

DESCRIPTION

Title of Invention

NON-HALOGEN FLAME RETARDANT RESIN COMPOSITION AND ELECTRIC
WIRE OR CABLE USING SAME

Technical Field

[0001]

The present invention relates to a non-halogen flame retardant resin composition suitably used as a coating layer of an electric wire or the like and an electric wire or cable using the resin composition.

Background Art

[0002]

In the internal wiring of OA equipment, such as copying machines and printers, and electronic devices, many wire harnesses, which feed power and transmit signals between printed-circuit boards and between printed-circuit boards and electronic components, such as sensors, actuators, and motors, are used.

[0003]

A wire harness includes a plurality of electric wires or cables bound together, and terminals, such as pluggable connectors, fitted to the end portions of the wires or cables. In view of flame retardance, electrical insulation, and the like, PVC electric wires including polyvinyl chloride (PVC) as an insulating material are used as electric wires for wire harnesses. Since PVC electric wires have excellent flexibility, good manageability is obtained even when formed into wire harnesses. Furthermore, since PVC electric wires have sufficient strength, no problems occur such as breaking or abrasion of the insulator during installation of wire harnesses. Moreover, PVC electric wires have excellent fitting workability in fitting insulation displacement connectors to the end portions thereof.

[0004]

However, since PVC electric wires contain a halogen element, hydrogen chloride-based toxic gases may be generated when used wire harnesses are subjected to incineration treatment, or dioxins may be generated depending on the incineration conditions, which is a problem. Therefore, under the requirement of reducing environmental load, PVC is not considered to be desirable as an insulating material.

[0005]

In recent years, in order to meet the increasing demand for reduction in environmental load, halogen-free electric wires using a coating material that does not contain a polyvinyl chloride resin or halogen-based flame retardant have been developed. In the meantime, electric wires such as insulated electric wires and insulated cables used for internal wiring of electronic devices, are, in general, required to have various properties conforming to the UL (Underwriters Laboratories Inc.) standards. The UL standards specify various properties, such as flame retardance, heat distortion properties, low temperature properties, and initial tensile properties and tensile properties after heat aging of a coating material, which are required to be fulfilled by products.

[0006]

Regarding electric wires used for insulation displacement contact or crimping, it is necessary to route wire harnesses inside electronic devices. In this process, there is a possibility that insulating coatings of electric wires may be damaged or broken, and as a result, the electric wires may become defective. Therefore, insulated electric wires used for wire harnesses are required to have high cut-through strength.

[0007]

Japanese Unexamined Patent Application Publication No. 2002-105255 (PTL 1) discloses a flame retardant resin composition which includes a thermoplastic resin component prepared by blending an elastomer, such as ethylene-propylene rubber or styrene-butadiene rubber, with a polypropylene resin, and a metal hydrate heated and kneaded with the thermoplastic resin component. Filler acceptability can be enhanced by blending the elastomer, and it is also considered to balance mechanical properties such as flexibility and elongation, extrusion processability, and flame retardance by dynamically vulcanizing the elastomer. However, such a material has low wear resistance and low strength against metal edge (cut-through properties) compared with PVC. When an attempt is made to improve these properties, flexibility decreases, resulting in a loss of balance between the properties, which is a problem.

[0008]

Furthermore, Japanese Unexamined Patent Application Publication No. 2008-169234 (PTL 2) discloses a non-halogen flame retardant resin composition which includes a resin component containing a polyamide resin or polyester resin, a polyphenylene-ether-

based resin, and a styrene-based elastomer resin, and a nitrogen-based flame retardant. By mixing a hard polyphenylene-ether-based resin having a high modulus of elasticity and a soft styrene-based elastomer having high elongation, and by further mixing therewith a polyamide resin or polyester resin which is a crystalline resin and which can maintain an adequate modulus of elasticity and retain extensibility even at a temperature equal to or higher than the glass-transition temperature, it is possible to obtain an insulated electric wire having flexibility, wear resistance, and strength against metal edge equivalent to those of PVC.

Citation List

Patent Literature

[0009]

PTL 1: Japanese Unexamined Patent Application Publication No. 2002-105255

PTL 2: Japanese Unexamined Patent Application Publication No. 2008-169234

Summary of Invention

Technical Problem

[0010]

Insulated electric wires used for wire harnesses are required to have high cut-through strength, and it is necessary to increase the strength compared to existing insulated electric wires. At the same time, insulated electric wires need to meet requirements for flame retardance, heat resistance, and mechanical properties under the UL standards. In order to increase the cut-through strength, it is conceivable to blend a large amount of a hard material, i.e., a material having a high modulus of elasticity, into an insulating material. In doing so, there is a possibility that tensile elongation, in particular, tensile elongation after heat aging, may be decreased and thus unable to meet the UL standards. Furthermore, In view of connector fitting ability, strain relief may be broken.

[0011]

Accordingly, it is an object of the present invention to provide a non-halogen flame retardant resin composition which has excellent mechanical strength, such as flexibility and wear resistance, excellent flame retardance, particularly excellent cut-through properties, and tensile elongation properties satisfying the UL standards, and to provide an electric wire or cable using the flame retardant resin composition as a coating layer.

Solution to Problem

[0012]

The present invention relates to a non-halogen flame retardant resin composition which includes 100 parts by mass of a resin component and 5 to 40 parts by mass of a phosphorus-based flame retardant, in which the 100 parts by mass of the resin component includes 30 to 85 parts by mass of a polyolefin-based resin, 10 to 50 parts by mass of a polyphenylene-ether-based resin, and 5 to 30 parts by mass of a styrene-based elastomer, and the polyolefin-based resin includes an ethylene-propylene random copolymer polymerized using a metallocene catalyst in the amount of 5% to 60% by mass relative to the entire polyolefin-based resin, and a block copolymer polypropylene resin in the amount of 30% to 95% by mass relative to the entire polyolefin-based resin (Claim 1).

[0013]

The polyphenylene-ether-based resin is a hard material having a high modulus of elasticity at normal temperature. The polyolefin-based resin has excellent flexibility and can improve mechanical properties. The styrene-based elastomer not only has excellent flexibility and extrusion processability, but also serves as a compatibilizing agent. By adding a compatibilizing agent, the polyolefin-based resin and the polyphenylene-ether-based resin are mixed with each other satisfactorily, enabling improved mechanical properties.

[0014]

As the polyolefin-based resin, an ethylene-propylene random copolymer polymerized using a metallocene catalyst (hereinafter, may be described as a "metallocene random PP") and a block copolymer polypropylene are used. The metallocene random PP has uniform molecular weight and crystallinity, and includes small amounts of low-molecular-weight components and low-crystalline components. Therefore, the metallocene random PP is flexible and has excellent heat aging resistance, thus being effective in increasing tensile elongation and tensile elongation after heat aging. On the other hand, the block copolymer polypropylene has a high modulus of elasticity and is effective in increasing cut-through strength. By using the metallocene random PP and the block copolymer polypropylene at a specific ratio as the polyolefin-based resin, both cut-through strength and tensile elongation after heat aging can be achieved. As the polyolefin-based resin, in addition to the two types, a homopolypropylene or polyethylene may be used.

[0015]

An invention according to Claim 2 relates to the non-halogen flame retardant resin composition according to Claim 1, in which the polyolefin-based resin further includes a low-density polyethylene in the amount of 5% to 20% by mass relative to the entire polyolefin-based resin. By further incorporating the low-density polyethylene, tensile elongation and tensile elongation properties after heat aging can be further improved.

[0016]

An invention according to Claim 3 relates to the non-halogen flame retardant resin composition according to Claim 1 or 2, characterized in that the styrene-based elastomer is a block copolymer elastomer of styrene and a rubber component. Since the styrene-based elastomer is a block copolymer elastomer of styrene and a rubber component, compatibility between the polyolefin-based resin and the polyphenylene-ether-based resin is improved, and it is possible to obtain a resin composition having excellent mechanical properties.

[0017]

An invention according to Claim 4 relates to the non-halogen flame retardant resin composition according to any one of Claims 1 to 3, characterized in that the polyphenylene ether is a polyphenylene ether resin with which polystyrene is melt blended. By using the polyphenylene ether resin with which polystyrene is melt blended, workability during melt mixing and extrusion processability are improved.

[0018]

An invention according to Claim 5 relates to an electric wire or cable which uses the non-halogen flame retardant resin composition as a coating layer. The present invention makes it possible to obtain a non-halogen insulated electric wire having excellent flame retardance, flexibility, and cut-through properties.

[0019]

An invention according to Claim 6 relates to the electric wire or cable, characterized in that the thickness of the coating layer is 0.3 mm or less. In the case where the insulating coating layer is thin with a thickness of 0.3 mm or less, there occurs a significant difference in characteristics, such as cut-through properties, from electric wires according to conventional techniques, and excellent advantageous effects are achieved.

[0020]

An invention according to Claim 7 relates to the electric wire or cable according to Claim 5 or 6, characterized in that the coating layer is cross-linked by irradiation with ionizing radiation. Since the coating layer is cross-linked, heat resistance and mechanical strength are improved.

Advantageous Effects of Invention

[0021]

According to the present invention, it is possible to provide a non-halogen flame retardant resin composition which has excellent flame retardance, excellent mechanical strength, such as flexibility and wear resistance, particularly excellent cut-through properties, and tensile elongation properties satisfying the UL standards, and to provide an electric wire or cable using the same.

Brief Description of Drawing

[0022]

[Fig. 1] Figure 1 is a schematic view showing a method of measuring cut-through strength.

Description of Embodiments

[0023]

First, description will be made on various materials used for a non-halogen flame retardant resin composition. A polyphenylene ether is an engineering plastic obtained by oxidative polymerization of 2,6-xyleneol which is synthesized using methanol and phenol as raw materials. Furthermore, various materials obtained by melt blending polystyrene with polyphenylene ethers in order to improve forming processability of the polyphenylene ethers are commercially available as modified polyphenylene ether resins. As the polyphenylene-ether-based resin used in the present invention, both the simple polyphenylene ether resin and the polyphenylene ether resin with which polystyrene is melt blended can be used. Furthermore, a polyphenylene ether to which a carboxylic acid, such as maleic anhydride, is introduced can be appropriately blended before use.

[0024]

When a polyphenylene ether resin with which polystyrene is melt blended is used as the polyphenylene-ether-based resin, workability during melt mixing with the styrene-based elastomer is improved, which is preferable. The polyphenylene ether resin with which polystyrene is melt blended has excellent compatibility with the styrene-based

elastomer. Therefore, the resin pressure during extrusion is reduced, and extrusion processability is improved.

[0025]

In such a polyphenylene-ether-based resin, the heat deflection temperature changes depending on the blending ratio of polystyrene. When the polyphenylene-ether-based resin with a heat deflection temperature of 130°C or higher is used, the mechanical strength of the electric wire coating is high, and excellent heat-distortion properties are exhibited, which is preferable. Note that the heat deflection temperature is defined as the value measured under a load of 1.80 MPa by the method according to ISO75-1, 2.

[0026]

As the styrene-based elastomer used in the present invention, for example, a styrene-ethylenebutene-styrene copolymer, a styrene-ethylenepropylene-styrene copolymer, a styrene-ethylene-ethylenepropylene-styrene copolymer, a styrene-butylene-styrene copolymer, or the like may be used, and examples include hydrogenated polymers thereof and partially hydrogenated polymers thereof. Furthermore, a styrene-based elastomer to which a carboxylic acid, such as maleic anhydride, is introduced can be appropriately blended before use.

[0027]

Above all, when a block copolymer elastomer of styrene and a rubber component is used, in addition to the improvement of extrusion processability, tensile elongation at break is improved, and shock resistance is also improved, which is preferable. Furthermore, as the block copolymer, a triblock copolymer, such as a hydrogenated-styrene-butylene-styrene block copolymer or a styrene-isobutylene-styrene copolymer, or a diblock copolymer, such as a styrene-ethylene copolymer or a styrene-ethylenepropylene copolymer, can be used. When a triblock component is contained in the amount of 50% by weight or more in the styrene-based elastomer, strength and hardness of the electric wire coating are improved, which is preferable.

[0028]

Furthermore, a styrene-based elastomer with a styrene content of 20% by weight or more can be suitably used in view of mechanical properties and flame retardance. When the styrene content is less than 20% by weight, hardness and extrusion processability decrease. On the other hand, when the styrene content exceeds 50% by weight, tensile

elongation at break decreases, which is not preferable.

Furthermore, the melt flow rate (abbreviated as "MFR"; measured at $230^{\circ}\text{C} \times 2.16$ kgf according to JIS K 7210), which is an index of molecular weight, is preferably in a range of 0.8 to 15 g/10 min. The reason for this is that at a melt flow rate of less than 0.8 g/10 min, extrusion processability decreases, and at more than 15 g/10 min, mechanical strength decreases.

[0029]

Examples of the polyolefin-based resin that can be used include polypropylenes (homopolymer, block polymer, and random polymer), polypropylene-based thermoplastic elastomers, reactor-type polypropylene-based thermoplastic elastomers, dynamically-cross-linked-type polypropylene-based thermoplastic elastomers, polyethylenes (high-density polyethylene, linear low-density polyethylene, low-density polyethylene, very low density polyethylene), ethylene-vinylacetate copolymers, ethylene-ethyl acrylate copolymers, ethylene-methyl methacrylate copolymers, ethylene-methyl acrylate copolymer, ethylene-ethyl acrylate copolymers, ethylene-butyl acrylate copolymers, ethylene-propylene rubber, ethylene-acrylic rubber, ethylene-glycidyl methacrylate copolymers, ethylene-methacrylic acid copolymers, and ionomer resins in which molecules of an ethylene-methacrylic acid copolymer or ethylene-acrylic acid copolymer are linked with each other by intermolecular bonding through a metal ion of sodium, zinc, or the like. Furthermore, these resins modified with maleic anhydride or the like, and these resins containing an epoxy group, amino group, or imide group can also be used.

[0030]

Among the polyolefin-based resins described above, a metallocene random PP and a block copolymer polypropylene are essential components. The content of the metallocene random PP is 5% to 60% by mass relative to the entire polyolefin-based resin, and the content of the block copolymer polypropylene is 30% to 95% by mass relative to the entire polyolefin-based resin. When the content of the metallocene random PP is lower than the range described above, elongation after heat aging decreases and is unable to satisfy the UL standards. When the content of the block copolymer polypropylene is lower than the range described above, cut-through strength becomes insufficient. Moreover, when a low-density polyethylene is further contained in the amount of 5% to 20% by mass relative to the entire polyolefin-based resin, elongation and elongation

properties after heat aging can be improved, which is preferable.

[0031]

As the phosphorus-based flame retardant, a phosphate ester, a metal phosphinate, a melamine phosphate compound, an ammonium phosphate compound, a polyphosphazene compound obtained by ring-opening polymerization of a cyclophosphazene, or the like can be used. These phosphorus-based flame retardants may be used alone or in combination of two or more.

[0032]

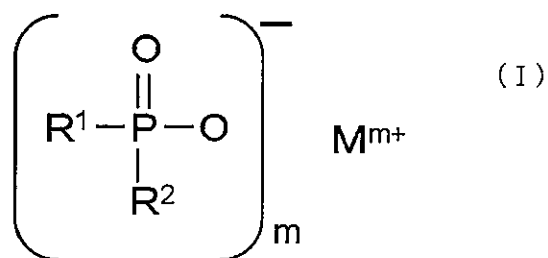
Examples of the phosphate ester that can be used include trimethyl phosphate, triethyl phosphate, triphenyl phosphate, tricresyl phosphate, trixylenyl phosphate, cresyl phenyl phosphate, cresyl 2,6-xylenyl phosphate, 2-ethylhexyldiphenyl phosphate, 1,3-phenylenebis(diphenyl phosphate), 1,3-phenylenebis (di-2,6-xylenyl phosphate), bisphenol-A bis(diphenylphosphate), resorcinol bis-diphenylphosphate, octyl diphenylphosphate, diethylene ethyl ester phosphate, dihydroxy propylene butyl ester phosphate, ethylene disodium ester phosphate, tert-butylphenyl diphenyl phosphate, bis-(tert-butylphenyl) phenyl phosphate, tris-(tert-butylphenyl) phosphate, isopropylphenyl diphenyl phosphate, bis-(isopropylphenyl) diphenyl phosphate, tris-(isopropylphenyl) phosphate, tris-(2-ethylhexyl) phosphate, tris-(butoxyethyl) phosphate, tris-isobutyl phosphate, methylphosphonic acid, dimethyl methylphosphonate, diethyl methylphosphonate, ethylphosphonic acid, propylphosphonic acid, butylphosphonic acid, 2-methyl-propylphosphonic acid, tert-butylphosphonic acid, 2,3-dimethylbutylphosphonic acid, octylphosphonic acid, phenylphosphonic acid, diethylphosphinic acid, methylethylphosphinic acid, methylpropylphosphinic acid, dioctylphosphinic acid, phenylphosphinic acid, diethylphenylphosphinic acid, diphenylphosphinic acid, and alkyl phosphate.

[0033]

A metal phosphinate is a compound represented by the formula (I) below. In the formula, R^1 and R^2 each represent an alkyl group having 1 to 6 carbon atoms or an aryl group having 12 carbon atoms or less, M represents calcium, aluminum, or zinc, $m = 3$ when M is aluminum, and otherwise, $m = 2$.

[0034]

[Chem. 1]



[0035]

Examples of the metal phosphinate that can be used include aluminum salts of organo-phosphinic acids, such as EXOLIT OP1230, EXOLIT OP1240, EXOLIT OP930, and EXOLIT OP935 manufactured by Clariant K.K., and blends of an aluminum salt of an organo-phosphinic acid, such as EXOLIT OP1312, and melamine polyphosphate.

[0036]

Examples of the melamine phosphate compound include melamine polyphosphate, such as MELAPUR200 manufactured by Ciba Specialty Chemicals Inc., melamine polyphosphate, melamine phosphate, melamine orthophosphate, and melamine pyrophosphate.

[0037]

Examples of the ammonium phosphate compound that can be used include ammonium polyphosphate, amide polyphosphate, amide ammonium polyphosphate, and carbamic acid polyphosphate.

[0038]

As the polyphosphazene compound obtained by ring-opening polymerization of a cyclophosphazene, SPR-100, SA-100, SR-100, SRS-100, or SPB-100L manufactured by Otsuka Chemical Co., Ltd. or the like can be used.

[0039]

The content of the phosphorus-based flame retardant is 5 to 40 parts by mass relative to 100 parts by mass of the resin component. When the content is less than 5 parts by mass, flame retardance is insufficient. When the content exceeds 40 parts by mass, mechanical properties decrease. The content of the phosphorus-based flame retardant is more preferably 5 to 30 parts by mass. The surface of the phosphorus-based flame retardant may be treated with melamine, melamine cyanurate, a fatty acid, or a silane coupling agent before use. Instead of performing surface treatment in advance, it may be possible to perform an integral blend in which a surface treatment agent is added when

mixing with the thermoplastic resin. Furthermore, a nitrogen-based flame retardant may be used together with the phosphorus-based flame retardant. As the nitrogen-based flame retardant, melamine, melamine cyanurate, or the like can be used.

[0040]

Furthermore, a cross-linking aid may be added to the non-halogen flame retardant resin composition of the present invention. As the cross-linking aid, a multifunctional monomer having a plurality of carbon-carbon double bonds in the molecule, such as trimethylolpropane trimethacrylate, triallylcyanurate, or triallylisocyanurate, can be preferably used. Furthermore, the cross-linking aid is preferably a liquid at normal temperature. The reason for this is that being a liquid makes it easy to be mixed with the polyphenylene-ether-based resin and the styrene-based elastomer. Furthermore, when trimethylolpropane trimethacrylate is used as the cross-linking aid, compatibility with the resin improves, which is preferable.

[0041]

As necessary, an antioxidant, a processing stabilizer, a coloring agent, a heavy-metal inactivator, a blowing agent, a multifunctional monomer, and the like can be appropriately mixed into the non-halogen flame retardant resin composition of the present invention. These materials can be mixed using a known melt mixer, such as a short screw extrusion-type mixer, a pressure kneading machine, or a banbury mixer.

[0042]

An insulated electric wire of the present invention has a coating layer composed of the flame retardant resin composition described above, in which the coating layer is formed on a conductor directly or with another layer therebetween. A known extruder, such as a melt extruder, can be used to form the insulating coating layer. Furthermore, the insulating layer is preferably cross-linked by irradiation with ionizing radiation.

[0043]

As the conductor, a copper wire, an aluminum wire, or like, which has excellent conductivity, can be used. Although the diameter of the conductor may be appropriately selected according to the intended use, the diameter is preferably set at 2 mm or less in order to allow wiring to be installed in a narrow space. Furthermore, in view of ease of handling, the diameter is preferably set at 0.1 mm or more. The conductor may be a solid conductor or a stranded conductor in which a plurality of wires are stranded together.

[0044]

Although the thickness of the coating layer may be appropriately selected depending on the diameter of the conductor, the thickness is preferably set at 0.3 mm or less in view of mechanical strength. In halogen-free electric wires according to conventional techniques, wear resistance and cut-through strength decrease when the thickness of the coating layer is 0.3 mm or less. In contrast, in the present invention, even when the thickness of the coating layer is 0.3 mm or less, excellent properties are obtained, and there occurs a significant difference from electric wires according to conventional techniques. Furthermore, in electric wires for insulation displacement contact, in view of connector fitting ability, electric wires in which the thickness of the coating layer is 0.3 mm or less are preferably used.

[0045]

When the coating layer is cross-linked by irradiation with ionizing radiation, mechanical strength is improved, which is preferable. As the ionizing radiation source, for example, an accelerated electron beam, gamma ray, X-ray, alpha-ray, ultraviolet ray, or the like may be used. In view of ease of use of the radiation source, ionizing radiation transmission thickness, speed of cross-linking treatment, and the like, from the standpoint of industrial application, the accelerated electron beam can be most preferably used.

EXAMPLES

[0046]

The present invention will be described in more detail on the basis of the examples below. However, it is to be understood that the present invention is not limited to the examples.

[0047]

[EXAMPLES 1 to 5]

(Formation of non-halogen flame retardant resin composition pellets)

The individual components were mixed according to the formulation shown in Table I. In the table, the units of measure for the base resin, the flame retardant, the deterioration inhibitor, and the cross-linking aid are parts by mass. Using a twin-screw mixer (45 mm ϕ , L/D = 42), melt mixing was performed at a cylinder temperature of 240°C and a screw rotation speed of 100 rpm, and the mixture was melt extruded into strands. Next, the molten strands were cooled and cut to form pellets.

[0048]

(Production of insulated electric wire)

Using a single screw extruder (30 mm ϕ , L/D = 24), extrusion coating was performed on a conductor (seven tin-plated annealed copper wires stranded; conductor diameter: 0.42 mm) such that the thickness was 0.14 mm. An electron beam in a dose of 30 or 60 kGy at an accelerating voltage of 2 MeV was radiated to produce an insulated electric wire. Note that mechanical properties (original and after heat aging) were evaluated using a sample including only the coating layer obtained by removing the conductor from the insulated electric wire.

[0049]

(Evaluation of coating layer: tensile properties)

The conductor was taken out of the resulting electric wire, and a tensile test was carried out on the coating layer. Testing conditions were as follows: rate of pulling = 500 mm/min, gauge length = 25 mm, and temperature = 23°C. The tensile strength and tensile elongation (elongation at break) were each measured on three samples, and the average values thereof were determined. A sample having a tensile strength of 10.3 MPa or more and a tensile elongation of 150% or more were evaluated as "Pass".

[0050]

(Evaluation of coating layer: secant modulus)

Using samples similar to those in the tensile test described above, a tensile test was carried out under the conditions of rate of pulling = 50 mm/min, gauge length = 25 mm, and temperature = 23°C. Then, the modulus of elasticity at the point where elongation is 2% was calculated from the stress-elongation curve.

[0051]

(Evaluation of coating layer: heat resistance)

An insulated electric wire was left to stand in a Geer oven set at 136°C for 168 hours (7 days). Then, a tensile test was carried out as in the evaluation of tensile properties, and comparison was made with tensile strength and tensile elongation before heat treatment. A retention of 75% or more of the tensile strength before heat treatment and a retention of 45% or more of the tensile elongation before heat treatment were defined as a pass level.

[0052]

(Evaluation of insulated electric wire: flame retardance test)

The VW-1 Vertical-specimen-flame test according to Section 1080 of UL Standard 1581 was carried out on five specimens. When a flame was applied to each specimen for 15 seconds and this was repeated five times, the case in which burning stopped within 60 seconds, absorbent cotton lying beneath is not ignited by dropping material, and kraft paper attached to the upper side of the specimen was not burned or scorched was evaluated as pass. The case in which even one specimen out of five was not at the pass level was evaluated as failure.

[0053]

(Evaluation of insulated electric wire: cut-through strength)

Using a measuring device shown in Fig. 1, cut-through strength was measured. A blade 4 having a 90° sharp edge (edge R = 0.125 mm, edge angle 90°) is brought into contact onto an insulated electric wire 3 including a conductor 1 and a coating layer 2, and the value of a current flowing between the conductor and the sharp edge is measured. In the initial state, since the conductor and the sharp edge are insulated from each other by the coating layer 2, a current does not flow. When the coating layer 2 is cut by the blade 4, a current flows between the conductor and the sharp edge. A load is applied to the blade 4, and the maximum load endured by the coating layer 2 without being cut is measured. The test is performed in the atmosphere of a temperature of 23°C and a humidity of 50% RH. A load of 70N or more is defined as a pass level.

[0054]

[COMPARATIVE EXAMPLES 1 to 7]

Insulated electric wires were produced as in EXAMPLES 1 to 5 except that resin compositions having the formulations shown in Table II were used, and a series of evaluations were conducted. In the table, the units of measure for the base resin, the flame retardant, the deterioration inhibitor, and the cross-linking aid are parts by mass. The results are shown in Table II.

[0055]

[Table I]

		Example 1	Example 2	Example 3	Example 4	Example 5
Base resin	Block PP (*1)	50	50	35	35	20
	Metallocene random PP(*2)	5	5	20	25	35
	Homo PP(*3)					
	LDPE(*4)		10	10	5	10
	PPE(*5)	35	30	30	30	30
	SEBS(*6)	10	5	5	5	5
Flame retardant		20	20	20	20	20
Deterioration inhibitor	Condensed phosphate ester(*7)					
	Deterioration inhibitor(*8)	4	4	4	4	4
	Sulfur-based deterioration inhibitor(*9)	1	1	1	1	1
	Gross-linking aid(*10)	2	2	2	2	2
Dose of electron beam	(kGy)	30	30	60	60	60
Cut-through strength	(N)	75	72	80	83	85
Original	Secant modulus (MPa)	1230	1180	820	790	570
	Tensile strength (MPa)	44	42	40	43	41.4
	Tensile elongation (%)	210	225	273	295	360
After heat aging	Tensile strength (MPa)	43	39	37	40	36.8
	Tensile elongation (%)	120	145	185	240	211
	Retention (strength, elongation) (%)	98, 57	93, 64	93, 68	93, 81	89, 59
Flame retardance Vertical-specimen-flame test VW-1		5/5 Pass	5/5 Pass	5/5 Pass	5/5 Pass	5/5 Pass

[0057]

(Footnote)

(*1) Block copolymer polypropylene resin: Novatec EC9 manufactured by Japan Polypropylene Corporation

(*2) Ethylene-propylene random copolymer polymerized using a metallocene catalyst: WELNEX RFG4VA manufactured by Japan Polypropylene Corporation

(*3) Homopolypropylene: Novatec EA9BT manufactured by Japan Polypropylene Corporation

(*4) Low-density polyethylene: NUC-8007 (MFR = 7 g/10 min) manufactured by Nippon Unicar Co., Ltd.

(*5) Polyphenylene ether resin with an intrinsic viscosity of 0.47 dl/g

(*6) Styrene-based elastomer: manufactured by Asahi Kasei Corporation: Tuftec (registered trademark) H1043

(*7) Condensed phosphate ester: PX-200 (phosphorus 9.0%) manufactured by Daihachi Chemical Industry Co., Ltd.

(*8) Irganox1010 manufactured by Chiba Specialty Chemicals Inc.

(*9) SEENOX 412S manufactured by Shipro Kasei Kaisha, LTD.

(*10) Trimethylolpropane trimethacrylate: TD1500S manufactured by DIC Corporation

[0058]

The insulated electric wires of EXAMPLES 1 to 5 all have a cut-through strength of 70 N or more, thus having high strength. Furthermore, the original tensile elongation and the tensile elongation after heat aging reach the pass level. In comparison with EXAMPLE 1 in which the low-density polyethylene is not used, the tensile elongation after heat aging is high in EXAMPLES 2 to 5 in which the low-density polyethylene is used. Furthermore, when the content of the metallocene random PP is increased, the tensile elongation and the tensile elongation after heat aging increase.

[0059]

The non-halogen flame retardant resin compositions used in the insulated electric wires of COMPARATIVE EXAMPLES 1 to 7 do not contain the metallocene random PP. In all of them, although the cut-through strength is high and at the pass level, the tensile elongation after heat aging is low and evaluated as failure. In COMPARATIVE EXAMPLES 6 and 7, the homo PP having high modulus of elasticity is added, and the

resin compositions have high modulus of elasticity. Although the cut-through strength is high because of the improved modulus of elasticity, the tensile elongation after heat aging is low, which does not reach the pass level.

Reference Signs List

[0060]

- 1 conductor
- 2 coating layer
- 3 insulated electric wire
- 4 blade

CLAIMS

[Claim 1]

A non-halogen flame retardant resin composition comprising 100 parts by mass of a resin component and 5 to 40 parts by mass of a phosphorus-based flame retardant,

wherein the 100 parts by mass of the resin component includes 30 to 85 parts by mass of a polyolefin-based resin, 10 to 50 parts by mass of a polyphenylene-ether-based resin, and 5 to 30 parts by mass of a styrene-based elastomer; and

the polyolefin-based resin includes an ethylene-propylene random copolymer polymerized using a metallocene catalyst in the amount of 5% to 60% by mass relative to the entire polyolefin-based resin, and a block copolymer polypropylene resin in the amount of 30% to 95% by mass relative to the entire polyolefin-based resin.

[Claim 2]

The non-halogen flame retardant resin composition according to Claim 1, wherein the polyolefin-based resin further includes a low-density polyethylene in the amount of 5% to 20% by mass relative to the entire polyolefin-based resin.

[Claim 3]

The non-halogen flame retardant resin composition according to Claim 1 or 2, wherein the styrene-based elastomer is a block copolymer elastomer of styrene and a rubber component.

[Claim 4]

The non-halogen flame retardant resin composition according to any one of Claims 1 to 3, wherein the polyphenylene ether is a polyphenylene ether resin with which polystyrene is melt blended.

[Claim 5]

An electric wire or cable which uses, as a coating layer, the non-halogen flame retardant resin composition according to any one of Claims 1 to 4.

[Claim 6]

The electric wire or cable according to Claim 5, wherein the thickness of the coating layer is 0.3 mm or less.

[Claim 7]

The electric wire or cable according to Claim 5 or 6, wherein the coating layer is cross-linked by irradiation with ionizing radiation.