl, 2-diethylaminoethyl, 3-dimethylaminopropyl, 3-diethylaminopropyl, 2-methoxyethyl, 2-ethoxyethyl, 2-methoxypropyl, 3-methoxypropyl, 2-ethoxypropyl,

3-isopropoxypropyl and hydroxyethyl. Preferred examples are 3-dimethylaminopropyl, 3-methoxypropyl and 2-methoxyethyl.

[0050] Examples of C₃-C₂₀alkenyl are allyl, 2-methylallyl, butenyl, pentenyl, hexenyl and oleyl. The carbon atom in position 1 is preferably saturated. Preferred examples are allyl and oleyl.

[0051] Examples of C₅-C₁₂cycloalkyl are cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl and cyclododecyl. Preferred examples are cyclohexyl, cycloheptyl, cyclooctyl and cyclododecyl.

[0052] Preferred examples of C₅-C₁₂cycloalkyl substituted by 1, 2 or 3 C₁-C₁₀alkyl are 3-methylcyclohexyl and 2,3-dimethylcyclohexyl.

[0053] An example of cyclohexylmethyl substituted by 1, 2 or 3 C₁-C₁₀alkyl is 1-cyclohexylethyl.

[0054] An example of C₅-C₉cycloalkenyl is cyclohexenyl.

[0055] An example of C₅-C₉cycloalkenyl substituted by 1, 2 or 3 C₁-C₁₀alkyl is methylcyclohexenyl.

[0056] Examples of phenyl substituted by 1, 2 or 3 radicals selected from the group consisting of C₁-C₁₀alkyl, C₁-C₁₀alkyloxy, hydroxy, halogen, trihalogenmethyl, trihalogenmethoxy, benzoyl, phenylamino, acylamino and phenylazo are 4-methylphenyl, 2-ethylphenyl, 4-ethylphenyl, 4-isopropylphenyl, 4-tert-butylphenyl, 4-sec-butylphenyl, 4-isobutylphenyl, 3,5-dimethylphenyl, 3,4-dimethylphenyl, 2,4-dimethylphenyl, 2,6-diethylphenyl, 2-ethyl-6-methylphenyl, 2,6-diisopropylphenyl, 4-methoxyphenyl, 4-ethoxyphenyl, 4-hydroxyphenyl, 4-fluorophenyl, 3,5-difluorophenyl, 2-chlorophenyl, 3-chlorophenyl, 3-chloro-6-methylphenyl, 3,5-di(trifluoromethyl)phenyl, 4-trifluoromethoxyphenyl, 2-benzoylphenyl, 4-phenylaminophenyl, 4-acetamidophenyl and 4-(phenylazo)phenyl. A preferred example is 3,4-dimethylphenyl.

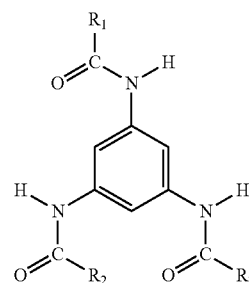
[0057] Examples of C₇-C₉phenylalkyl are benzyl and 2-phenylethyl. Benzyl is preferred.

[0058] Examples of C₇-C₉phenylalkyl which is substituted on the phenyl by 1, 2 or 3 radicals selected from the group consisting of C₁-C₁₀alkyl, C₁-C₁₀alkoxy and hydroxy are methylbenzyl, dimethylbenzyl, trimethylbenzyl, tert-butylbenzyl, methoxybenzyl and 3,5-di-tert-butyl-4-hydroxybenzyl.

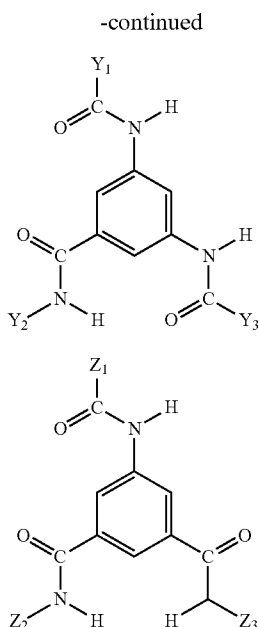
[0059] An example of naphthyl substituted by C₁-C₁₀alkyl is methyl-naphthyl.

[0060] Examples of a 5 to 6 membered heterocyclic group are 2-picolyl, (2-furyl)methyl, (2-tetrahydrofuryl)methyl, 2-pyrimidyl, 6-methyl-2-pyridyl, 1,2,4-triazol-3-yl and 2-(1-piperazinyl)ethyl.

[0061] The aromatic trisamides are for example of formulae IIa, IIb or IIc



(IIa)



wherein

- [0062] R_1 , R_2 and R_3 , or Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3 independently of one another are
- [0063] C_1 - C_{20} alkyl unsubstituted or substituted by one or more hydroxy;
- [0064] C_2 - C_{20} alkenyl unsubstituted or substituted by one or more hydroxy;
- [0065] C_2 - C_{20} alkyl interrupted by oxygen or sulfur;
- [0066] C_3 - C_{12} cycloalkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0067] (C_3 - C_{12} cycloalkyl)- C_1 - C_{10} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0068] bis[C_3 - C_{12} cycloalkyl]- C_1 - C_{10} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0069] a bicyclic or tricyclic hydrocarbon radical with 5 to 20 carbon atoms unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0070] phenyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl,
- [0071] C_1 - C_{20} alkoxy, C_1 - C_{20} alkylamino, di(C_1 - C_{20} alkyl) amino, hydroxy and nitro;
- [0072] phenyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl, C_3 - C_{12} cycloalkyl, phenyl, C_1 - C_{20} alkoxy and hydroxy;
- [0073] phenylethenyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0074] biphenyl-(C_1 - C_{10} alkyl) unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0075] naphthyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0076] naphthyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0077] naphthoxymethyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;
- [0078] biphenylenyl, flourenyl, anthryl;
- [0079] a 5- to 6-membered heterocyclic radical unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

[0080] a C_1 - C_{20} hydrocarbon radical containing one or more halogen; or

[0081] tri(C_1 - C_{10} alkyl)silyl(C_1 - C_{10} alkyl);

with the proviso that at least one of the radicals R_1 , R_2 and R_3 , or Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3 is

[0082] branched C_3 - C_{20} alkyl unsubstituted or substituted by one or more hydroxy;

[0083] C_2 - C_{20} alkyl interrupted by oxygen or sulfur;

[0084] C_3 - C_{12} cycloalkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

[0085] (C_3 - C_{12} cycloalkyl)- C_1 - C_{10} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

[0086] a bicyclic or tricyclic hydrocarbon radical with 5 to 20 carbon atoms unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

[0087] phenyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl,

[0088] C_1 - C_{20} alkoxy, C_1 - C_{20} alkylamino, di(C_1 - C_{20} alkyl) amino, hydroxy and nitro;

[0089] phenyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl, C_3 - C_{12} cycloalkyl, phenyl, C_1 - C_{20} alkoxy and hydroxy;

[0090] biphenyl-(C_1 - C_{10} alkyl) unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

[0091] naphthyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl; or

[0092] tri(C_1 - C_{10} alkyl)silyl(C_1 - C_{10} alkyl).

[0093] According to a preferred embodiment, at least one of the radicals R_1 , R_2 and R_3 , or Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3 is branched C_3 - C_{20} alkyl, or C_3 - C_{12} cycloalkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl.

[0094] According to a particular preferred embodiment, at least one of the radicals R_1 , R_2 and R_3 , or Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3 is branched C_3 - C_{10} alkyl.

[0095] Examples of C_1 - C_{20} alkyl, e.g. branched C_3 - C_{20} alkyl, unsubstituted or substituted by one or more hydroxy, e.g. 1, 2 or 3 hydroxy, are ethyl, n-propyl, 1-methylethyl, n-butyl, 2-methylpropyl, 1-methylpropyl, tert-butyl, pentyl, 1-methylbutyl, 2-methylbutyl, 3-methylbutyl, 1,1-dimethylpropyl, 1-ethylpropyl, tert-butylmethyl, hexyl, 1-methylpentyl, heptyl, isoheptyl, 1-ethylhexyl, 2-ethylpentyl, 1-propylbutyl, octyl, nonyl, isononyl, neononyl, 2,4,4-trimethylpentyl, undecyl, tridecyl, pentadecyl, heptadecyl, hydroxymethyl and 1-hydroxyethyl. Branched C_3 - C_{10} alkyl is particularly preferred. One of the preferred meanings of the radicals R_1 , R_2 and R_3 , or

Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3 is branched C_3 - C_{10} alkyl with a quaternary C atom in position 1, in particular $-\text{C}(\text{CH}_3)_2-\text{H}$ or $-\text{C}(\text{CH}_3)_2-(\text{C}_1-\text{C}_7\text{alkyl})$.

[0096] Examples of C_2 - C_{20} alkenyl unsubstituted or substituted by one or more hydroxy, e.g. 1, 2 or 3 hydroxy, are 9-decenyl, 8-heptadecenyl and 11-hydroxy-8-heptadecenyl.

[0097] Examples of C_2 - C_{20} alkyl interrupted by oxygen are t-butoxymethyl, t-butoxyethyl, t-butoxypropyl and t-butoxybutyl.

[0098] Examples of C_2 - C_{20} alkyl interrupted by sulfur are $(\text{H}_3\text{C})_3\text{C}-\text{S}-\text{CH}_2-$, $(\text{H}_3\text{C})_3\text{C}-\text{S}-\text{C}_2\text{H}_4-$, $(\text{H}_3\text{C})_3\text{C}-\text{S}-\text{C}_3\text{H}_6-$ and $(\text{H}_3\text{C})_3\text{C}-\text{S}-\text{C}_4\text{H}_8-$.

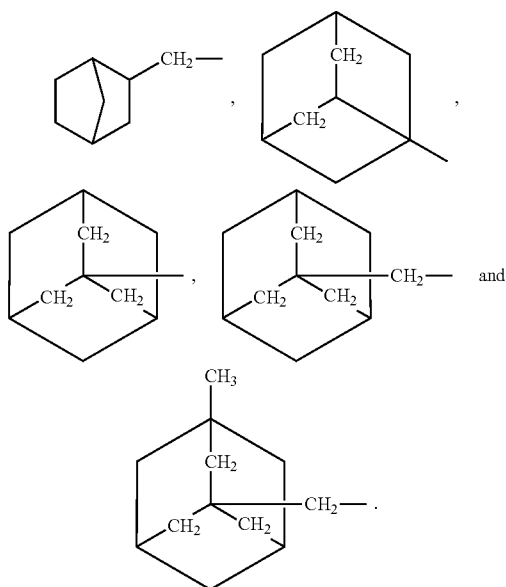
[0099] Examples of C_3 - C_{12} cycloalkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl, e.g. 1, 2, 3 or 4 C_1 - C_4 alkyl, are cyclopropyl, 3-methylcyclopropyl, 2,2,3,3-tetramethylcyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl,

1-methylcyclohexyl, 2-methylcyclohexyl, 3-methylcyclohexyl, 4-methylcyclohexyl, 4-tert-butylcyclohexyl and cycloheptyl.

[0100] Examples of (C₃-C₁₂cycloalkyl)-C₁-C₁₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, are cyclopentylmethyl, 2-cyclopentylethyl, cyclohexylmethyl, 2-cyclohexylethyl, 3-cyclohexylpropyl, 4-cyclohexylbutyl and (4-methylcyclohexyl)methyl.

[0101] An example of bis[C₃-C₁₂cycloalkyl]-C₁-C₁₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, is dicyclohexylmethyl.

[0102] Examples of a bicyclic or tricyclic hydrocarbon radical with 5 to 20 carbon atoms unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, are



[0103] Examples of phenyl unsubstituted or substituted by one or more radicals, e.g. 1, 2 or 3 radicals, selected from C₁-C₂₀alkyl, C₁-C₂₀alkoxy, C₁-C₂₀alkylamino, di(C₁-C₂₀alkyl)amino, hydroxy and nitro, preferably C₁-C₄alkyl, C₁-C₄alkoxy, C₁-C₄alkylamino, di(C₁-C₄alkyl)amino, hydroxy and nitro, are phenyl, 3-methylphenyl, 3-methoxyphenyl, 4-methylphenyl, 4-ethylphenyl, 4-propylphenyl, 4-isopropylphenyl, 4-tert-butylphenyl, 4-isopropoxyphenyl, 2,3-dimethoxyphenyl, 2-nitrophenyl, 3-methyl-6-nitrophenyl, 4-dimethylaminophenyl, 2,3-dimethylphenyl, 2,6-dimethylphenyl, 2,4-dimethylphenyl, 3,4-dimethylphenyl, 3,5-dimethylphenyl, 3,5-di-tert-butylphenyl, 2,4,6-trimethylphenyl and 3,5-di-tert-butyl-4-hydroxyphenyl.

[0104] Examples of phenyl-C₁-C₂₀alkyl unsubstituted or substituted by one or more radicals, e.g. 1, 2 or 3 radicals, selected from C₁-C₂₀alkyl, C₃-C₁₂cycloalkyl, phenyl, C₁-C₂₀alkoxy and hydroxy, preferably C₁-C₄alkyl, C₃-C₆cycloalkyl, phenyl, C₁-C₄alkoxy and hydroxy, are benzyl, α -cyclohexylbenzyl, diphenylmethyl, 1-phenylethyl, α -hydroxybenzyl, 2-phenylethyl, 2-phenylpropyl, 3-phenylpropyl, 3-methylbenzyl, 3,4-dimethoxybenzyl and 2-(3,4-dimethoxyphenyl)ethyl.

[0105] An example of phenylethenyl unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, is 2-(4-methylphenyl)ethenyl.

[0106] An example of biphenyl-(C₁-C₁₀alkyl) unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, is 4-biphenylmethyl.

[0107] Examples of naphthyl unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, are 1-naphthyl and 2-naphthyl.

[0108] Examples of naphthyl-C₁-C₂₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, are 1-naphthylmethyl and 2-naphthylmethyl.

[0109] An example of naphthoxymethyl unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, is 1-naphthoxymethyl.

[0110] An examples of biphenylenyl, flourenyl or anthryl is 2-biphenylenyl, 9-flourenyl, 1-flourenyl or 9-anthryl, respectively.

[0111] Examples of a 5- to 6-membered heterocyclic radical unsubstituted or substituted by one or more C₁-C₂₀alkyl, e.g. 1, 2 or 3 C₁-C₄alkyl, are 3-pyridinyl, 4-pyridinyl, 2-hydroxypyridin-3-yl, 3-quinolinyl, 4-quinolinyl, 2-furyl, 3-furyl and 1-methyl-2-pyrryl.

[0112] Examples of a C₁-C₂₀hydrocarbon radical containing one or more halogen, e.g. 1, 2, 3, 4, 5, or 6 —F, —Cl or —J, are 1-bromo-2-methylpropyl, dichloromethyl, pentafluoroethyl, 3,5-bis[trifluoromethyl]phenyl, 2,3,5,6-tetrafluoro-p-tolyl, 2,3-dichlorophenyl, 3,4-dichlorophenyl and 2,4-bis[trifluoromethyl]phenyl.

[0113] Examples of compounds of formula (IIa) are:

[0114] 1,3,5-tris[cyclohexylcarbonylamino]benzene,

[0115] 1,3,5-tris[2,2-dimethylpropionylamino]benzene,

[0116] 1,3,5-tris[4-methylbenzoylamino]benzene,

[0117] 1,3,5-tris[3,4-dimethylbenzoylamino]benzene,

[0118] 1,3,5-tris[3,5-dimethylbenzoylamino]benzene,

[0119] 1,3,5-tris[cyclopentanecarbonylamino]benzene,

[0120] 1,3,5-tris[1-adamantanecarbonylamino]benzene,

[0121] 1,3,5-tris[2-methylpropionylamino]benzene,

[0122] 1,3,5-tris[3,3-dimethylbutyrylamino]benzene,

[0123] 1,3,5-tris[2-ethylbutyrylamino]benzene,

[0124] 1,3,5-tris[2,2-dimethylbutyrylamino]benzene,

[0125] 1,3,5-tris[2-cyclohexyl-acetylamino]benzene,

[0126] 1,3,5-tris[3-cyclohexyl-propionylamino]benzene,

[0127] 1,3,5-tris[4-cyclohexyl-butyrylamino]benzene,

[0128] 1,3,5-tris[5-cyclohexyl-valeroylamino]benzene,

[0129] 1-isobutyrylamino-3,5-bis[pivaloylamino]benzene,

[0130] 2,2-dimethylbutyrylamino-3,5-bis[pivaloylamino]benzene,

[0131] 3,3-dimethylbutyrylamino-3,5-bis[pivaloylamino]benzene,

[0132] 1,3-bis[isobutyrylamino]-5-pivaloylaminobenzene,

[0133] 1,3-bis[isobutyrylamino]-5-(2,2-dimethyl-buteryl)aminobenzene,

[0134] 1,3-bis[isobutyrylamino]-5-(3,3-dimethyl-buteryl)aminobenzene,

[0135] 1,3-bis[2,2-dimethylbutyrylamino]-5-pivaloylaminobenzene,

[0136] 1,3-bis[2,2-dimethylbutyrylamino]-5-isobutyrylamino-benzene,

[0137] 1,3-bis[2,2-dimethylbutyrylamino]-5-(3,3-dimethylbutyryl)-aminobenzene,

[0138] 1,3-bis[3,3-dimethylbutyrylamino]-5-pivaloylamino-benzene,

[0139] 1,3-bis[3,3-dimethylbutyrylamino]-5-isobutyrylamino-benzene,

- [0140]** 1,3-bis[3,3-dimethylbutyrylamino]-5-(2,2-dimethyl-butylamino)aminobenzene, and
- [0141]** 1,3,5-tris[3-(trimethylsilyl)propionylamino]benzene.
- [0142]** Further examples of compounds of formula (IIa) are:
- [0143]** 1,3,5-tris[2,2-dimethylvaleroylamino]benzene,
- [0144]** 1,3,5-tris[3,3-dimethylvaleroylamino]benzene,
- [0145]** 1,3,5-tris[2,4-dimethylvaleroylamino]benzene,
- [0146]** 1,3,5-tris[4,4-dimethylvaleroylamino]benzene,
- [0147]** 1,3,5-tris[4-methylvaleroylamino]benzene,
- [0148]** 1,3,5-tris[2-methylbutyrylamino]benzene,
- [0149]** 1,3,5-tris[2-methylvaleroylamino]benzene,
- [0150]** 1,3,5-tris[3-methylvaleroylamino]benzene,
- [0151]** 1,3,5-tris[2,2,3,3-tetramethyl-cyclopropanecarbonylamino]benzene,
- [0152]** 1,3,5-tris[cyclopentylacetylaminolamino]benzene,
- [0153]** 1,3,5-tris[3-cyclopentylpropionylaminolamino]benzene,
- [0154]** 1,3,5-tris[2-norbornyl-acetylaminolamino]benzene,
- [0155]** 1,3,5-tris[4-t-butylcyclohexane-1-carbonylamino]benzene,
- [0156]** 1,3,5-tris[2-(t-butoxy)-acetylaminolamino]benzene,
- [0157]** 1,3,5-tris[3-(t-butoxy)-propionylaminolamino]benzene,
- [0158]** 1,3,5-tris[4-(t-butoxy)-butyrylamino]benzene,
- [0159]** 1,3,5-tris[5-t-butoxy-valeroylamino]benzene,
- [0160]** 1,3,5-tris[cyclopropanecarbonylamino]benzene,
- [0161]** 1,3,5-tris[2-methylcyclopropane-1-carbonylamino]benzene,
- [0162]** 1,3,5-tris[3-noradamantane-1-carbonylamino]benzene,
- [0163]** 1,3,5-tris[biphenyl-4-acetylaminolamino]benzene,
- [0164]** 1,3,5-tris[2-naphthyl-acetylaminolamino]benzene,
- [0165]** 1,3,5-tris[3-methylphenyl-acetylaminolamino]benzene,
- [0166]** 1,3,5-tris[(3,4-dimethoxyphenyl)-acetylaminolamino]benzene,
- [0167]** 1,3,5-tris[(3-trimethylsilyl-propionylaminolamino]benzene, and
- [0168]** 1,3,5-tris[(4-trimethylsilyl-butylaminolamino]benzene.
- [0169]** Examples of compounds of formula (IIb) are:
- [0170]** N-t-butyl-3,5-bis-(3-methylbutyrylamino)-benzamide,
- [0171]** N-t-butyl-3,5-bis-(pivaloylamino)-benzamide,
- [0172]** N-t-octyl-3,5-bis-(pivaloylamino)-benzamide,
- [0173]** N-(1,1-dimethyl-propyl)-3,5-bis-(pivaloylamino)-benzamide,
- [0174]** N-(t-octyl)-3,5-bis-(isobutyrylamino)-benzamide,
- [0175]** N-(t-butyl)-3,5-bis-(pivaloylamino)-benzamide,
- [0176]** N-(2,3-dimethyl-cyclohexyl)-3,5-bis-(pivaloylamino)-benzamide,
- [0177]** N-t-butyl-3,5-bis-(cyclopentanecarbonylamino)-benzamide,
- [0178]** N-(3-methylbutyl)-3,5-bis-(3-methylbutyrylamino)-benzamide,
- [0179]** N-(3-methylbutyl)-3,5-bis-(pivaloylamino)-benzamide,
- [0180]** N-(3-methylbutyl)-3,5-bis-(4-methylpentanoylamino)-benzamide,
- [0181]** N-(3-methylbutyl)-3,5-bis-(cyclopentanecarbonylamino)-benzamide,
- [0182]** N-(3-methylbutyl)-3,5-bis-(cyclohexanecarbonylamino)-benzamide,
- [0183]** N-cyclopentyl-3,5-bis-(3-methylbutyrylamino)-benzamide,
- [0184]** N-cyclopentyl-3,5-bis-(pivaloylamino)-benzamide,
- [0185]** N-cyclopentyl-3,5-bis-(4-methylpentanoylamino)-benzamide,
- [0186]** N-cyclopentyl-3,5-bis-(cyclopentanecarbonylamino)-benzamide,
- [0187]** N-cyclopentyl-3,5-bis-(cyclohexanecarbonylamino)-benzamide,
- [0188]** N-cyclohexyl-3,5-bis-(3-methylbutyrylamino)-benzamide,
- [0189]** N-cyclohexyl-3,5-bis-(pivaloylamino)-benzamide,
- [0190]** N-cyclohexyl-3,5-bis-(4-methylpentanoylamino)-benzamide,
- [0191]** N-cyclohexyl-3,5-bis-(cyclopentanecarbonylamino)-benzamide,
- [0192]** N-cyclohexyl-3,5-bis-(cyclohexanecarbonylamino)-benzamide,
- [0193]** N-isopropyl-3,5-bis-(pivaloylamino)-benzamide,
- [0194]** N-isopropyl-3,5-bis-(isobutyrylamino)-benzamide,
- [0195]** N-t-butyl-3,5-bis-(2,2-dimethylbutyrylamino)-benzamide, and
- [0196]** N-t-octyl-3,5-bis-(2,2-dimethylbutyrylamino)-benzamide.
- [0197]** Examples of compounds of formula (IIc) are:
- [0198]** 5-pivaloylamino-isophthalic acid N,N'-di-t-butyl-diamide,
- [0199]** 5-pivaloylamino-isophthalic acid N,N'-di-t-octyl-diamide,
- [0200]** 5-(2,2-dimethylbutyrylamino)-isophthalic acid N,N'-di-t-butyl-diamide,
- [0201]** 5-(2,2-dimethylbutyrylamino)-isophthalic acid N,N'-di-t-octyl-diamide,
- [0202]** 5-(3-methylbutyrylamino)-isophthalic acid N,N'-di-cyclohexyldiamide,
- [0203]** 5-(pivaloylamino)-isophthalic acid N,N'-di-cyclohexyldiamide,
- [0204]** 5-(cyclopentanecarbonylamino)-isophthalic acid N,N'-di-cyclohexyldiamide,
- [0205]** 5-(cyclohexylcarbonylamino)-isophthalic acid N,N'-di-cyclohexyldiamide,
- [0206]** 5-(cyclopentanecarbonylamino)-isophthalic acid N,N'-bis-(2-methylcyclohexyl)diamide,
- [0207]** 5-(cyclohexanecarbonylamino)-isophthalic acid N,N'-bis-(2-methylcyclohexyl)diamide,
- [0208]** 5-((1-methylcyclohexanecarbonyl)amino)-isophthalic acid N,N'-bis-(2-methylcyclohexyl)diamide, and
- [0209]** 5-((2-methylcyclohexanecarbonyl)amino)-isophthalic acid N,N'-bis-(2-methylcyclohexyl)diamide.
- [0210]** The addition of the aromatic trisamides to the thermoplastic polymer can be carried out in all customary mixing machines in which the polymer is melted and mixed with the additives.
- [0211]** Suitable machines are known to those skilled in the art. They are predominantly mixers, kneaders and extruders.
- [0212]** The process is preferably carried out in an extruder by introducing the additives during processing.

[0213] Particularly preferred processing machines are single-screw extruders, contrarotating and corotating twin-screw extruders, planetary-gear extruders, ring extruders or cokneaders. It is also possible to use processing machines provided with at least one gas removal compartment to which a vacuum can be applied.

[0214] Suitable extruders and kneaders are described, for example, in *Handbuch der Kunststoffextrusion*, Vol. 1 Grundlagen, Editors F. Hensen, W. Knappe, H. Potente, 1989, pp. 3-7, ISBN:3-446-14339-4 (Vol. 2 Extrusionsanlagen 1986, ISBN 3-446-14329-7).

[0215] For example, the screw length is 1-60 screw diameters, preferably 35-48 screw diameters. The rotational speed of the screw is preferably 10-600 rotations per minute (rpm), very particularly preferably 25-300 rpm.

[0216] The maximum throughput is dependent on the screw diameter, the rotational speed and the driving force. The process of the present invention can also be carried out at a level lower than maximum throughput by varying the parameters mentioned or employing weighing machines delivering dosage amounts.

[0217] If a plurality of components are added, these can be premixed or added individually.

[0218] The polymers need to be subjected to an elevated temperature for a sufficient period of time during incorporation of additives. The temperature is generally above the softening point of the polymers.

[0219] In a preferred embodiment of the processes of the present invention, a temperature range lower than 280° C., particularly from about 160° C. to 280° C. is employed. In a particularly preferred process variant, the temperature range from about 200° C. to 270° C. is employed.

[0220] In the processes and compositions of the present invention the above-described aromatic trisamide compounds are present in concentrations, based on the amount of the polymer, of from about 0.001 to about 1.0% by weight. For instance, the trisamides are present from about 0.005 to 0.5% by weight, from about 0.01 to about 0.1% by weight, from about 0.01 to about 0.09% by weight, based on the weight of the polymer. The aromatic trisamides can be added as individual compounds or as mixtures to the polymer.

[0221] Incorporation of additives into the polymers can be carried out, for example, by mixing the above-described aromatic trisamides or mixtures thereof and, if desired, further additives into the polymers using the methods customary in process technology.

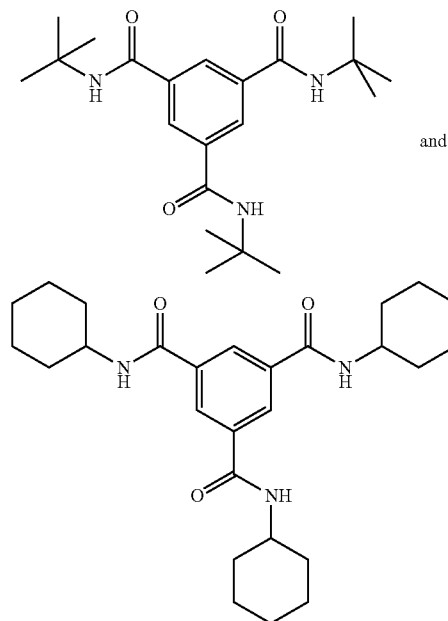
[0222] The aromatic trisamides can also be added to the polymers in the form of a masterbatch in which these compounds are present, for example, in a concentration of from about 1 to 25% by weight. The present invention therefore further provides a concentrate in which the compounds of the invention are present in a concentration of 1-25% by weight and which can be added to the thermoplastic polymer.

[0223] Another aspect of this invention is that instead of melt blending, the present trisamides may be topically applied to the electret material.

[0224] For example in the case where the electret material is cotton the present trisamides may be topically applied.

[0225] Another aspect of this invention is the co-use of certain other additives along with the present aromatic trisamides. These certain other additives are incorporated in the same manner as the trisamides.

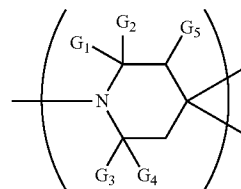
[0226] When employed without certain co-additives, the trisamides



[0227] are excluded from the present invention.

[0228] For instance, the class of stabilizers of the hindered amine light stabilizers (HALS) are advantageously also employed in the present compositions and processes.

[0229] The present sterically hindered amine stabilizers contain at least one moiety of formula



where G_1 , G_2 , G_3 and G_4 are independently alkyl of 1 to 8 carbon atoms or G_1 and G_2 or G_3 and G_4 together are pentamethylene and G_5 is hydrogen or alkyl of 1 to 8 carbon atoms.

[0230] The hindered amines are disclosed for example in U.S. Pat. Nos. 5,004,770, 5,204,473, 5,096,950, 5,300,544, 5,112,890, 5,124,378, 5,145,893, 5,216,156, 5,844,026, 5,980,783, 6,046,304, 6,117,995, 6,271,377, 6,297,299, 6,392,041, 6,376,584, 6,472,456, and 7,030,196. The relevant disclosures of these patents are hereby incorporated by reference.

[0231] U.S. Pat. Nos. 6,271,377, 6,392,041 and 6,376,584, cited above disclose hindered hydroxyalkoxyamine stabilizers.

[0232] Suitable hindered amines include for example:

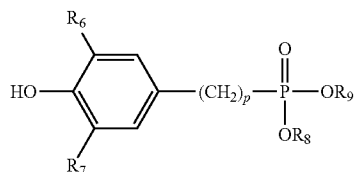
[0233] 1) 1-cyclohexyloxy-2,2,6,6-tetramethyl-4-octadecylaminopiperidine,

[0234] 2) bis(2,2,6,6-tetramethylpiperidin-4-yl) sebacate,

[0235] 3) bis(1-acetoxy-2,2,6,6-tetramethylpiperidin-4-yl) sebacate,

- [0236] 4) bis(1,2,2,6,6-pentamethyl-4-yl) sebacate,
 [0237] 5) bis(1-cyclohexyloxy-2,2,6,6-tetramethylpiperidin-4-yl) sebacate,
 [0238] 6) bis(1-octyloxy-2,2,6,6-tetramethylpiperidin-4-yl) sebacate;
 [0239] 7) bis(1-acyl-2,2,6,6-tetramethylpiperidin-4-yl) sebacate,
 [0240] 8) bis(1,2,2,6,6-pentamethyl-4-piperidyl) n-butyl-3,5-di-tert-butyl-4-hydroxybenzylmalonate
 [0241] 9) 2,4-bis[(1-cyclohexyloxy-2,2,6,6-tetramethylpiperidin-4-yl)butylamino]-6-(2-hydroxy-ethylamino)-s-triazine,
 [0242] 10) bis(1-cyclohexyloxy-2,2,6,6-tetramethylpiperidin-4-yl) adipate,
 [0243] 11) 2,4-bis[(1-cyclohexyloxy-2,2,6,6-piperidin-4-yl)butylamino]-6-chloro-s-triazine,
 [0244] 12) 1-(2-hydroxy-2-methylpropoxy)-4-hydroxy-2,2,6,6-tetramethylpiperidine,
 [0245] 13) 1-(2-hydroxy-2-methylpropoxy)-4-oxo-2,2,6,6-tetramethylpiperidine,
 [0246] 14) 1-(2-hydroxy-2-methylpropoxy)-4-octadecanoyloxy-2,2,6,6-tetramethylpiperidine,
 [0247] 15) bis(1-(2-hydroxy-2-methylpropoxy)-2,2,6,6-tetramethylpiperidin-4-yl) sebacate,
 [0248] 16) bis(1-(2-hydroxy-2-methylpropoxy)-2,2,6,6-tetramethylpiperidin-4-yl) adipate,
 [0249] 17) 2,4-bis[N-[1-(2-hydroxy-2-methylpropoxy)-2,2,6,6-tetramethylpiperidin-4-yl]-N-butyl-amino]-6-(2-hydroxyethylamino)-s-triazine,
 [0250] 18) 4-benzoyl-2,2,6,6-tetramethylpiperidine,
 [0251] 19) di-(1,2,2,6,6-pentamethylpiperidin-4-yl) p-methoxybenzylidenemalonate,
 [0252] 20) 4-stearyl-2,2,6,6-tetramethylpiperidine,
 [0253] 21) bis(1-octyloxy-2,2,6,6-tetramethylpiperidyl) succinate,
 [0254] 22) 1,2,2,6,6-pentamethyl-4-aminopiperidine,
 [0255] 23) 2-undecyl-7,7,9,9-tetramethyl-1-oxa-3,8-diaza-4-oxo-spiro[4,5]decane,
 [0256] 24) tris(2,2,6,6-tetramethyl-4-piperidyl) nitrilotriacetate,
 [0257] 25) tris(2-hydroxy-3-(amino-(2,2,6,6-tetramethylpiperidin-4-yl)propyl) nitrilotriacetate,
 [0258] 26) tetrakis(2,2,6,6-tetramethyl-4-piperidyl)-1,2,3,4-butane-tetracarboxylate,
 [0259] 27) tetrakis(1,2,2,6,6-pentamethyl-4-piperidyl)-1,2,3,4-butane-tetracarboxylate,
 [0260] 28) 1,1'-(1,2-ethanediyl)-bis(3,3,5,5-tetramethylpiperazinone),
 [0261] 29) 3-n-octyl-7,7,9,9-tetramethyl-1,3,8-triazaspiro[4,5]decane-2,4-dione,
 [0262] 30) 8-acetyl-3-dodecyl-7,7,9,9-tetramethyl-1,3,8-triazaspiro[4,5]decane-2,4-dione,
 [0263] 31) 3-dodecyl-1-(2,2,6,6-tetramethyl-4-piperidyl) pyrrolidin-2,5-dione,
 [0264] 32) 3-dodecyl-1-(1,2,2,6,6-pentamethyl-4-piperidyl)pyrrolidine-2,5-dione,
 [0265] 33) N,N'-bis-formyl-N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine,
 [0266] 34) the reaction product of 2,4-bis[(1-cyclohexyloxy-2,2,6,6-piperidin-4-yl)butylamino]-6-chloro-s-triazine with N,N'-bis(3-aminopropyl)ethylenediamine),
 [0267] 35) the condensate of 1-(2-hydroxyethyl)-2,2,6,6-tetramethyl-4-hydroxypiperidine and succinic acid,
 [0268] 36) linear or cyclic condensates of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)-hexamethylenediamine and 4-tert-octylamino-2,6-dichloro-1,3,5-triazine,
 [0269] 37) linear or cyclic condensates of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)-hexamethylenediamine and 4-cyclohexylamino-2,6-dichloro-1,3,5-triazine,
 [0270] 38) linear or cyclic condensates of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)-hexamethylenediamine and 4-morpholino-2,6-dichloro-1,3,5-triazine,
 [0271] 39) linear or cyclic condensates of N,N'-bis(1,2,2,6,6-pentamethyl-4-piperidyl)-hexamethylenediamine and 4-morpholino-2,6-dichloro-1,3,5-triazine,
 [0272] 40) the condensate of 2-chloro-4,6-bis(4-n-butylamino-2,2,6,6-tetramethylpiperidyl)-1,3,5-triazine and 1,2-bis(3-aminopropylamino)ethane,
 [0273] 41) the condensate of 2-chloro-4,6-di-(4-n-butylamino-1,2,2,6,6-pentamethylpiperidyl)-1,3,5-triazine and 1,2-bis(3-aminopropylamino)ethane,
 [0274] 42) a reaction product of 7,7,9,9-tetramethyl-2-cycloundecyl-1-oxa-3,8-diaza-4-oxospiro [4,5]decane and epichlorohydrin,
 [0275] 43) poly[methyl(3-oxy-(2,2,6,6-tetramethylpiperidin-4-yl)propyl)] siloxane, CAS#182635-99-0,
 [0276] 44) reaction product of maleic acid anhydride-C₁₈-C₂₂- α -olefin-copolymer with 2,2,6,6-tetramethyl-4-aminopiperidine,
 [0277] 45) the oligomeric compound which is the condensation product of 4,4'-hexamethylene-bis(amino-2,2,6,6-tetramethylpiperidine) and 2,4-dichloro-6-[(2,2,6,6-tetramethylpiperidin-4-yl)butylamino]-s-triazine end-capped with 2-chloro-4,6-bis(dibutylamino)-s-triazine,
 [0278] 46) the oligomeric compound which is the condensation product of 4,4'-hexamethylene-bis(amino-1,2,2,6,6-pentaamethylpiperidine) and 2,4-dichloro-6-[(1,2,2,6,6-pentaamethylpiperidin-4-yl)butylamino]-s-triazine end-capped with 2-chloro-4,6-bis(dibutylamino)-s-triazine,
 [0279] 47) the oligomeric compound which is the condensation product of 4,4'-hexamethylene-bis(amino-1-propoxy-2,2,6,6-tetramethylpiperidine) and 2,4-dichloro-6-[(1-propoxy-2,2,6,6-tetra-methylpiperidin-4-yl)butylamino]-s-triazine end-capped with 2-chloro-4,6-bis(dibutylamino)-s-triazine,
 [0280] 48) the oligomeric compound which is the condensation product of 4,4'-hexamethylene-bis(amino-1-acyloxy-2,2,6,6-tetramethylpiperidine) and 2,4-dichloro-6-[(1-acyloxy-2,2,6,6-tetra-methylpiperidin-4-yl)butylamino]-s-triazine end-capped with 2-chloro-4,6-bis(dibutylamino)-s-triazine and
 [0281] 49) product obtained by reacting a product, obtained by reacting 1,2-bis(3-amino-propylamino)ethane with cyanuric chloride, with (2,2,6,6-tetramethylpiperidin-4-yl)butylamine.
 [0282] Also included are the sterically hindered N—H, N-methyl, N-methoxy, N-propoxy, N-octyloxy, N-cyclohexyloxy, N-(2-hydroxy-2-methylpropoxy) and N-acyl analogues of any of the above mentioned compounds. For example, replacing an N-H hindered amine with an N-methyl hindered amine would be employing the N-methyl analogue in place of the N—H.
 [0283] The class of additives known as the hydroxyphenylalkylphosphonic esters or monoesters are also advantageously employed in the processes and compositions of this invention. The hydroxyphenylalkylphosphonic esters or monoesters are disclosed for example in U.S. published app.

No. 2004/0106767, the disclosure of which is hereby incorporated by reference. The hydroxyphenylalkylphosphonic esters or monoesters are of the formula



wherein

[0284] R₆ is isopropyl, tert-butyl, cyclohexyl or cyclohexyl which is substituted by 1-3 C₁-C₄alkyl groups,

[0285] R₇ is hydrogen, C₁-C₄alkyl, cyclohexyl or cyclohexyl which is substituted by 1-3 C₁-C₄alkyl groups,

[0286] R₈ is C₁-C₂₀alkyl, unsubstituted or C₁-C₄alkyl-substituted phenyl or naphthyl,

[0287] R₉ is hydrogen, C₁-C₂₀alkyl, unsubstituted or C₁-C₄alkyl-substituted phenyl or naphthyl; or is

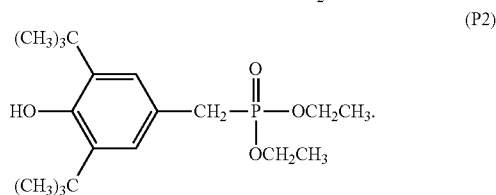
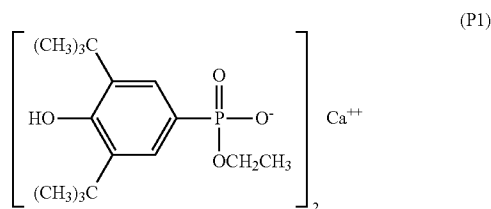


[0288] M^{r+} is an r-valent metal cation,

[0289] p is 1, 2, 3, 4, 5 or 6, and

[0290] r is 1, 2 or 3.

[0291] For example, the present hydroxyphenylalkylphosphonic ester or monoester is a compound of the formula P1 or P2



[0292] The further additives of the hindered amine light stabilizers and the hydroxyphenylalkylphosphonic esters or monoesters are employed at levels, based on the weight of the polymer, of from about 0.001 to 5.0% by weight, in particular from 0.01 to 2.0% by weight and particularly preferably from 0.02 to 1.0% by weight.

[0293] The following Examples further illustrate the invention. All percentages are in weight percent unless otherwise indicated.

EXAMPLE 1

[0294] Polypropylene with MFI index of 1,100 is tumble mixed to contain 5.0% total weight of a sterically hindered

amine (HALS), 2.0% total weight of a sterically hindered hydroxyphenylalkylphosphonic monoester (HPPME), 0.25% total weight aromatic trisamide (TA1)-(TA14).

[0295] These mixes are individually compounded using a Leistritz 27 mm twin screw extruder. The melt is cooled in a water trough and the strand is converted into pellets via a Conair-Jetro Model 304 pelletizer. The pellets collected are considered the masterbatches.

[0296] The same polypropylene is tumble mixed with the appropriate amounts of masterbatch for each of the evaluations. The tumble mixing is via a Marion Mixer SPS 1224 which is a paddle type slow RPM mixer. These are considered the final mixes.

[0297] Final mixes at 45 Kg each are converted into melt blown non woven textiles using a 500 mm Reifenhäuser Meltblowing Pilot Line. Also a 1,500 g portion of each final mix is processed on a 6-inch Meltblowing Pilot Line.

[0298] The polypropylene webs are then treated by corona discharge. The samples are tested using TSI Filter Tester (Model 8130) which employs challenges of sodium chloride aerosol at 32 liters per minute using a test area of 100 cm².

[0299] Results are in the tables below.

TABLE 1

6-inch Meltblowing Pilot Line					
Filtration Efficiency (%)					
Formulation	Basis Weight (g/m ²)	Before charging	After charging	Charged & aged (70° C./24 hrs)	Filtration Efficiency Loss (%)
Polypropylene (control)	30.6	23.2	88.0	72.4	17.7
0.5% HALS	30.5	16.8	91.5	82.1	10.2
0.5% HPPME	30.6	18.7	93.3	90.6	2.9
0.05% TA1	30.4	18.0	93.4	93.3	0.1
0.02% TA2	30.5	18.3	92.2	91.3	0.9

TABLE 2

6-inch Meltblowing Pilot Line					
Filtration Efficiency (%)					
Formulation	Basis Weight (g/m ²)	Before charging	After charging	Charged & aged (70° C./24 hrs)	Filtration Efficiency Loss (%)
Polypropylene (control)	58.3	34.6	96.9	90.6	6.4
0.5% HALS	60.4	32.8	99.0	97.0	2.0
0.5% HPPME	59.2	31.4	98.9	97.7	1.2
0.05% TA1	58.0	31.9	99.0	98.5	0.5
0.02% TA2	60.9	44.5	98.4	97.4	1.0

TABLE 3

500 mm Reifenhäuser Meltblowing Pilot Line					
Filtration Efficiency (%)					
Formulation	Basis Weight (g/m ²)	Before charging	After charging	Charged & aged (70° C./24 hrs)	Filtration Efficiency Loss (%)
Polypropylene (control)	30.6	17.0	81.4	65.6	19.4

TABLE 3-continued

500 mm Reifenhäuser Meltblowing Pilot Line					
Formulation	Basis Weight (g/m ²)	Filtration Efficiency (%)			Filtration Efficiency Loss (%)
		Before charging	After charging	Charged & aged (70° C./24 hrs)	
0.5% HALS	30.5	15.8	90.0	85.4	5.1
0.5% HPPME	30.6	16.8	90.4	86.8	4.0
0.05% TA1	30.4	16.2	92.1	90.8	1.4
0.02% TA2	30.5	13.8	90.4	88.0	2.8

TABLE 4

500 mm Reifenhäuser Meltblowing Pilot Line					
Formulation	Basis Weight (g/m ²)	Filtration Efficiency (%)			Filtration Efficiency Loss (%)
		Before charging	After charging	Charged & aged (70° C./24 hrs)	
Polypropylene (control)	58.3	28.0	94.7	78.4	17.2
0.5% HALS	60.4	29.4	96.6	90.2	6.6
0.5% HPPME	59.2	27.4	94.8	92.6	2.2
0.05% TA1	58.0	28.4	95.8	94.8	1.0
0.02% TA2	60.9	26.6	93.4	91.8	1.7

TABLE 5

PP 6-inch Meltblowing Pilot Line					
Formulation	Basis Weight (g/m ²)	Filtration Efficiency (%)			Filtration Efficiency Loss (%)
		Before charging	After charging	Charged & aged (70° C./24 hrs)	
Polypropylene (control)	30.9	22.2	85.6	67.7	20.9
0.5% HALS	30.5	24.4	91.2	78.9	13.5
0.025% TA3	29.4	32.7	92.8	80.7	13.1
0.025% TA4	27.8	22.8	92.7	86.0	7.2
0.025% TA5	27.5	24.0	90.5	79.5	12.2
0.025% TA6	29.3	31.2	93.3	81.4	12.7

TABLE 6

PP 6-inch Meltblowing Pilot Line					
Formulation	Basis Weight (g/m ²)	Filtration Efficiency (%)			Filtration Efficiency Loss (%)
		Before charging	After charging	Charged & aged (70° C./24 hrs)	
Polypropylene (control)	30.1	17.0	86.7	60.9	29.8
0.5% HALS	29.1	15.2	88.7	68.3	23.0
0.0125% TA7	29.5	11.6	80.5	63.4	21.3
0.0125% TA4	29.0	11.7	81.2	68.0	16.3

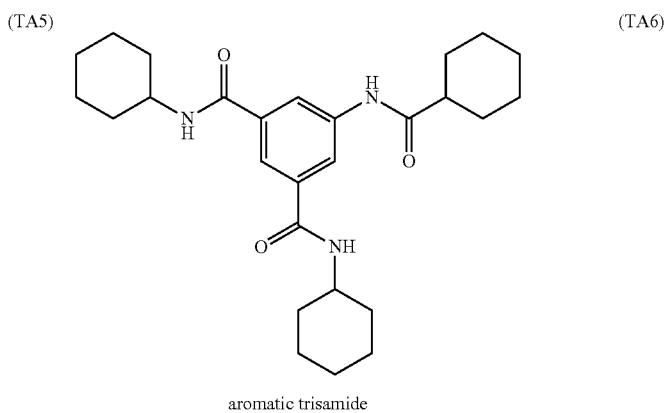
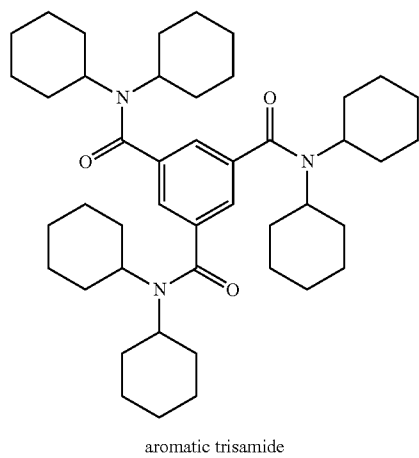
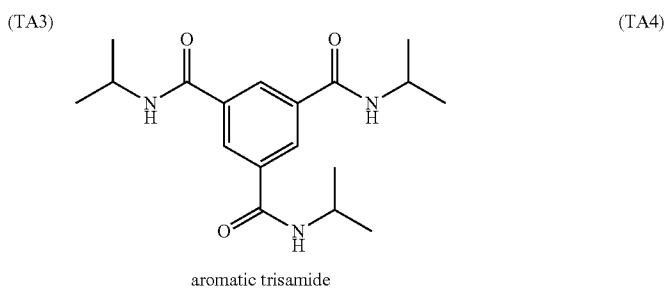
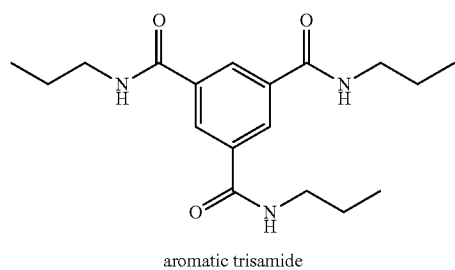
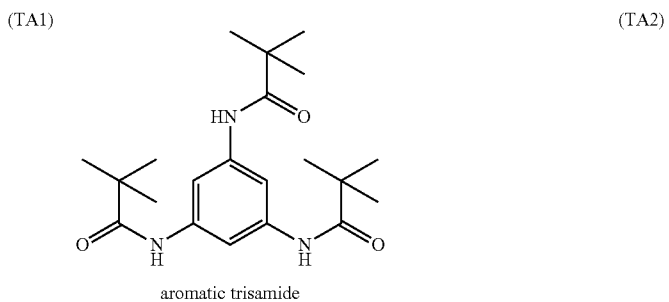
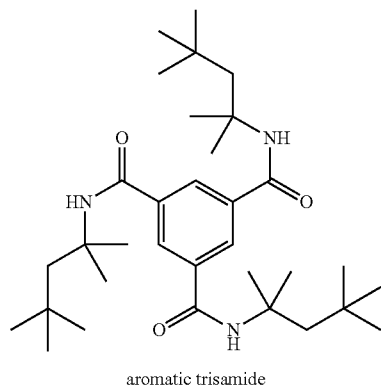
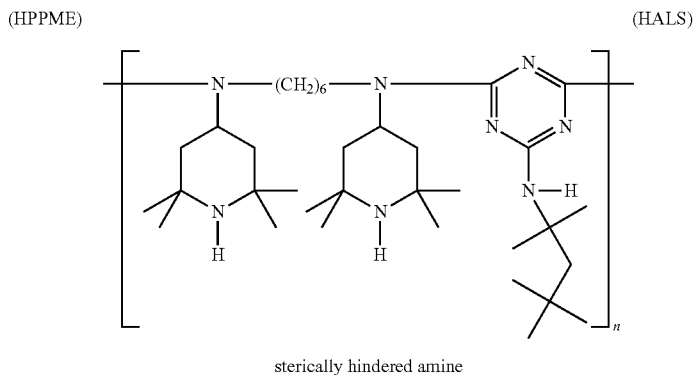
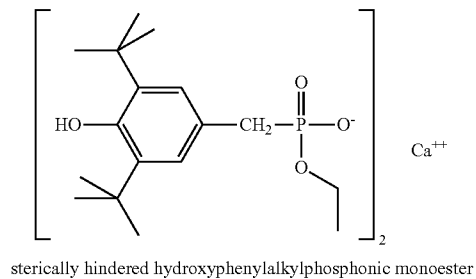
TABLE 7

6-inch Meltblowing Pilot Line					
Formulation	Basis Weight (g/m ²)	Filtration Efficiency (%)			Filtration Efficiency Loss (%)
		Before charging	After charging	Charged & aged (70° C./24 hrs)	
Polypropylene (control)	29.6	20.5	76.1	54.9	27.9
0.5% HALS	29.2	17.9	84.0	66.6	20.7
0.02% TA8	27.2	21.6	90.9	84.7	6.9
0.02% TA9	28.6	22.8	91.2	83.0	9.0
0.02% TA10	28.2	23.1	88.4	70.6	20.1
0.02% TA11	29.3	20.7	88.9	74.5	16.2
0.02% TA12	29.1	21.5	89.8	78.7	12.4
0.02% TA13	27.7	21.9	89.9	77.0	14.4

TABLE 8

6-inch Meltblowing Pilot Line					
Formulation	Basis Weight (g/m ²)	Filtration Efficiency (%)			Filtration Efficiency Loss (%)
		Before charging	After charging	Charged & aged (70° C./24 hrs)	
Polypropylene (control)	29.6	20.5	76.1	54.9	27.9
0.5% HALS	29.2	17.9	84.0	66.6	20.7
0.5% HPPME	30.6	21.4	88.7	74.6	15.9
0.02% TA8	27.2	19.9	87.2	83.4	4.4
0.02% TA10	27.5	16.1	82.4	77.3	6.2

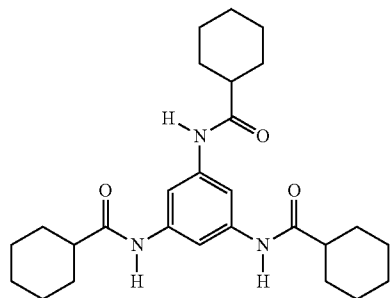
[0300] It can be seen that the present aromatic trisamides provide polypropylene with excellent thermal and charge stability. The trisamides are present at very low levels.



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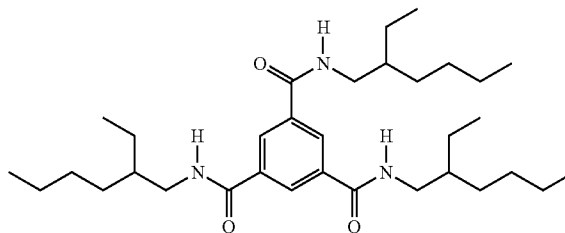
(TA7)

(TA8)



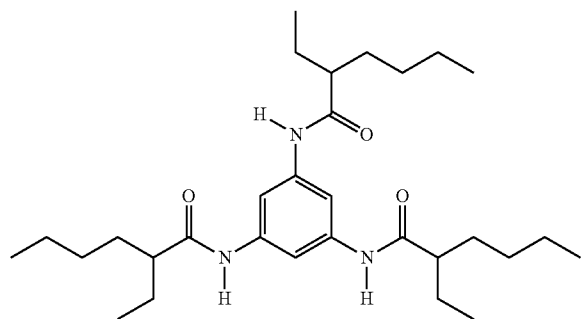
aromatic trisamide

(TA9)



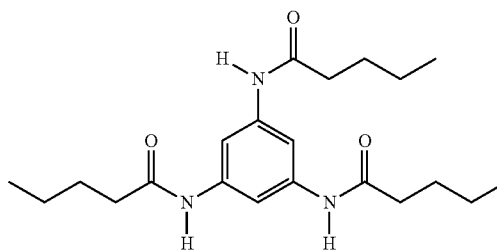
aromatic trisamide

(TA10)



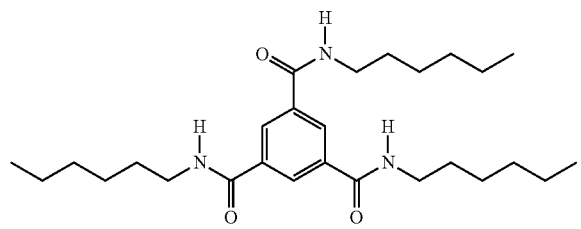
aromatic trisamide

(TA11)

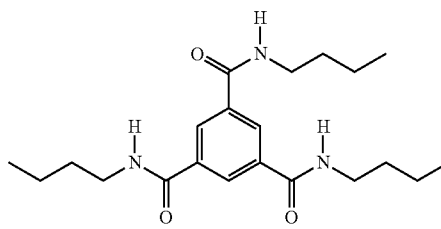


aromatic trisamide

(TA12)

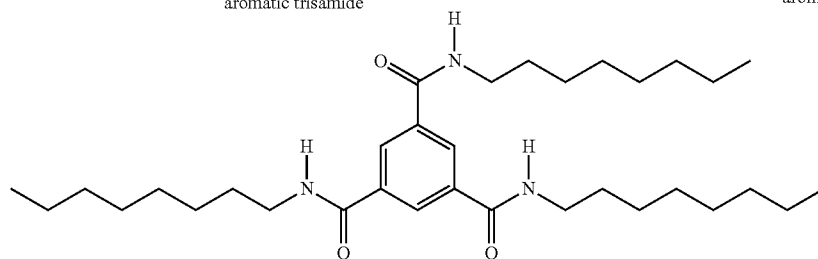


aromatic trisamide



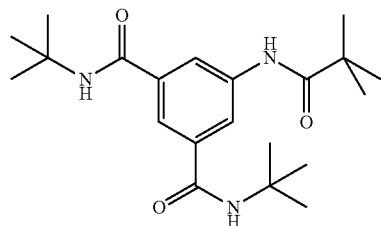
aromatic trisamide

(TA13)



aromatic trisamide

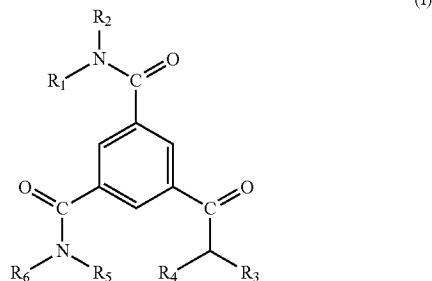
(TA14)



aromatic trisamide

What is claimed is:

1. An electret material with enhanced thermal and charge stability, which material has been subjected to an electret treatment, comprising
a thermoplastic polymer and incorporated therein,
one or more aromatic trisamide compounds of formula I



wherein

R₁, R₂, R₃, R₄, R₅ and R₆, independently of one another, are hydrogen,

C₁-C₂₀alkyl,

C₂-C₂₀alkyl substituted by C₁-C₁₀alkylamino, di(C₁-C₁₀alkyl)amino, C₁-C₁₀alkoxy or hydroxy;

C₃-C₂₀alkenyl,

C₅-C₁₂cycloalkyl,

C₅-C₁₂cycloalkyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

cyclohexylmethyl;

cyclohexylmethyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

C₅-C₉cycloalkenyl,

C₅-C₉cycloalkenyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

phenyl substituted by 1, 2 or 3 radicals selected from the group consisting of C₁-C₁₀alkyl,

C₁-C₁₀alkoxy, hydroxy, halogen, trihalogenmethyl, trihalogenmethoxy, benzoyl, phenylamino, acylamino and phenylazo;

C₇-C₉phenylalkyl,

C₇-C₉phenylalkyl which is substituted on the phenyl by 1, 2 or 3 radicals selected from the group consisting of C₁-C₁₀alkyl, C₁-C₁₀alkoxy and hydroxy;

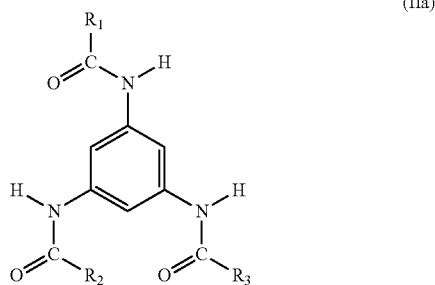
naphthyl,

naphthyl substituted by C₁-C₁₀alkyl;

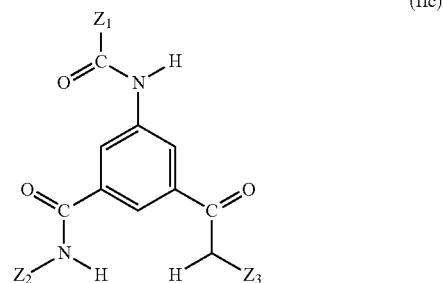
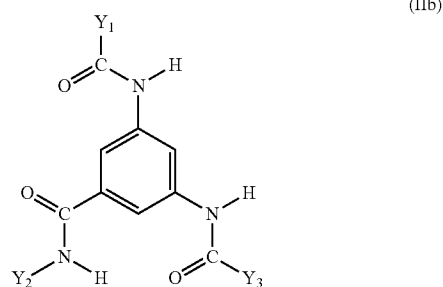
adamantyl, or

a 5 to 6 membered heterocyclic group;

or one or more aromatic trisamide compounds of the formula IIa, IIb or IIc



-continued



wherein

R₁, R₂ and R₃, or Y₁, Y₂ and Y₃, or Z₁, Z₂ and Z₃ independently of one another are

C₁-C₂₀alkyl unsubstituted or substituted by one or more hydroxy;

C₂-C₂₀alkenyl unsubstituted or substituted by one or more hydroxy;

C₂-C₂₀alkyl interrupted by oxygen or sulfur;

C₃-C₁₂cycloalkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

(C₃-C₁₂cycloalkyl)-C₁-C₁₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

bis[C₃-C₁₂cycloalkyl]-C₁-C₁₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

a bicyclic or tricyclic hydrocarbon radical with 5 to 20 carbon atoms unsubstituted or substituted by one or more C₁-C₂₀alkyl;

phenyl unsubstituted or substituted by one or more radicals selected from C₁-C₂₀alkyl,

C₁-C₂₀alkoxy, C₁-C₂₀alkylamino, di(C₁-C₂₀alkyl)amino, hydroxy and nitro;

phenyl-C₁-C₂₀alkyl unsubstituted or substituted by one or more radicals selected from C₁-C₂₀alkyl, C₃-C₁₂cycloalkyl, phenyl, C₁-C₂₀alkoxy and hydroxy;

phenylethenyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

biphenyl-(C₁-C₁₀alkyl) unsubstituted or substituted by one or more C₁-C₂₀alkyl;

naphthyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

naphthyl-C₁-C₂₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

naphthoxymethyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

biphenylenyl, fluorenyl, anthryl;

a 5- to 6-membered heterocyclic radical unsubstituted or substituted by one or more C₁-C₂₀alkyl;

a C₁-C₂₀hydrocarbon radical containing one or more halogen; or

tri(C₁-C₁₀alkyl)silyl(C₁-C₁₀alkyl);

with the proviso that at least one of the radicals selected from R₁, R₂ and R₃, or Y₁, Y₂ and Y₃, or Z₁, Z₂ and Z₃ is

branched C₃-C₂₀alkyl unsubstituted or substituted by one or more hydroxy;

C₂-C₂₀alkyl interrupted by oxygen or sulfur;

C₃-C₁₂cycloalkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

(C₃-C₁₂cycloalkyl)-C₁-C₁₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl;

a bicyclic or tricyclic hydrocarbon radical with 5 to 20 carbon atoms unsubstituted or substituted by one or more C₁-C₂₀alkyl;

phenyl unsubstituted or substituted by one or more radicals selected from C₁-C₂₀alkyl,

C₁-C₂₀alkoxy, C₁-C₂₀alkylamino, di(C₁-C₂₀alkyl)amino, hydroxy and nitro;

phenyl-C₁-C₂₀alkyl unsubstituted or substituted by one or more radicals selected from

C₁-C₂₀alkyl, C₃-C₁₂cycloalkyl, phenyl, C₁-C₂₀alkoxy and hydroxy;

biphenyl-(C₁-C₁₀alkyl) unsubstituted or substituted by one or more C₁-C₂₀alkyl;

naphthyl-C₁-C₂₀alkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl; or

tri(C₁-C₁₀alkyl)silyl(C₁-C₁₀alkyl),

where the aromatic trisamide compounds are present from about 0.005 to 0.5% by weight, based on the weight of the thermoplastic polymer.

2. An electret material according to claim 1 comprising one or more trisamide compounds of formula I.

3. An electret material according to claim 1 comprising one or more trisamide compounds of formula IIa, IIb or IIc.

4. An electret material according to claim 1 in which the thermoplastic polymer is polypropylene.

5. An electret material according to claim 1 in which the thermoplastic polymer is a nonwoven polypropylene web.

6. An electret material according to claim 1 where in the compounds of formula IIa, IIb and IIc, that

at least one of the radicals selected from R₁, R₂ and R₃, or Y₁, Y₂ and Y₃, or Z₁, Z₂ and Z₃ is

branched C₃-C₂₀alkyl, or is C₃-C₁₂cycloalkyl unsubstituted or substituted by one or more C₁-C₂₀alkyl.

7. An electret material according to claim 1 where the electret treatment is a corona treatment.

8. An electret material according to claim 1 wherein the thermoplastic polymer further has incorporated therein an additive selected from the group consisting of the hindered amine light stabilizers.

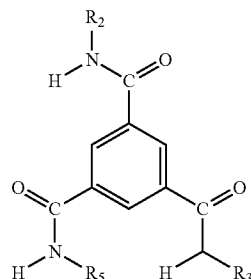
9. An electret material according to claim 1 wherein the thermoplastic polymer further has incorporated therein an additive selected from the group consisting of the hydroxyphenylalkylphosphonic esters or monoesters.

10. An electret material according to claim 1 wherein the aromatic trisamide compounds are present from about 0.01 to about 0.09% by weight, based on the weight of the thermoplastic polymer.

11. A method for preparing an electret material with enhanced thermal and charge stability, which method comprises

melt blending a thermoplastic polymer with one or more aromatic trisamide compounds of formula I

(I)



wherein

R₁, R₂ and R₃, independently of one another, are

C₁-C₂₀alkyl,

C₂-C₂₀alkyl substituted by C₁-C₁₀alkylamino, di(C₁-C₁₀alkyl)amino, C₁-C₁₀alkoxy or hydroxy;

C₃-C₂₀alkenyl,

C₅-C₁₂cycloalkyl,

C₅-C₁₂cycloalkyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

cyclohexylmethyl;

cyclohexylmethyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

C₅-C₉cycloalkenyl,

C₅-C₉cycloalkenyl substituted by 1, 2 or 3 C₁-C₁₀alkyl;

phenyl substituted by 1, 2 or 3 radicals selected from the group consisting of C₁-C₁₀alkyl,

C₁-C₁₀alkoxy, hydroxy, halogen, trihalogenmethyl, trihalogenmethoxy, benzoyl, phenylamino, acylamino and phenylazo;

C₇-C₉phenylalkyl,

C₇-C₉phenylalkyl which is substituted on the phenyl by 1, 2 or 3 radicals selected from the group consisting of C₁-C₁₀alkyl, C₁-C₁₀alkoxy and hydroxy;

naphthyl,

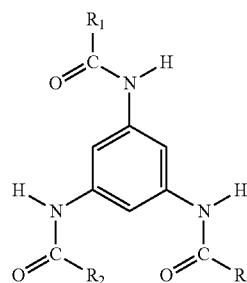
naphthyl substituted by C₁-C₁₀alkyl;

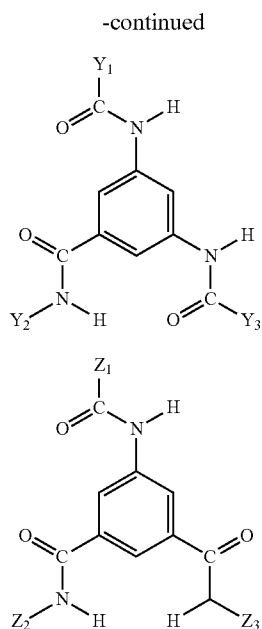
adamantyl, or

a 5 to 6 membered heterocyclic group;

or one or more aromatic trisamide compounds of formula IIa, IIb or IIc

(IIa)





wherein

R_1 , R_2 and R_3 , or Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3 independently of one another are

C_1 - C_{20} alkyl unsubstituted or substituted by one or more hydroxy;

C_2 - C_{20} alkenyl unsubstituted or substituted by one or more hydroxy;

C_2 - C_{20} alkyl interrupted by oxygen or sulfur;

C_3 - C_{12} cycloalkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

(C_3 - C_{12} cycloalkyl)- C_1 - C_{10} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

bis[C_3 - C_{12} cycloalkyl]- C_1 - C_{10} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

a bicyclic or tricyclic hydrocarbon radical with 5 to 20 carbon atoms unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

phenyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl,

C_1 - C_{20} alkoxy, C_1 - C_{20} alkylamino, di(C_1 - C_{20} alkyl)amino, hydroxy and nitro;

phenyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl, C_3 - C_{12} cycloalkyl, phenyl, C_1 - C_{20} alkoxy and hydroxy;

phenylethenyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

biphenyl-(C_1 - C_{10} alkyl) unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

naphthyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

naphthyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

naphthoxymethyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

biphenylenyl, flourenyl, anthryl;

a 5- to 6-membered heterocyclic radical unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

a C_1 - C_{20} hydrocarbon radical containing one or more halogen; or

tri(C_1 - C_{10} alkyl)silyl(C_1 - C_{10} alkyl);

with the proviso that at least one of the radicals selected from R_1 , R_2 and R_3 , or Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3 is

branched C_3 - C_{20} alkyl unsubstituted or substituted by one or more hydroxy;

C_2 - C_{20} alkyl interrupted by oxygen or sulfur;

C_3 - C_{12} cycloalkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

(C_3 - C_{12} cycloalkyl)- C_1 - C_{10} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

a bicyclic or tricyclic hydrocarbon radical with 5 to 20 carbon atoms unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

phenyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl,

C_1 - C_{20} alkoxy, C_1 - C_{20} alkylamino, di(C_1 - C_{20} alkyl)amino, hydroxy and nitro;

phenyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more radicals selected from C_1 - C_{20} alkyl, C_3 - C_{12} cycloalkyl, phenyl, C_1 - C_{20} alkoxy and hydroxy;

biphenyl-(C_1 - C_{10} alkyl) unsubstituted or substituted by one or more C_1 - C_{20} alkyl;

naphthyl- C_1 - C_{20} alkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl; or

tri(C_1 - C_{10} alkyl)silyl(C_1 - C_{10} alkyl) and

subjecting the blend to an electret treatment,

where the aromatic trisamide compounds are present from about 0.005 to 0.5% by weight, based on the weight of the thermoplastic polymer.

12. A method according to claim 11 comprising melt blending the thermoplastic polymer with one or more trisamide compounds of formula I.

13. A method according to claim 11 comprising melt blending the thermoplastic polymer with one or more trisamide compounds of formula IIa, IIb or IIc.

14. A method according to claim 11 in which the thermoplastic polymer is polypropylene.

15. A method according to claim 11 in which the blend is a nonwoven polypropylene web.

16. A method according to claim 11 where in the compounds of formula IIa, IIb and IIc,

at least one of the radicals selected from R_1 , R_2 and R_3 , or Y_1 , Y_2 and Y_3 , or Z_1 , Z_2 and Z_3

is

branched C_3 - C_{20} alkyl, or is C_3 - C_{12} cycloalkyl unsubstituted or substituted by one or more C_1 - C_{20} alkyl.

17. A method according to claim 11 where the electret treatment is a corona treatment.

18. A method according to claim 11 which comprises melt blending the thermoplastic polymer with a further additive selected from the group consisting of the hindered amine light stabilizers.

19. A method according to claim 11 which comprises melt blending the thermoplastic polymer with a further additive selected from the group consisting of the hydroxyphenylalkylphosphonic esters or monoesters.

20. A method according to claim 11 where the aromatic trisamides are present from about 0.01 to about 0.09% by weight, based on the weight of the thermoplastic polymer.

21. An electret material according to claim 1 which is in the form of a nonwoven fibrous web.

22. A method according to claim 11, which method further comprises converting the melt blend to a nonwoven fibrous web.

* * * * *