

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 041 581 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

04.10.2000 Bulletin 2000/40

(51) Int Cl.7: **H01B 3/44**

(21) Application number: **00302623.4**

(22) Date of filing: **29.03.2000**

(84) Designated Contracting States:

**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**

Designated Extension States:

AL LT LV MK RO SI

(30) Priority: **31.03.1999 US 282358**

(71) Applicant: **UNION CARBIDE CHEMICALS &**

PLASTICS TECHNOLOGY CORPORATION

Danbury, Connecticut 06817-0001 (US)

(72) Inventor: **Keogh, Michael John**

Pinehurst, North Carolina 28374 (US)

(74) Representative: **Hayes, Adrian Chetwynd et al**

Boult Wade Tennant,

Verulam Gardens

70 Gray's Inn Road

London WC1X 8BT (GB)

(54) **A crosslinkable polyethylene composition**

(57) A composition comprising:

(a) a VLDPE made by a low pressure process having a density in the range of 0.860 to 0.915 gram per cubic centimeter;

(b) as a scorch inhibitor, a substituted hydroquinone, in an amount of about 0.02 to about 0.09 part by weight per 100 parts of VLDPE;

(c) a cure booster; and

(d) an organic peroxide having a one hour half life decomposition temperature of at least about 125 degrees C, as measured in benzene.

EP 1 041 581 A1

Description**Technical Field**

5 **[0001]** This invention relates to compositions useful in the preparation of cable insulation, semiconducting shields, and jackets.

Background Information

10 **[0002]** A typical electric power cable generally comprises one or more conductors in a cable core that is surrounded by several layers of polymeric materials including a first semiconducting shield layer (conductor or strand shield), an insulating layer, a second semiconducting shield layer (insulation shield), a metallic tape or wire shield, and a protective jacket. Additional layers within this construction such as moisture impervious materials are often incorporated. Other cable constructions such as plenum and riser cable omit the shield.

15 **[0003]** In many cases, crosslinking of the polymeric materials is essential to the particular cable application, and, in order to accomplish this, useful compositions generally include a polymer; a crosslinking agent, usually an organic peroxide; and antioxidants, and, optionally, various other additives such as a scorch inhibitor or retardant and a crosslinking booster. Crosslinking assists the polymer in meeting mechanical and physical requirements such as improved thermal aging and lower deformation under pressure.

20 **[0004]** The crosslinking of polymers with free radical initiators such as organic peroxides is well known. Generally, the organic peroxide is incorporated into the polymer by melt blending in a roll mill, a biaxial screw kneading extruder, or a Banbury™ or Brabender™ mixer at a temperature lower than the onset temperature for significant decomposition of the peroxide. Peroxides are judged for decomposition based on their half life temperatures as described in Plastic Additives Handbook, Gachter et al, 1985, pages 646 to 649. An alternative method for organic peroxide incorporation
25 into a polymeric compound is to mix liquid peroxide and pellets of the polymer in a blending device, such as a Henschel™ mixer or a soaking device such as a simple drum tumbler, which are maintained at temperatures above the freeze point of the organic peroxide and below the decomposition temperature of the organic peroxide and the melt temperature of the polymer. Following the organic peroxide incorporation, the polymer/organic peroxide blend is then, for example, introduced into an extruder where it is extruded around an electrical conductor at a temperature lower than
30 the decomposition temperature of the organic peroxide to form a cable. The cable is then exposed to higher temperatures at which the organic peroxide decomposes to provide free radicals, which leads to the crosslinking of the polymer.

[0005] Polymers containing peroxides are vulnerable to scorch (premature crosslinking occurring during the extrusion process). Scorch causes the formation of discolored gel-like particles in the resin. Further, to achieve a high crosslink density, high levels of organic peroxide have been used. This leads to a problem known as sweat-out, which has a
35 negative effect on the extrusion process and the cable product. Sweat-out dust is an explosion hazard, may foul filters, and can cause slippage and instability in the extrusion process. The cable product exposed to sweat-out may have surface irregularities such as lumps and pimples and voids may form in the insulation layer.

[0006] Industry is constantly seeking to find crosslinkable polyethylene compositions, which can be extruded at high temperatures (although limited by the decomposition temperature of the organic peroxide) and rates with a minimum
40 of scorch and yet be crosslinked at a fast cure rate to a high crosslink density, all with essentially no sweat out., i.e., crystallization of the organic peroxide on the surface of the extrudate.

[0007] A substituted hydroquinone has been suggested as a scorch inhibitor in United States patent 5,292,791 at levels of at least 0.1 percent by weight based on the weight of the polymer. At the levels taught in that patent, however, substituted hydroquinones seriously decrease the cure density in high pressure low density polyethylene (HP-LDPE) and are therefore not suitable for use at levels above about 0.1 weight percent for thermosetting wire and cable formulations based on HP-LDPE. Further, higher melting additives such as the substituted hydroquinones above about
45 0.1 percent often exhibit sweatout leading to dust handling and extrusion complications.

Disclosure of the Invention

50 **[0008]** An object of this invention, therefore, is to provide a crosslinkable resin composition, which can be processed at high temperatures; is improved in terms of scorch inhibition and cure rate; and exhibits high temperature heat stability. Other objects and advantages will become apparent hereinafter.

[0009] According to the invention, such a composition has been discovered. The composition comprises:

- 55 (a) a VLDPE made by a low pressure process having a density in the range of 0.860 to 0.915 gram per cubic centimeter;
- (b) as a scorch inhibitor, a substituted hydroquinone, in an amount of about 0.02 to about 0.09 part by weight per

- 100 parts of VLDPE;
 (c) a cure booster; and
 (d) an organic peroxide having a one hour half life decomposition temperature of at least about 125 degrees C, as measured in benzene.

Description of the Preferred Embodiment(s)

[0010] The VLDPE can be a copolymer of ethylene and one or more alpha-olefins having 3 to 12 carbon atoms and preferably 3 to 8 carbon atoms. Examples of the alpha-olefins are propylene, 1-butene, 1-hexene, 4-methyl-1-pentene, and 1-octene. The density of the VLDPE can be in the range of 0.860 to 0.915 gram per cubic centimeter. The melt index of the VLDPE can be in the range of about 0.1 to about 20 grams per 10 minutes and is preferably in the range of about 0.3 to about 5 grams per 10 minutes. The portion of the VLDPE attributed to the comonomer(s), other than ethylene, can be in the range of about 1 to about 49 percent by weight based on the weight of the copolymer and is preferably in the range of about 15 to about 40 percent by weight. A third comonomer can be included, e.g., another alpha-olefin or a diene such as ethylidene norbornene, butadiene, 1,4-hexadiene, or a dicyclopentadiene. The third comonomer can be present in an amount of about 1 to 15 percent by weight based on the weight of the copolymer and is preferably present in an amount of about 1 to about 10 percent by weight. It is preferred that the copolymer contain two or three comonomers inclusive of ethylene.

[0011] The VLDPE can be homogeneous or heterogeneous. The homogeneous polyethylenes usually have a polydispersity (Mw/Mn) in the range of about 1.5 to about 3.5 and an essentially uniform comonomer distribution, and are characterized by single and relatively low DSC melting points. The heterogeneous polyethylenes, on the other hand, have a polydispersity (Mw/Mn) greater than 3.5 and do not have a uniform comonomer distribution. Mw is defined as weight average molecular weight and Mn is defined as number average molecular weight.

[0012] The VLDPEs are produced by low pressure processes. They are preferably produced in the gas phase, but they can also be produced in the liquid phase in solutions or slurries by conventional techniques. Low pressure processes are typically run at pressures below 1000 psi.

[0013] Typical catalyst systems, which can be used to prepare these polyethylenes, are magnesium/titanium based catalyst systems, which can be exemplified by the catalyst system described in United States patent 4,302,565 (heterogeneous polyethylenes); vanadium based catalyst systems such as those described in United States patents 4,508,842 (heterogeneous polyethylenes) and 5,332,793; 5,342,907; and 5,410,003 (homogeneous polyethylenes); a chromium based catalyst system such as that described in United States patent 4,101,445; a metallocene catalyst system such as that described in United States patents 4,937,299 and 5,317,036 (homogeneous polyethylenes); or other transition metal catalyst systems. Many of these catalyst systems are often referred to as Ziegler-Natta catalyst systems or Phillips catalyst systems. Catalyst systems, which use chromium or molybdenum oxides on silica-alumina supports, can be included here. Typical processes for preparing the polyethylenes are also described in the aforementioned patents.

[0014] The scorch inhibitor is a substituted hydroquinone. Preferably it is a hydroquinone substituted at the 2 position with a tertiary alkyl group or at the 2 and 5 positions with the same or different tertiary alkyl groups. Examples of tertiary alkyl groups are tertiary butyl and tertiary amyl. The alkyl group can have 1 to 18 carbon atoms.

[0015] The cure (crosslinking) booster can be any one, or a mixture, of a broad selection of boosters. An important point here is to select a cure booster with good heat stability. For example, it can be an ester, ether, or ketone containing at least 2, and preferably 3, unsaturated groups such as a cyanurate, an isocyanurate, a phosphate, an ortho formate, an aliphatic or aromatic ether, or an allyl ester of benzene tricarboxylic acid. The number of carbon atoms in the ester, ether, or ketone can be in the range of 9 to 40 or more, and is preferably 9 to 20. Preferred esters, ethers, and ketones are essentially non-volatile at storage temperatures, and the unsaturated groups are preferably allyl groups. Specific examples are triallyl cyanurate (TAC); triallyl-1,3,5-triazine-2,4,6(1H,3H,5H)-trione also known as triallyl isocyanurate (TAIC); triallyl phosphate; triallyl ortho formate; tetra-allyloxy-ethane; triallyl benzene-1,3,5-tricarboxylate; diallyl phthalate; zinc dimethacrylate; ethoxylated bisphenol A dimethacrylate; methacrylate terminated monomer with average chain length of C₁₄ or C₁₅; pentaerythritol tetraacrylate; dipentaerythritol pentaacrylate; pentaerythritol triacrylate; dimethylolpropane tetraacrylate; ethoxylated trimethylolpropane triacrylate; trimethylolpropane triacrylate; and 2,4,6-triallyl-1,3,5-trione. Also see United States patent 4,018,852.

[0016] Preferred boosters are triallyl cyanurate (TAC); 3,9-divinyl-2,4,8,10-tetra-oxaspiro[5.5]undecane (DVS); triallyl isocyanurate (TAIC); and triallyl trimellitate (TATM).

[0017] The weight ratio of scorch inhibitor to cure booster can be in the range of about 0.2:1 to about 0.5:1, and is preferably in the range of about 0.05:1 to about 0.25:1.

[0018] The organic peroxide preferably has a one hour half life decomposition temperature measured in benzene of about 125 to about 150 degrees C and can be exemplified by the following compounds [the numbers set off by the parentheses are their one hour half life decomposition temperatures (in degrees C)]: t-butyl peroxy benzoate (125);

dicumyl peroxide (135); alpha, alpha'-bis-t-butylperoxy-1,4-diisopropylbenzene (137); 2,5-dimethyl-2,5-di(t-butyl-peroxy)hexane (138); t-butyl cumyl peroxide (138); t-butyl hydroperoxide (140); di-t-butyl peroxide (149); and 2,5-dimethyl-2,5-di(t-butyl peroxy)hexane-3 (149). Alpha, alpha'-bis-t-butylperoxy-1,4-diisopropylbenzene is preferred.

[0019] Based on 100 parts by weight of the VLDPE, the proportions of the compounds can be about as follows (in parts by weight):

Component	Broad Range	Preferred Range
(b) scorch inhibitor	0.02 to 0.09	0.05 to 0.09
(c) cure booster	0.2 to 1	0.3 to 0.6
(d) organic peroxide	0.4 to 4	0.6 to 2

[0020] It should be understood that these proportions can vary outside of the stated ranges depending on the desired properties. For example, to achieve a low dissipation factor in wire and cable applications, the amount of cure booster can be lowered and the amount of peroxide raised. Variations can also be considered for other properties such as heat aging characteristics and tensile properties.

[0021] The composition of the invention can be processed in various types of extruders, e.g., single or twin screw types. A description of a conventional extruder can be found in United States patent 4,857,600. A typical extruder has a hopper at its upstream end and a die at its downstream end. The hopper feeds into a barrel, which contains a screw.

At the downstream end, between the end of the screw and the die, is a screen pack and a breaker plate. The screw portion of the extruder is considered to be divided up into three sections, the feed section, the compression section, and the metering section, and two zones, the back heat zone and the front heat zone, the sections and zones running from upstream to downstream. In the alternative, there can be multiple heating zones (more than two) along the axis running from upstream to downstream. If it has more than one barrel, the barrels are connected in series. The length to diameter ratio of each barrel is in the range of about 15:1 to about 30:1. For the purposes of this specification, it will be understood that the term "extruder" includes, in addition to conventional extruders, the combination of an extruder, crosshead, die, and a heating or cooling zone where a further forming of the material can be accomplished. The heating or cooling follows the die and may be, for example, an oven. In wire coating, where the material is crosslinked after extrusion, the die of the crosshead feeds directly into a heating zone, and this zone can be maintained at a temperature in the range of about 130 to about 260 degrees C, and preferably in the range of about 170 to about 220 degrees C.

[0022] The extrudate is then crosslinked by exposing it to a temperature greater than the decomposition temperature of the organic peroxide. The crosslinking can be accomplished in, for example, an oven or a continuous vulcanizable (CV) tube. With steam CV equipment, a pressure rated vulcanizing tube is mechanically coupled to the extruder crosshead such that the polymer melt exits the crosshead/die assembly into a vulcanizing pipe running perpendicular to the extruder. In a typical CV operation, compositions incorporating peroxides are extrusion fabricated into insulation and cable jacketing at low melt extrusion temperatures to avoid premature crosslinking in the extruder. The fabricated melt shape exits the shaping die into the steam vulcanizing tube where post extrusion peroxide initiated crosslinking occurs. The steam tube is filled with saturated steam which continues to heat the polyolefin melt to the increased temperatures needed for crosslinking. Most of the CV tube is filled with saturated steam to maximize dwell time for crosslinking to occur. The final length before exiting the tube is filled with water to cool the now crosslinked insulation/jacketing. At the end of the CV tube, the insulated wire or cable passes through an end seal incorporating close fitting gaskets, which minimize the cooling water leakage. Steam regulators, water pumps, and valves maintain equilibrium of the steam and water and the respective fill lengths within the steam CV tube. Hot inert gases such as nitrogen can be used as an alternative to steam for the heating.

[0023] Conventional additives can be added to the polymer either before or during processing. The amount of additive is usually in the range of about 0.01 to about 50 percent by weight based on the weight of the resin. Useful additives are antioxidants, ultraviolet absorbers, antistatic agents, pigments, carbon black, dyes, fillers, slip agents, fire retardants, plasticizers, processing aids, lubricants, stabilizers, smoke inhibitors, halogen scavengers, flow aids, lubricants, water tree inhibitors such as polyethylene glycol, and viscosity control agents.

[0024] In order to provide a semiconducting shield it is necessary to incorporate conductive particles into the composition. These conductive particles are generally provided by particulate carbon black. Useful carbon blacks can have a surface area of about 50 to about 1000 square meters per gram. The surface area is determined under ASTM D 4820-93a (Multipoint B.E.T. Nitrogen Adsorption). The carbon black is used in the semiconducting shield composition in an amount of about 20 to about 60 percent by weight based on the weight of the composition, and is preferably used in an amount of about 25 to about 45 percent by weight. Examples of conductive carbon blacks are the grades described by ASTM N550, N472, N351, N110, and acetylene black.

[0025] Examples of antioxidants are: hindered phenols such as tetrakis[methylene(3,5-di-tert-butyl-4-hydroxyhydrocinnamate)]methane, bis[(beta-(3,5-di-tert-butyl-4-hydroxybenzyl)methylcarboxyethyl)]sulphide, 4,4'-thiobis(2-tert-

butyl-5-methylphenol), 2,2'-thiobis(4-methyl-6-tert-butylphenol), and thiodiethylene bis(3,5-di-tert-butyl-4-hydroxy hydrocinnamate); phosphites and phosphonites such as tris(2,4-di-tert-butylphenyl)phosphite and di-tert-butylphenylphosphonite; thio compounds such as dilaurylthiodipropionate, and dimyristylthiodipropionate; various siloxanes; and various amines such as polymerized 2,2,4-trimethyl-1,2-dihydroquinoline, 4,4'-bis(alpha,alpha-dimethylbenzyl)diphenylamine, and alkylated diphenylamines. Antioxidants can be used in amounts of about 0.1 to about 5 percent by weight based on the weight of the composition.

[0026] Advantages of the invention are low scorch, high cure rate, high cure density, higher useful extrusion temperatures, less molecular weight degradation of copolymer, less dusting of resin due to peroxide sweat out, and, under suitable circumstances, higher throughput of wire or cable through the continuous vulcanizing oven. Another advantage relates to the solubility of the scorch inhibitor in the VLDPE. Its high effectiveness at about 0.09 part by weight and below allows use below its solubility limits. This reduces or eliminates blooming at the surface as well as crystallization in the resin matrix.

[0027] At least three methods exist for quantifying the degree of crosslinking of the resin: (i) by "hot-set". This is accomplished by attaching a weight to the crosslinked composition in plaque form at 200 degrees C. If the elongation is at least 100 percent, the crosslink density is sufficient for industrial purposes. (ii) by decalin extractables. The uncrosslinked polymer dissolves in the hot decalin solvent and the value is reported in percent by weight decalin extractables. A value below 30 percent, and preferably below 20 percent, is judged to be acceptable. (iii) by rheometer, which checks the viscosity. The rheometer test procedure is described in United States Patent 3,954,907. The first two methods are industry standards. The third method is a diagnostic tool particularly suitable for accurate screening and laboratory study.

[0028] The higher the extrusion temperature, the hotter the resin composition going into the CV tube to be crosslinked and, thus, the faster the cure rate, simply because the resin composition doesn't have to be heated up as much for the cure step. The maximum extrusion temperature relates to the decomposition temperature of the organic peroxide, i. e., the extrusion temperature cannot be as high as the temperature at which significant decomposition of the peroxide takes place. Thus, it is advantageous to be able to use an organic peroxide having a higher decomposition temperature if the other components of the composition of the invention will tolerate a higher extrusion temperature.

[0029] The term "surrounded" as it applies to a substrate being surrounded by an insulating composition, jacketing material, or other cable layer is considered to include extruding around the substrate; coating the substrate; or wrapping around the substrate as is well known by those skilled in the art. The substrate can include, for example, a core including a conductor or a bundle of conductors, or various underlying cable layers as noted above.

[0030] It is understood that the term "decomposition temperature" as it relates to organic peroxides is the onset temperature for significant decomposition of the organic peroxide. This temperature is based on the half life temperature of the organic peroxide.

[0031] All molecular weights mentioned in this specification are weight average molecular weights unless otherwise designated.

[0032] The patents and patent application mentioned in this specification are incorporated by reference herein.

[0033] The invention is illustrated by the following examples.

Examples 1 to 27

[0034] 100 parts by weight of the ethylene polymer are fluxed in a Brabender™ mixer heated to 150 degrees C. The additives are added to the fluxed resin and mixed at a temperature of up to about 170 degrees C during a five minute period. The resulting composition is cooled and transferred to a heated two roll mill where the peroxide is added and blended at a temperature below 130 degrees C for three minutes. The hot sheeted peroxide composition is then fed to a granulator to provide a granulated product for use in the examples. Variables and results are set forth in the Table. Amounts of components are given in parts by weight.

Table

Exam- ple	1	2	3	4	5	6	7
VLDPE I	100	-----	-----	100	100	100	100
VLDPE II	-----	100	100	-----	-----	-----	-----
A/O	0.2	0.15	0.15	0.2	0.2	0.2	-----
DSTDp	0.2	0.15	0.15	0.2	0.2	0.2	-----
VCP	0.95	1.08	-----	-----	1	-----	-----
DCP	-----	-----	1.55	1.6	-----	1.5	1.5
Rheom.	44.5	53	45.5	51	50	50	57
S _T	1.83	1.7	1.2	1.18	1.68	1.3	1.03
C _T -S _T	5.97	5.8	3.7	-----	-----	3.6	3.67

Table (continued)

Exam- ple	8	9	10	11	12	13	14
VLDPE	100	100	100	100	100	100	100
I							
A/O	0.2	-----	0.1	0.1	0.1	0.1	0.1
DSTDP	0.2	0.2	0.1	0.1	0.1	0.1	0.1
HQ I	-----	0.2	0.05	-----	0.05	-----	-----
HQ II	-----	-----	-----	0.05	-----	0.05	0.05
TAC	-----	0.4	0.4	0.4	0.4	0.4	0.6
VCP	-----	0.65	-----	-----	0.75	0.75	0.6
DCP	1.5	-----	1.2	1.2	-----	-----	-----
Rheom.	50	54	59	61	59	57	56
S _T	1.3	2.2	1.26	1.27	1.75	1.7	1.87
C _T -S _T	3.6	4.8	2.89	2.85	5	4.5	4.73
Eff.	-----	-----	25.7	27.2	20.7	21.5	22.1

Table (continued)

	Exam- ple	15	16	17	18	19	20	21
5	VLDPE	100	100	-----	-----	-----	100	100
	I							
10	VLDPE	-----	-----	100	100	100	-----	-----
	II							
	A/O	0.1	0.1	0.15	0.15	0.15	-----	-----
15	DSTDP	0.1	0.1	0.2	0.2	0.2	0.2	0.2
	HQ I	0.05	0.05	0.05	0.05	0.05	0.2	0.2
	TAC	0.4	0.45	-----	-----	-----	-----	-----
20	DVS	-----	-----	-----	-----	-----	0.4	-----
	TATM	-----	-----	0.6	-----	0.6	-----	0.4
	TAIC	-----	-----	-----	0.6	-----	-----	-----
25	VCP	1.15	0.85	0.75	0.75	0.78	-----	-----
	DCP	-----	-----	-----	-----	-----	1.2	1.2
	Rheom.	85	71	58.5	68	63.5	50	58
30	S _T	1.5	1.72	2.03	1.9	1.9	1.46	1.45
	C _T -S _T	5.3	4.73	4.87	-----	-----	3.14	3
35	Eff.	24	25.8	-----	-----	-----	-----	-----

40

45

50

55

Table (continued)

Exam- ple	22	23	24	25	26	27
VLDPE I	100	100	100	100	100	100
A/O	-----	0.15	0.15	0.15	0.15	0.15
DSTDP	0.2	0.2	0.2	0.2	0.2	0.2
HQ I	0.2	0.05	0.05	-----	0.05	0.05
HQ II	-----	-----	-----	0.05	-----	-----
TAC	-----	-----	-----	0.6	0.6	-----
DVS	-----	0.6	0.44	-----	-----	0.6
TAIC	0.4	-----	-----	-----	-----	-----
VCP	-----	0.7	0.8	0.7	0.7	0.7
DCP	1.2	-----	-----	-----	-----	-----
Rheom.	60	55	56.5	65	68.5	53
S _T	1.04	1.82	1.72	1.84	1.9	2
C _T -S _T	3.16	3.33	3.23	4.86	4.85	4.9

Notes to Table:

1. VLDPE I = a copolymer of ethylene and 1-butene. The alpha-olefin is present in an amount of about 20 percent by weight based on the weight of the copolymer. It has a density of 0.905 gram per cubic centimeter and a melt index of 4 grams per 10 minutes.
2. VLDPE II = a copolymer of ethylene and 1-butene . The alpha-olefin is present in an amount of about 25 percent by weight based on the weight of the copolymer. It has a density of 0.899 gram per cubic centimeter and a melt index of 5 grams per 10 minutes.
3. A/O = the antioxidant thiodiethylene bis(3,5-di-tert-butyl-4-hydroxy hydrocinnamate).
4. DSTDP = distearylthiodipropionate.

5. HQ I = a substituted hydroquinone, substituted at the 2 and 5 positions with a tertiary amyl.
6. HQ II = a substituted hydroquinone, substituted at the 2 position with a tertiary butyl.
7. TAC = triallyl cyanurate.
8. DVS = 3,9-divinyl-2,4,8,10-tetra-oxaspiro[5.5]undecane
9. TATM = triallyl trimellitate
10. TAIC = triallyl isocyanurate
11. VCP = alpha,alpha'-bis-t-butylperoxy-1,4-diisopropylbenzene
12. DCP = dicumyl peroxide
13. Rheom. = Rheometer (lbs-inches) measured in accordance with the test described in United States Patent 3,954,907.
14. S_T = time in minutes for a rise in the torque over the minimum torque to 10 inch-pounds; representative of the material's propensity for scorch.
15. C_T = time in minutes to reach 90 percent of the maximum torque.
16. $C_T - S_T$ = difference in time, in minutes, between C_T and S_T measured at 182 degrees C. It reflects the cure time for a composition.
17. Eff. = efficiency, i.e., $(H \text{ times } S_T) \text{ divided by } (C_T - S_T)$; represents the efficiency of a particular curing agent system.

Claims

1. A composition comprising:
 - (a) a VLDPE made by a low pressure process having a density in the range of 0.860 to 0.915 gram per cubic centimeter;
 - (b) as a scorch inhibitor, a substituted hydroquinone, in an amount of 0.02 to 0.09 part by weight per 100 parts of VLDPE;
 - (c) a cure booster; and
 - (d) an organic peroxide having a one hour half life decomposition temperature of at least 125 degrees C, as measured in benzene.
2. The composition defined in claim 1 wherein the substituted hydroquinone is a hydroquinone substituted at the 2 position with a tertiary alkyl group or at the 2 and 5 positions with the same or different tertiary alkyl groups.
3. The composition defined in claim 1 or 2 wherein the scorch inhibitor is present in an amount of 0.05 to 0.09 part by weight based on 100 parts by weight of the polyethylene.

4. The composition defined in any one of the preceding claims wherein the cure booster is present in an amount of 0.2 to 1 part by weight based on 100 parts by weight of the polyethylene.

5. The composition defined in any one of the preceding claims wherein the organic peroxide is present in an amount of 0.4 to 4 parts by weight based on 100 parts by weight of the polyethylene.

6. The composition defined in any one of claims 1 to 3 wherein, for each 100 parts by weight of polyethylene, other components are present as follows:

- (c) 0.3 to 0.6 part by weight of cure booster; and
- (d) 0.6 to 2 parts by weight of organic peroxide.

7. A cable comprising one or more electrical conductors or a core of electrical conductors, each conductor or core being surrounded by a composition comprising:

- (a) a crosslinked VLDPE made by a low pressure process having a density in the range of 0.860 to 0.915 gram per cubic centimeter;
- (b) as a scorch inhibitor, a substituted hydroquinone, in an amount of 0.02 to 0.09 part by weight per 100 parts of VLDPE; and
- (c) a cure booster.

8. A process for extrusion comprising extruding around one or more electrical conductors or a core of electrical conductors, at a temperature below the decomposition temperature of the organic peroxide, a composition comprising

- (a) a VLDPE made by a low pressure process having a density in the range of 0.860 to 0.915 gram per cubic centimeter;
- (b) as a scorch inhibitor, a substituted hydroquinone, in an amount of 0.02 to 0.09 part by weight per 100 parts of VLDPE;
- (c) a cure booster; and an organic peroxide having a one hour half life decomposition temperature of at least 125 degrees C, as measured in benzene, and curing the extrudate.

9. The process defined in claim 8 wherein, for each 100 parts by weight of polyethylene, other components are present as follows:

- (b) 0.05 to 0.09 part by weight of scorch inhibitor;
- (c) 0.2 to 1 part by weight of cure booster; and
- (d) 0.4 to 4 parts by weight of organic peroxide.

10. The cable defined in claim 7 wherein the cure booster is present in an amount of 0.2 to 1 part by weight per 100 parts by weight of polyethylene.



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 30 2623

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
P,X	EP 0 966 000 A (UNION CARBIDE CHEM PLASTIC) 22 December 1999 (1999-12-22) * page 3, line 52 - line 57 * * page 4, line 20 - line 55 * ---	1-10	H01B3/44
P,X	EP 0 965 998 A (UNION CARBIDE CHEM PLASTIC) 22 December 1999 (1999-12-22) * page 3, line 7 * * page 3, line 11 - line 55 * ---	1-10	
P,X	EP 0 965 999 A (UNION CARBIDE CHEM PLASTIC) 22 December 1999 (1999-12-22) * page 4, line 23 - line 28 * * page 6, line 1 - line 2 * ---	1-10	
A	EP 0 785 229 A (ATOCHEM ELF ITALIA) 23 July 1997 (1997-07-23) * claims 1,5,7 * * page 2, line 12 - line 27 * ---	1-10	
A	US 5 292 791 A (GROEPPER JURGEN ET AL) 8 March 1994 (1994-03-08) * claim 1 * * column 4, line 57 - line 64 * -----	1-10	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 July 2000	Examiner Paalman, R
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03 82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 30 2623

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-07-2000

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0966000	A	22-12-1999	NONE		
EP 0965998	A	22-12-1999	NONE		
EP 0965999	A	22-12-1999	NONE		
EP 0785229	A	23-07-1997	IT	MI960029 U	18-07-1997
			US	5994473 A	30-11-1999
US 5292791	A	08-03-1994	DE	3820252 A	21-12-1989
			US	5245084 A	14-09-1993
			AT	99345 T	15-01-1994
			DE	58906528 D	10-02-1994
			EP	0346863 A	20-12-1989