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(54) FLAME-RETARDANT POLYAMIDE FILAMENTS AND THEIR USE

(57) A flame retardant polyamide filament comprising a polyamide resin composition which has a tensile strength of not less than 2.0 cN/dtex as measured according to JIS L1013 and comprises 98 to 80 parts by weight of a polyamide resin having a relative viscosity of 2.0 to 4.0 and 2 to 20 parts by weight of a triazine-based flame retardant which is dispersed in the polyamide filament and has an average particle size of less than 5 µm. Such a flame retardant polyamide filament is not required to contain any halogen-based compound and, therefore, can exhibit a high safety to environments and an excellent strength. Accordingly, the polyamide filament is suitable for production of a multi-filament, especially polyamide BCF obtained by crimping the multi-filament, and further carpets using the polyamide BCF. Also, the polyamide filament in the form of a monofilament is applicable to guard nets for wire harness, mesh sheets, etc., and the polyamide filament in the form of a multi-layer filament is also applicable to mesh sheets.

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Description

TECHNICAL FIELD

[0001] The present invention relates to a filament comprising a specific polyamide resin composition having excellent flame retardancy and strength, and more particularly to a multi-filament comprising a plurality of monofilaments, especially to crimped textured yarn, i.e., BCF (bulked continuous filament). Further, the present invention relates to carpets exhibiting a high safety and an excellent flame retardancy irrespective of no inclusion of halogen compounds by using the BCF. In addition, the present invention relates to application of the monofilament to guard nets for wire harness as well as mesh sheets, and a specific multi-layer filament suitably applicable to mesh sheets, etc.

BACKGROUND ART

[0002] Flame retardant polyamide filaments have been used in the form of monofilament or multi-filament in various applications. In particular, the monofilament has been applied mainly to guard nets for wire harness of domestic electric appliances, vehicles, air planes, etc., as well as raw yarn for multi-filament, etc. Especially, BCF (bulked continuous filament) has been applied to carpets used in houses, buildings, automobiles, railway vehicles, air planes, etc. As such carpets, there have been conventionally used mat-shaped carpets comprising a ground fabric tufted with a twist yarn composed of 2 to 3 multi-filaments called BCF which are obtained by subjecting a non-flame retardant polypropylene or nylon to spinning-coupled stretching/crimping process, and a rubber sheet adhered to a rear surface of the tufted ground fabric.

[0003] In recent years, from the standpoint of safety, there is a public demand for providing carpets having a flame retardancy. In addition, it has been required to obtain such flame retardant carpets without using halogen-based flame retardants that tend to cause environmental pollution and damage to human health.

[0004] In order to impart a flame retardancy to polypropylene resins without using the halogen-based flame retardants, there has been proposed such a method of blending magnesium hydroxide or urea therewith. However, in this case, it is necessary to use the magnesium hydroxide or urea in an amount as large as not less than 40 parts by weight based on 100 parts by weight of the polyolefine resins, resulting in considerable deterioration in strength of the obtained monofilament. As a result, mat-shaped products obtained from such a monofilament are practically unusable.

[0005] On the other hand, although the methods of imparting a flame retardancy to polyamide resins without using halogen-based flame retardants have been proposed by Japanese Patent Application Laid-Open (KOKAI) Nos. 51-54655 and 11-335552, the obtained polyamide resins are still unsatisfactory in strength required in applications such as BCF, carpets and guard nets for wire harness.

[0006] An object of the present invention is to provide a flame retardant polyamide filament having a excellent flame retardancy without using any halogen-based compound as well as a high safety to environments and an excellent strength, especially a multi-filament, a polyamide BCF obtained by crimping the multi-filament, and carpets using the polyamide BCF.

DISCLOSURE OF THE INVENTION

[0007] The present invention has been made to solve the above problems. According to an aspect of the present invention, there is provided a flame retardant polyamide filament comprising a polyamide resin composition which has a tensile strength of not less than 2.0 cN/dtex as measured according to JIS L1013 and comprises 98 to 80 parts by weight of a polyamide resin having a relative viscosity of 2.0 to 4.0 and 2 to 20 parts by weight of a triazine-based flame retardant which is dispersed in the polyamide filament and has an average particle size of less than 5 µm.

[0008] According to another aspect of the present invention, there is provided the flame retardant polyamide filament as defined above which is in the form of a multi-filament comprising a plurality of monofilaments.

[0009] According to a further aspect of the present invention, there is provided a flame retardant polyamide BCF (bulked continuous filament) produced by subjecting the above multi-filament to a crimping process.

[0010] According to a still further aspect of the present invention, there is provided a carpet using the above flame retardant polyamide BCF.

[0011] According to a still further aspect of the present invention, there are provided the flame retardant polyamide filament as defined above which is in the form of a monofilament having a fineness of 300 to 56,500 dtex, and a guard net for wire harness produced by knitting the monofilament into a net around an electric cable.

[0012] According to a still further aspect of the present invention, there are provided the flame retardant polyamide filament as defined above which is in the form of a monofilament having a fineness of 400 to 11,000 dtex, and a mesh sheet produced by knitting the monofilaments into a net which has a porosity representing a mesh size of 20 to 30%, and a basis weight of 100 to 600 g/m^2.

[0013] According to a still further aspect of the present invention, there are provided a flame retardant multi-layer filament which has said multi-layer filament comprises an inner layer constituted of a flame retardant polyamide resin layer A comprising a polyamide resin composition comprising 98 to 80 parts by weight of a polyamide resin having a relative viscosity of 2.0 to 4.0 and 2 to 20 parts by weight of a triazine-based flame retardant which has an average particle size of less than 5 μm and is dispersed in the filament; and

a surface layer formed on the inner layer and constituted of any one of the flame retardant polyamide resin layer A, a polyamide resin layer B having a composition other than that of the flame retardant polyamide resin layer A and a polyolefin resin layer C.

[0014] According to a still further aspect of the present invention, there is provided the flame retardant multi-layer filament as defined above, wherein a melting point of the polyamide resin contained in the polyamide resin layer A constituting the inner layer is higher by 5°C or more, than a melting point of the resin used in the surface layer, and a mesh sheet produced by interlacing the multi-layer filaments as defined in the above into a net, and heat-fusing crossing portions of the warp and weft filaments at the surface layer thereof.

[0015] The present invention is described in detail below.

Polyamide Resin:

[0016] In the present invention, as the polyamide resin, there may be used various polyamides produced by polycondensation of 3 or more-membered lactams, polymerizable ω-amino acids, dibasic acids, diamines and the like. Specific examples of the polyamides may include polymers of ε-caprolactam, aminocaproic acid, enanthlactam, 7-amino-heptanoic acid, 11-amino-undecanoic acid, 9-amino-nonanoic acid, α-pyrrolidone, α-piperidone or the like; aliphatic polyamides or copolymers thereof such as polyamides 4, 6, 7, 8, 11, 12, 66, 69, 610, 611, 612, 6/66 and 6/12 as well as aromatic polyamides or copolymers thereof such as polyamides 6T, 6/6T, 6T/6I and MXD6 which are polymers or copolymers obtained by polycondensing a diamine such as hexamethylenediamine, nonamethylenediamine, undecamethylenediamine, dodecamethylenediamine and m-xylylenediamine with a dicarboxylic acid such as terephthalic acid, isophthalic acid, adipic acid, sebacic acid, dodecanedioic acid and glutaric acid; or the like. These polyamide resins may be used in combination of any two or more thereof.

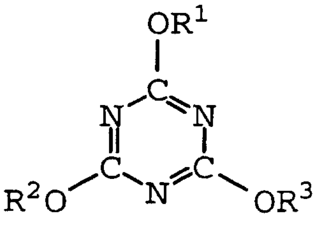
[0017] In the present invention, among these polyamide resins, especially preferred are polyamide 6, copolyamide 6/66 and polyamide 66 from the standpoints of flame retardancy, mechanical strength and moldability.

[0018] The polyamide resin used in the present invention may be terminal-sealed with carboxylic acids or amines, preferably with carboxylic acids or amines having 6 to 22 carbon atoms. Specific examples of the carboxylic acids used for the terminal-sealing may include aliphatic monocarboxylic acids such as caproic acid, caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid and behenic acid, or the like. Specific examples of the amines used for the terminal-sealing may include aliphatic primary amines such as hexylamine, octylamine, decylamine, laurylamine, myristylamine, palmitylamine, stearylamine and behenylamine, or the like.
The amount of the carboxylic acid or amine used for the terminal-sealing is about 30 μeq/g.

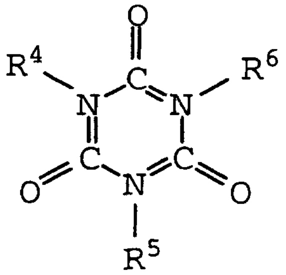
[0019] The polyamide resin used in the present invention has such a degree of polymerization that its relative viscosity as measured with respect to a 1% solution of polyamide in 98% sulfuric acid at 25°C according to JIS K6810, is in the range of 2.0 to 4.0. When the relative viscosity is less than 2.0, the polyamide resin may show a too low melt viscosity, resulting in not only difficulty in spinning, but also poor mechanical strength and, therefore, rupture upon BCF processing stage. When the relative viscosity is more than 4.0, the polyamide resin not only may fail to show a good melt fluidity, but also may not be stably spun due to heat deterioration upon shearing.

Triazine-based flame retardant:

[0020] Examples of the triazine-based flame retardant used in the present invention may include compounds represented by the following general formula (1) or (2):



(1)



(2)

wherein R^1 to R^6 are independently hydrogen or alkyl; melamines; and reaction products obtained by reacting cyanuric acid with the melamines at a molar ratio of 1:1.

[0021] Specific examples of the compounds represented by the above general formula (1) may include cyanuric acid, trimethyl cyanurate, triethyl cyanurate, tri(n-propyl) cyanurate, methyl cyanurate, diethyl cyanurate or the like.

[0022] Specific examples of the compounds represented by the above general formula (2) may include isocyanuric acid, trimethyl isocyanurate, triethyl isocyanurate, tri(n-propyl) isocyanurate, diethyl isocyanurate, methyl isocyanurate or the like.

[0023] As the melamines, there may be used melamine, melamine derivatives, compounds having a similar structure to that of melamine, condensates of melamine or the like. Specific examples of the melamines may include melamine, ammelide, ammeline, formoguanamine, guanyl melamine, cyanomelamine, aryl guanamine, melam, melem, melon or like.

[0024] In the present invention, among these triazine-based flame retardants, preferred are the reaction products obtained by reacting cyanuric acid with melamines at a molar ratio of 1:1, because these compounds show a good thermal stability, i.e., are free from defects such as blooming of decomposition products onto the surface of molded products upon molding process, and more preferred is melamine cyanurate. Also, some of amino groups or hydroxyl groups of the melamine cyanurate may be substituted with other groups. The melamine cyanurate may be produced, for example, by mixing an aqueous cyanuric acid solution and an aqueous melamine solution with each other, reacting these compounds at a temperature of 90 to 100°C under stirring, and then filtering the resultant reaction solution to separate precipitates produced therefrom. The melamine cyanurate is commercially available in the form of a white solid, and the commercially available melamine cyanurate may be used immediately or may be preferably pulverized into a fine powder before use.

Average particle size of triazine-based flame retardant:

[0025] The triazine-based flame retardant is usually present in the form of agglomerates composed of fine particles each having a particle size of submicron order. The average particle size of the triazine-based flame retardant is expressed by an average particle size of dispersed particles in the form of the agglomerates composed of fine particles each having a particle size of submicron order. In the present invention, the average particle size means a number-average particle diameter. Further, in the case of the stretched filament, the average particle size of the triazine-based flame retardant represents an average value of measured particle sizes of the dispersed particles contained in the stretched filament. The average particle size of the triazine-based flame retardant dispersed in the filament can be determined, for example, by cutting the filament, removing the triazine-based flame retardant from the cut section of the filament, and observing traces formed on the section after removal of the triazine-based flame retardant by SEM to measure the sizes thereof.

[0026] In the present invention, the average particle size of the triazine-based flame retardant dispersed in the filament is less than 5 µm. When the average particle size is more than 5 µm, the monofilament may be ruptured during the filament molding process, i.e., at any stage of monofilament-spinning, stretching and crimping processes.

[0027] Meanwhile, when the triazine-based flame retardant is blended in the polyamide resin, the agglomerates thereof may be broken upon blending or spinning step. In order to stably perform the filament molding process, i.e., spinning, stretching, etc. of the monofilament, the agglomerates of the triazine-based flame retardant are preferably previously pulverized into a suitable size before use. The average particle size of the triazine-based flame retardant before blending in the polyamide resin may be measured by existing particle size measuring devices, for example, a precipitation granulometer, a laser diffraction-type granulometer, ordinary optical microscopes or the like.

Polyamide resin composition:

[0028] The amount of the triazine-based flame retardant blended is usually 2 to 20 parts by weight, preferably 3 to 20 parts by weight based on 98 to 80 parts by weight of the polyamide resin. When the amount of the triazine-based flame retardant blended is less than 2 parts by weight, the obtained composition tends to be deteriorated in flame retardancy. When the amount of the triazine-based flame retardant blended is more than 20 parts by weight, the monofilament tends to be ruptured upon the production of BCF.

[0029] The blending of the triazine-based flame retardant in the polyamide resin may be conducted by various known methods at any optional stages up to the time immediately before the spinning step upon the production of BCF. Among these methods, the simplest one is such a method of melt-mixing given amounts of the triazine-based flame retardant and the polyamide resin, and then melt-extruding the resultant mixture to form pellets thereof. However, the polyamide resin composition having a predetermined blending ratio may be produced by previously forming master pellets by kneading an excessive amount of the triazine-based flame retardant in the polyamide resin according to the requirement, and then dry-blending the thus obtained master pellets with polyamide resin to dilute in the predetermined ratio. After the dry-blending, the obtained composition may be further melt-mixed and melt-extruded into pellets.

[0030] Also, the polyamide resin composition may contain, in addition to the triazine-based flame retardant, various known additives such as pigments, dyes, fillers, nucleating agents, mold release agents, stabilizers, antistatic agents or the like. Further, the polyamide resin composition of the present invention may be blended with thermoplastic resins other than polyamide resins unless the effects of the present invention are adversely affected by the addition thereof.

Flame retardant polyamide filament:

[0031] The polyamide filament of the present invention may be in the form of either a monofilament constituted of a single yarn obtained by an ordinary melt spinning process, or a multi-filament obtained by bundling or twisting a plurality of such monofilaments. Further, the polyamide filaments may be split fibers obtained by tearing films, slit (flat) fibers or the like. Among these filaments or fibers, the present invention is excellently applicable to the monofilament obtained by melt-spinning process or the multi-filament produced from such monofilaments. The monofilament may be in the form of either short fibers or long fibers, and may have a cross-section of a round shape and an elliptical shape as well as other shapes. The monofilament may be used as raw yarn for producing a multi-filament by bundling or twisting a plurality of the monofilaments, or may be used to produce a multi-filament by combining the monofilament as core with fibers made of other resins, or on the contrary, by combining the fibers made of other resins as core with the monofilament. Further, the monofilament may be sometimes directly used as fishing line, gut or the like. In addition, the monofilament may be processed, for example, knitted or woven to produce guard nets for wire harness, mesh sheets for building construction work, or the like. Further, the multi-filament, split fibers and slit fibers may also be practically used either immediately or after processing in similar applications to those of the monofilament.

Polyamide multi-filament:

[0032] The polyamide multi-filament of the present invention is produced by melting and spinning the polyamide resin composition obtained by blending a specific amount of the triazine-based flame retardant having a specific particle size in the polyamide resin, stretching the obtained filament, if required, and then subjecting the filament to bundling, twisting or the like processes. The thus spun monofilament may be formed into various sectional shapes, e.g., by varying the sectional shape of a spinning nozzle. In particular, in the case of BCF, the monofilament thereof may be a bulked continuous filament whose cross-section is formed into a Y-shape (Y-shaped section), a trilobal shape, etc., as well as hollow structures of these shapes and different shapes such as 田-shaped (lattice-shape) hollow structure.

[0033] The thickness (fineness) of the spun monofilament may be appropriately selected according to the applications of the multi-filament and, therefore, is not particularly restricted. When applied to BCF, the monofilament has a fineness of 4 to 90 dtex. When the section of the multi-filament is a round shape, the diameter of each monofilament may be in the range of 0.02 to 0.1 mm, and the total fineness of the multi-filament may be in the range of 1,111 to 3,333 dtex (1,000 to 3,000 denier).

[0034] Also, the multi-filament is usually produced by bundling or twisting a plurality of the monofilaments. In the production of BCF, about 10 to 100 monofilaments are bundled, and especially when ordinary BCF production apparatuses are used, 64 to 68 monofilaments are usually bundled.

Flame retardant polyamide BCF:

[0035] The flame retardant polyamide BCF (bulked continuous filament) of the present invention is made of a bulky continuous textured yarn having different cross-sections such as a trilobal cross-section, 田-shaped (lattice-shape) hollow cross-section, etc., which has been frequently used for the purpose of improving a covering property or antifouling property of carpets or the like, and can be produced by usually subjecting the polyamide resin composition containing the above flame retardant as raw material to three processes including spinning, stretching and crimping processes. For example, as described in Japanese Patent Application Laid-Open (KOKAI) No. 9-95834, "HANDBOOK OF FIBERS 2nd-edition" (edited by Maruzen), etc., immediately after about 64 to 68 monofilaments are spun, the obtained monofilaments are stretched at a stretch ratio of about 3.0 to 4.5 times, preferably about 3.0 to 4.0 times by a heat roll, and the stretched filaments are immediately crimped by fluid-intrusion process using pressurized steam, etc. Successively, the crimped filaments are relaxed for cooling and then wound up on a bobbin, thereby obtaining a multi-filament composed 64 to 68 monofilaments (64-68 F) which has a fineness of 1,111 to 3,333 dtex (1,000 to 3,000 denier). In commercial production facilities, the BCF production is performed at a line speed of 2,000 to 3,000 m/min. The above BCF also includes a twist yarn (occasionally referred to as BCF pile yarn) obtained by further twisting 2 to 4 BCF multi-filaments (each occasionally referred to as BCF ply yarn) each composed of 64 to 68 monofilaments.

Polyamide monofilament:

[0036] The polyamide monofilament of the present invention may be directly applied to fishing line, gut, etc. In the present invention, from the standpoints of flame retardancy and strength, the polyamide monofilament may be processed into woven fabric or knitted fabric, and suitably applied to guard nets for wire harness as well as curing or protective sheets with a mesh structure, i.e., so-called mesh sheets used for building construction work, etc.

[0037] The guard net for wire harness is a tubular protective net formed by densely knitting monofilaments, for the purpose of protecting the wire harness (such as electric cables and signal cables) used in domestic electric appliances, vehicles, air planes, etc., against impact and stress exerted thereon from outside. The polyamide monofilament used for this purpose is stretched, for example, at a stretch ratio of 3.5 to 5.0 times, preferably 3.5 to 4.5 times. Such a polyamide monofilament has a diameter of preferably 0.01 to 3 mm, more preferably 0.02 to 2.5 mm. When applied to the guard nets for wire harness, the polyamide monofilament has a diameter of still more preferably about 0.1 to 0.8 mm, most preferably 0.2 to 0.5 mm. The fineness of the polyamide monofilament is preferably in the range of 300 to 56,500 dtex though it varies depending upon applications thereof.

[0038] The mesh sheet mainly used for construction work is frequently spread around buildings such as houses and office buildings or construction sites such as bridge construction sites for protection against dangers and accidents. The mesh sheet is produced by weaving or knitting the monofilaments into a net using a weaving or knitting machine. The mesh size of the mesh sheet is not particularly restricted as long as an appropriate air permeability is ensured. For example, the mesh sheet used for building construction work has a porosity representing the mesh size of 20 to 30%. The mesh sheet has a basis weight of 100 to 600 g/m^2, preferably 200 to 400 g/m^2.

In this case, the monofilaments to be knitted into a net are stretched, for example, at a stretch ratio of 3.5 to 5.5 times, preferably 4 to 5 times. The monofilament usually has a thread diameter of 0.1 to 1.5 mm, preferably 0.2 to 1.1 mm, and a fineness of 400 to 11,000 dtex.

Polyamide multi-layer monofilament:

[0039] The flame retardant multi-layer filament of the present invention comprises an inner layer constituted of a flame retardant polyamide resin layer A made of a polyamide resin composition obtained by blending 98 to 80 parts by weight of a polyamide resin having a relative viscosity of 2.0 to 4.0 with 2 to 20 parts by weight of a triazine-based flame retardant having an average particle size of less than 5 µm under the condition dispersed in the filament; and a surface layer formed on the inner layer and constituted of any one of the flame retardant polyamide resin layer A, a polyamide resin layer B having a composition other than that of the flame retardant polyamide resin layer A and a polyolefin resin layer C, and has a tensile strength of not less than 2.0 cN/dtex as measured according to JIS L1013. Meanwhile, the multi-layer filament may further comprise an intermediate layer such as an adhesive layer between the inner layer and the surface layer. In the multi-layer filament, a melting point of the polyamide resin contained in the polyamide resin layer A constituting the inner layer is higher by 5°C or more, than a melting point of the resin used in the surface layer. The multi-layer filament may be suitably used for production of mesh sheets without dislocation of meshes by interlacing the monofilaments or multi-filaments produced therefrom with each other into a net, and heat-fusing crossing portions of the warp and weft filaments at a surface layer thereof.

Tensile strength:

[0040] The polyamide filament of the present invention has a tensile strength of not less than 2.0 cN/dtex as measured according to JIS L1013. In the specific applications requiring a high strength such as mesh sheets for building construction work, the polyamide filament has a tensile strength of preferably not less than 2.5 cN/dtex, more preferably not less than 3.0 cN/dtex. The tensile strength used herein is expressed by a value obtained by dividing the applied tensile break load by the fineness of the filament, and the unit thereof is represented by cN/dtex as SI unit, wherein the tensile load cN means 1/100 x N, and the fineness dtex means grams per a length of 10,000 m. When the tensile strength is less than 2.0 cN/dtex, the obtained filament is insufficient in strength upon practical use or strength upon knitting into a net. As a result, the filament tends to be ruptured upon twisting, setting and tufting processes during the production of BCF, or when used as products such as carpets. Meanwhile, in the case of the multi-layer filament, the tensile strength is that of the multi-layer filament as a whole, and the preferred range thereof is the same as described above.

Oxygen index (LOI) :

[0041] The flame retardant polyamide filament of the present invention preferably exhibits such a flame retardancy that an oxygen index thereof is not less than 27 as measured according to JIS K7201. In the case of the multi-layer filament, the oxygen index thereof is represented by the value measured with respect to the multi-layer filament as a whole. The oxygen index means an oxygen concentration (% by volume) required to continue combustion of a sample. For example, in the case where the sample is in the form of a sheet having a thickness of about 1 mm, if its oxygen index is not less than 22, it is not possible to continuously burn the sample at an oxygen concentration in atmospheric air, namely it is meant that the sample is a self-extinguishing material. In the present invention, in the consideration of processed and used conditions for carpets, guard nets for wire harness, mesh sheets for construction work, etc., the oxygen index of the polyamide filament is preferably not less than 27 in order to achieve much stricter flame retardancy.

[0042] Meanwhile, the oxygen index may vary depending upon water absorption of the polyamide resin composition. In the present invention, after holding a test sample at 23°C and 65% RH for 24 hours or longer, the oxygen index thereof is measured according to JIS K7201. Also, in the case of BCF in the form of a so-called multi-filament composed of about 64 monofilaments each having a diameter of usually 20 to 100 μm, the oxygen index thereof can be directly measured by self-supporting the BCF in a sample holder specified by the JIS.

Inclusion of halogen compound:

[0043] The flame retardant polyamide filament of the present invention preferably contains no halogen compound. This means that the content of halogen elements such as fluorine, chlorine and bromine which is measured by burning a filament or BCF obtained by processing the filament as a test sample at 900°C to capture the combustion gas, and then subjecting the gas to ion chromatographic analysis, is not more than 10 ppm, preferably not more than 5 ppm, more preferably not more than 2 ppm based on the weight of the sample.

[0044] When the content of halogen elements is the above-specified value or less, it is considered that the gas generated upon combustion of the polyamide filament contains substantially no halogen elements, and the polyamide filament can exhibit a high safety to environments.

Application of BCF to carpets:

[0045] In the present invention, the flame retardant polyamide BCF is useful as raw yarn for carpets, and can be processed into a mat shape through various known processes such as twisting, setting, tufting, backing, etc., thereby obtaining carpets. For example, as described in Japanese Patent Application Laid-Open (KOAKI) Nos. 11-285466 and 10-225423, etc., 2 to 4 BCF multi-filaments each having a total fineness of 1,408 dtex which are each composed of 64 monofilaments (fineness of each monofilament: about 22 dtex) and produced using an ordinary spinning, stretching and crimping-coupled BCF production apparatus, are twisted and then subjected to wet-heat setting process at a temperature of 120 to 130°C for about one minute, thereby obtaining a pile yarn. Successively, after the thus obtained pile yarn is tufted in a ground fabric by a tufting machine, the tufted ground fabric is subjected to backing process in which a NBR rubber sheet blended with a vulcanizing agent is adhered onto a rear side thereof, and then pressed at 170°C under a pressure of 294 kPa (3 kg/cm^2), thereby obtaining a mat-shaped product, i.e., carpets.

BEST MODE FOR CARRYING OUT THE INVENTION

[0046] The present invention is described in more detail with reference to the following examples, but these examples are only illustrative and not intended to limit the present invention thereto.

[0047] Meanwhile, in the following Examples and Comparative Examples, the below-mentioned polyamide resins and triazine-based flame retardants were used.

<Polyamide 6 resin>

[0048] Polyamide 6 resin-1: "NOVAMID® 1015J" produced by Mitsubishi Engineering-Plastics Corporation (relative viscosity: 3.0)

[0049] Polyamide 6 resin-2: "NOVAMID® 1020J" produced by Mitsubishi Engineering-Plastics Corporation (relative viscosity: 3.5)

<Copolyamide 6/66 resin>

[0050] Copolyamide 6/66 resin-1: A 50% aqueous solution of a salt of adipic acid and hexamethylenediamine (hereinafter referred to merely as "AH salt") and ε-caprolactam (hereinafter referred to merely as "CL") were respectively heated to 100°C, and 15 parts by weight of AH salt and 85 parts by weight of CL were mixed together. Then, the resultant mixture was charged into a 200 liter autoclave and then heated to 270°C while maintaining an inner pressure of the autoclave at 1,275 kPa (13 kg/cm^2). Thereafter, the inner pressure of the autoclave was gradually reduced to 49 kPa (0.5 kg/cm^2) while maintaining the inner temperature at 245°C and stirring the contents thereof, and the polymerization was stopped at the time at which the agitation power reached a predetermined value.

[0051] Thereafter, nitrogen was introduced into the autoclave to return the inner pressure to the initial value, and the resultant polymer was taken out therefrom in the form of strands which are then pelletized. The obtained pellets were extracted with boiled water to remove unreacted compounds therefrom, and then dried, thereby obtaining a copolyamide 6/66 resin having a relative viscosity of 3.0 and a melting point of 202°C.

[0052] Copolyamide 6/66 resin-2: The same procedure as described above was conducted except that the polymerization was stopped at the time at which the relative viscosity of the obtained resin reached 3.5. It was confirmed that the obtained resin had a melting point of 202°C.

<Triazine-based flame retardant>

Triazine-based flame retardant A:

[0053] Melamine cyanurate "MCA-C0" produced by Mitsubishi Chemical Corporation (reaction product obtained by reacting cyanuric acid with melamine at an equimolar ratio) was pulverized by a bench ball mil. The average particle size of the pulverized product was measured by an automatic precipitation granulometer manufactured by Shimadzu Seisakusho Co., Ltd. As a result, it was confirmed that the average particle size was 2.5 µm.

Triazine-based flame retardant B:

[0054] Melamine cyanurate "MCA-C0" produced by Mitsubishi Chemical Corporation (reaction product obtained by reacting cyanuric acid with melamine at an equimolar ratio) was classified through a 50 mesh screen. The average particle size of the classified product was measured by an automatic precipitation granulometer manufactured by Shimadzu Seisakusho Co., Ltd. As a result, it was confirmed that the average particle size was 80 µm.

<Production of polyamide resin composition>

[0055] The above polyamide 6 resin and/or copolyamide 6/66 resin, and the triazine-based flame retardant A or B, were blended with each other at a mixing ratio shown in Table 1, and melt-kneaded at a resin temperature of 240 to 260°C using a vented twin-screw extruder having a cylinder diameter of 30 mm ("TEX30" manufactured by The Japan Steel Works, Ltd.), thereby obtaining a polyamide resin composition in the form of pellets.

[0056] Thereafter, the pellets of the thus obtained polyamide resin composition were dried for 6 hours at 120°C under reduced pressure, i.e., under a gauge pressure of -101 kPa, and molded into respective samples.

<Production of BCF>

Examples 1 to 3 and Comparative Example 1:

[0057] The polyamide resin composition shown in Table 1 was molded into a BCF multi-filament having a fineness of 1,408 dtex and a trilobal sectional shape which were composed of 64 monofilaments each having a fineness of 22 dtex using a spinning, stretching and crimping-coupled BCF production apparatus manufactured by FILTECO. Meanwhile, since the first roll speed was 500 m/min and the final roll speed was 1,900 m/min, the stretch ratio was 3.8 times.

[0058] The thus obtained BCF was tested to measure a tensile strength thereof. Also, the monofilaments constituting the BCF were subjected to measurement of average particle size of the triazine-based flame retardant contained therein, measurement of oxygen index thereof, and elemental analysis of halogens contained therein. The results are shown in Table 1.

[0059] The BCFs obtained in Examples 1 to 3 all were able to be molded into a mat shape through various processes including twisting, setting, tufting, backing, etc., thereby obtaining carpets containing no halogen compound and having a high safety and an excellent flame retardancy.

Comparative Examples 2 to 4:

[0060] It was attempted to mold the polyamide resin composition shown in Table 1 into BCF having a fineness of 1,408 dtex and a trilobal sectional shape which was composed of 64 monofilaments each having a fineness of 22 dtex using a spinning, stretching and crimping-coupled BCF production apparatus manufactured by FILTECO. However, in the stretching process, the filaments frequently suffered from breakage, thereby failing to obtain samples (BCF).

Examples 4 to 6 and Comparative Examples 5 to 8:

[0061] The polyamide resin composition shown in Table 2 was melt-spun at a resin temperature of 254°C using a single-screw extruder having a cylinder diameter of 30 mm and a ratio L/D of 27 which was fitted with a full-flighted screw and a gear pump at a tip end thereof, and passed through a cooling water vessel whose water temperature was maintained at 10°C for cooling and solidification thereof. Then, the obtained filament was sequentially subjected to wet-heat stretching at 98°C, 100% RH and a stretch ratio of 3.5 times, dry-heat stretching in dried air at 175°C and a stretch ratio of 1.34 times, and finally dry-heat annealing at 165°C and a relaxation ratio of 0.95 times, thereby obtaining a monofilament having a diameter of 0.2 mm.

[0062] The oxygen index, tensile strength, etc., of the thus obtained monofilament were measured. The results are shown in Table 2.

[0063] Further, the four monofilaments thus obtained were knitted into a net around an iron core as a jig having a diameter of 12 mm to produce a guard net. In Examples 4 to 6, the thus obtained guard net was fitted around a bundle of electric cables to constitute a wire harness. After the obtained wire harness was practically used for a long period of time, it was confirmed that the bundle of electric cables covered with the guard net was sufficiently protected against external stress.

Examples 7 and 8 and Comparative Examples 9 to 12:

[0064] The polyamide resin composition shown in Table 2 was melt-spun at a resin temperature of 247°C using a single-screw extruder having a cylinder diameter of 40 mm and a ratio L/D of 27 which was fitted with a full-flighted screw and a gear pump at a tip end thereof, and then passed through a cooling water vessel whose water temperature was maintained at 12°C for cooling and solidification thereof. Then, the obtained filament was sequentially subjected to wet-heat stretching at 98°C, 100% RH and a stretch ratio of 3.4 times, dry-heat stretching in dried air at 180°C and a stretch ratio of 1.3 times, and finally dry-heat annealing at 170°C and a relaxation ratio of 0.95 times, thereby obtaining a monofilament having a diameter of 2.0 mm.

[0065] The oxygen index, tensile strength, etc., of the thus obtained monofilament were measured. The results are shown in Table 2.

[0066] Further, the four monofilaments thus obtained were knitted into a net around an iron core as a jig having a diameter of 75 mm to produce a guard net. In Examples 7 and 8, the thus obtained guard net was fitted around a bundle of electric cables to constitute a wire harness. After the obtained wire harness was practically used for a long period of time, it was confirmed that the bundle of electric cables covered with the guard net was sufficiently protected against external stress.

Comparative Examples 13 and 14:

[0067] The same procedures as defined in Examples 5 and 8 were respectively conducted except that the triazine-based flame retardant A contained in the respective compositions was replaced with the triazine-based flame retardant B. However, the extruded filament was ruptured during the stretching process, thereby failing to obtain the aimed monofilament.

Example 9 and Comparative Examples 15 to 17:

[0068] The polyamide resin composition shown in Table 3 was melt-spun at a resin temperature of 254°C using a single-screw extruder having a cylinder diameter of 30 mm and a ratio L/D of 27 which was equipped with a full-flighted screw and a gear pump at a tip end thereof, and then passed through a cooling water vessel whose water temperature was maintained at 10°C for cooling and solidification thereof. Then, the obtained filament was sequentially subjected to wet-heat stretching at 98°C, 100% RH and a stretch ratio of 3.5 times, dry-heat stretching in dried air at 175°C and a stretch ratio of 1.43 times, and finally dry-heat annealing at 165°C and a relaxation ratio of 0.95 times, thereby obtaining a monofilament having a fineness of 2,060 dtex (diameter of about 0.48 mm). The oxygen index and tensile strength of the thus obtained monofilament were measured.

[0069] Further, the obtained monofilaments were knitted into a net to form a plain-woven mesh sheet having a size of 1 m x 1 m and a basis weight of 400 g/m^2.

Example 10 and Comparative Examples 18 to 20:

[0070] The polyamide resin composition shown in Table 4 was melt-spun at a resin temperature of 247°C using a single-screw extruder having a cylinder diameter of 40 mm and a ratio L/D of 27 which was equipped with a full-flighted screw and a gear pump at its tip end, and then passed through a cooling water vessel whose water temperature was maintained at 12°C for cooling and solidification thereof. Then, the obtained filament was sequentially subjected to wet-heat stretching at 98°C, 100% RH and a stretch ratio of 3.8 times, dry-heat stretching in dried air at 180°C and a stretch ratio of 1.3 times, and finally dry-heat annealing at 170°C and a relaxation ratio of 0.95 times, thereby obtaining a monofilament having a fineness of 8,950 dtex (diameter of about 1.0 mm).

[0071] The oxygen index and tensile strength of the thus obtained monofilament were measured.

[0072] Further, the obtained monofilaments were knitted into a net to form a plain-woven mesh sheet having a size of 1 m x 1 m and a basis weight of 400 g/m^2.

Examples 11 and 12 and Comparative Examples 21 to 24:

[0073] Using an extruding apparatus for forming a multi-layer monofilament comprising a single-screw extruder for an inner layer having a cylinder diameter of 30 mm and a ratio L/D of 27 and being equipped with a gear pump at its tip end and a full-flighted screw, and a single-screw extruder for a surface layer having a cylinder diameter of 20 mm and a ratio L/D of 25 and being equipped with a gear pump at its tip end both of which were connected to a common die for forming the multi-layer monofilament through the respective gear pumps, the polyamide resin composition shown in Table 5 for forming the inner layer, and the polyamide resin or polyamide resin composition for forming the surface layer, were charged into the respective single-screw extruders, and melt-spun into a multi-layer monofilament using the same molding temperature of 250°C for both the layers. The thus melt-spun multi-layer monofilament was passed through a cooling water vessel whose water temperature was maintained at 10°C for cooling and solidification thereof. Then, the obtained multi-layer monofilament was sequentially subjected to wet-heat stretching at 98°C, 100% RH and a stretch ratio of 3.5 times, dry-heat stretching in dried air at 175°C and a stretch ratio of 1.43 times, and finally dry-heat annealing at 165°C and a relaxation ratio of 0.95 times, thereby obtaining a monofilament having a fineness of 2,060 dtex (diameter of about 0.48 mm).

[0074] The thus obtained monofilament was sliced along its cross-sectional direction by a razor. The resultant section of the monofilament was observed by an optical microscope to measure a thickness of the surface layer thereof. Further, the oxygen index and tensile strength of the monofilament were measured.

[0075] Further, the obtained monofilaments were knitted into a net to form a plain-woven mesh sheet having a size of 1 m x 1 m and a basis weight of 400 g/m^2. The thus obtained mesh sheet was heated to 210°C by a hot-air heating device to heat-fuse crossing portions of the warp and weft filaments.

[0076] Meanwhile, in Comparative Example 22, although it was attempted to form a mesh sheet by knitting the obtained monofilaments into a net, the monofilaments were ruptured upon knitting into a net, thereby failing to obtain the mesh sheet as a final product. Also, in Comparative Examples 23 and 24, during the production of the multi-layer monofilament, the filament was ruptured upon stretching, thereby failing to obtain a filament having the aimed fineness.

Example 13 and Comparative Example 25:

[0077] The polyamide resin composition shown in Table 6 was melt-spun at a resin temperature of 250°C by a single-screw extruder having a cylinder diameter of 30 mm and a ratio L/D of 27 and being equipped with a full-flighted screw and a gear pump at its tip end, and then passed through a cooling water vessel whose water temperature was maintained at 10°C for cooling and solidification thereof. Then, the obtained filament was sequentially subjected to wet-heat stretching at 98°C, 100% RH and a stretch ratio of 3.5 times, dry-heat stretching in dried air at 175°C and a stretch ratio of 1.43 times, and finally dry-heat annealing at 165°C and a relaxation ratio of 0.95 times, thereby obtaining a single-layer monofilament having a fineness of 1,810 dtex (diameter of about 0.45 mm).

[0078] Then, LLDPE was extrusion-molded at a resin temperature of 180°C using a single-screw extruder equipped with a cross head die for coating to form a surface layer on the thus obtained single-layer monofilament, thereby obtaining a multi-layer monofilament.

[0079] The thus obtained multi-layer monofilament was sliced along its cross-sectional direction by a razor. The resultant section of the multi-layer monofilament was observed by an optical microscope to measure a thickness of the surface layer thereof. Further, the oxygen index and tensile strength of the multi-layer monofilament were measured.

[0080] In addition, the obtained multi-layer monofilaments were knitted into a net to form a plain-woven mesh sheet having a size of 1 m x 1 m and a basis weight of 400 g/m^2. The thus obtained mesh sheet was heated to 160°C by a hot-air heating device to heat-fuse crossing portions of the warp and weft filaments.

[0081] Meanwhile, in the above Examples and Comparative Examples, various properties were measured and evaluated by the following methods.

(1) Relative viscosity:

[0082] The relative viscosity was measured with respect to a 1% solution of the resin in 98% sulfuric acid at 25°C according to JIS K6810.

(2) Melting point:

[0083] According to JIS K7121, 10 mg of a sample was heated at a temperature rise rate of 10°C/min using "DSC20" manufactured by Seiko Denshi Kogyo Co., Ltd. to measure a melting peak temperature thereof.

(3) Average particle size of triazine-based flame retardant dispersed in monofilament:

[0084] The monofilament (in the case of BCF, monofilament removed therefrom) was notched by a razor, and broken along the notched line by using a liquid nitrogen. The resultant section of the monofilament was subjected to ultrasonic cleaning in n-hexane bath at ordinary temperature for 30 minutes to remove the triazine-based flame retardant from the section. Thereafter, platinum was vapor-deposited on the section of the monofilament, and the vapor-deposited section was observed by SEM at a magnification of 5,000 times to measure a major axis length of each of traces on the section which were formed after removal of the triazine-based flame retardant therefrom. An average value of the thus measured 100 lengths was calculated and determined to be an average particle size of the triazine-based flame retardant.

(4) Oxygen index:

[0085] After allowing a sample to stand in a room at 23°C and 65% RH for 24 hours or longer, the oxygen index of the sample was measured by a D-model candle-type flammability tester manufactured by Toyo Seiki Co., Ltd., according to JIS K7201.

(5) Halogen elemental analysis:

[0086] 0.05 mg of a sample was burned at 900°C by a sample combustion device "QF-02 Model" manufactured by Dia Instrument Co., Ltd. The resultant combustion gas was introduced into a 0.3% aqueous hydrogen peroxide solution and trapped therein. The obtained solution was subjected to quantitative analysis for fluorine, chlorine and bromine using an ion chromatographic analyzer "IC7000E" manufactured by Yokogawa Analytical Systems Co., Ltd.

(6) Tensile strength:

[0087] After allowing a sample to stand in a room at 23°C and 65% RH for 48 hours or longer, the tensile strength of the sample was measured according to JIS L1013. Meanwhile, the unit of the tensile strength was expressed by cN/dtex as SI unit.

Table 1

		Examples		
		1	2	3
Polyamide resin composition				
Polyamide 6 resin-1 (wt. part)		91	45	-
Copolyamide 6/66 resin-1 (wt. part)		-	45	94
Triazine-based flame retardant A (wt. part)		9	10	6
Triazine-based flame retardant B (wt. part)		-	-	-
Evaluation				
BCF moldability		Good	Good	Good
Tensile strength (cN/dtex)		3.0	2.8	3.1
Average particle size of flame retardant (µm)		1.0	1.0	1.0
Oxygen index (%)		29	31	28
Halogen elemental analysis (ppm)	F	ND	ND	ND
	Cl	<2	<2	<2
	Br	ND	ND	ND

Note: ND: Not detected

Table 1 (continued)

		Comparative Examples			
		1	2	3	4
Polyamide resin composition					
Polyamide 6 resin-1 (wt. part)		100	56	91	46
Copolyamide 6/66 resin-1 (wt. part)		-	14	-	46
Triazine-based flame retardant A (wt. part)		-	30	-	-
Triazine-based flame retardant B (wt. part)		-	-	9	8
Evaluation					
BCF moldability		Good	*2	*2	*2
Tensile strength (cN/dtex)		3.3	-	-	-
Average particle size of flame retardant (µm)		*1	-	-	-
Oxygen index (%)		23	-	-	-
Halogen elemental analysis (ppm)	F	ND	-	-	-
	Cl	<2	-	-	-
	Br	ND	-	-	-

Note: ND: Not detected

*1: No shape of flame retardant was recognized

*2: Breakage of filament frequently occurred upon stretching, thereby failing to obtain samples.

Table 2

		Examples				
		4	5	6	7	8
Polyamide resin composition						
Polyamide 6 resin-2 (wt. part)		95	46	-	28	-
Copolyamide 6/66 resin-2 (wt. part)		-	46	94	66	95
Triazine-based flame retardant A (wt. part)		5	8	6	6	5
Triazine-based flame retardant B (wt. part)		-	-	-	-	-
Evaluation						
Monofilament diameter (mm)		0.2	0.2	0.2	2.0	2.0
Monofilament fineness (dtex)		360	360	360	36000	36000
Tensile strength (cN/dtex)		4.2	4.3	4.0	3.5	3.4
Average particle size of flame retardant (μm)		0.8	0.8	0.8	1.2	1.2
Oxygen index (%)		27	30	28	28	27
Netting ability for forming guard net		Good	Good	Good	Good	Good
Halogen elemental analysis (ppm)	F	ND	ND	ND	ND	ND
	Cl	<2	<2	<2	<2	<2
	Br	ND	ND	ND	ND	ND

Note: ND: Not detected

Table 2 (continued)

		Comparative Examples				
		5	6	7	8	9
Polyamide resin composition						
Polyamide 6 resin-2 (wt. part)		99.5	75	69.6	56	30
Copolyamide 6/66 resin-2 (wt. part)		-	-	30	14	69.6
Triazine-based flame retardant A (wt. part)		0.5	25	0.4	30	0.4
Triazine-based flame retardant B (wt. part)		-	-	-	-	-
Evaluation						
Monofilament diameter (mm)		0.2	0.2	0.2	0.2	2.0
Monofilament fineness (dtex)		360	360	360	360	36000
Tensile strength (cN/dtex)		4.4	1.7	4.5	1.4	3.5
Average particle size of flame retardant (µm)		0.8	0.8	0.8	0.8	1.2
Oxygen index (%)		24	36	24	37	24
Netting ability for forming guard net		Good	B	Good	B	Good
Halogen elemental analysis (ppm)	F	ND	ND	ND	ND	ND
	Cl	<2	<2	<2	<2	<2
	Br	ND	ND	ND	ND	ND

Note: ND: Not detected
B: Breakage upon netting

Table 2 (continued)

		Comparative Examples				
		10	11	12	13	14
Polyamide resin composition						
Polyamide 6 resin-2 (wt. part)		22	-	-	46	-
Copolyamide 6/66 resin-2 (wt. part)		52	99.5	72	46	95
Triazine-based flame retardant A (wt. part)		26	0.5	28	-	-
Triazine-based flame retardant B (wt. part)		-	-	-	8	5
Evaluation						
Monofilament diameter (mm)		2.0	2.0	2.0	*3	*4
Monofilament fineness (dtex)		36000	36000	36000	-	-
Tensile strength (cN/dtex)		1.2	3.4	1.4	-	-
Average particle size of flame retardant (µm)		1.2	1.2	1.2	-	-
Oxygen index (%)		36	24	36	-	-
Netting ability for forming guard net		B	Good	B	-	-
Halogen elemental analysis (ppm)	F	ND	ND	ND	-	-
	Cl	<2	<2	<2	-	-
	Br	ND	ND	ND	-	-

Note: ND: Not detected; B: Breakage upon netting
*3: Ruptured upon stretching and failed to obtain a monofilament with a diameter of 0.2mm
*4: Ruptured upon stretching and failed to obtain a monofilament with a diameter of 2.0mm

Table 3

	Example	Comparative Examples		
	9	15	16	17
Polyamide resin composition				
Polyamide 6 resin-1 (wt. part)	95	99.5	75	95
Triazine-based flame retardant A (wt. part)	5	0.5	25	-
Triazine-based flame retardant B (wt. part)	-	-	-	5

Table 3 (continued)

	Example	Comparative Examples		
Evaluation				
Monofilament diameter (mm)	0.48	0.48	0.48	-
Monofilament fineness (dtex)	2060	2060	2060	*5
Monofilament tensile strength (cN/dtex)	4.5	4.9	1.8	-
Average particle size of flame retardant (μm)	0.8	0.8	0.8	-
Oxygen index (%)	27	24	36	-
Netting ability for forming mesh sheet	Good	Good	B	-
Note: *5: Ruptured upon stretching and failed to obtain a monofilament with fineness of 2,060 dtex B: Ruptured upon netting				

Table 4

	Example	Comparative Examples		
	10	18	19	20
Polyamide resin composition				
Polyamide 6 resin-1 (wt. part)	95	99.5	75	95
Triazine-based flame retardant A (wt. part)	5	0.5	25	-
Triazine-based flame retardant B (wt. part)	-	-	-	5
Evaluation				
Monofilament diameter (mm)	1	1	1	-
Monofilament fineness (dtex)	8950	8950	8950	*6
Monofilament tensile strength (cN/dtex)	4.2	4.6	1.5	-
Average particle size of flame retardant (μm)	0.8	0.8	0.8	-
Oxygen index (%)	27	24	36	-
Netting ability for forming mesh sheet	Good	Good	B	-
Note: *6: Ruptured upon stretching and failed to obtain a monofilament with fineness of 8,950 dtex B: Ruptured upon netting				

Table 5

	Examples		Comparative Examples			
	11	12	21	22	23	24
Composition of inner layer						
Polyamide 6 resin-1 (wt. part)	90	95	99.5	70	90	99.5
Triazine-based flame retardant A (wt. part)	10	5	0.5	30	-	0.5
Triazine-based flame retardant B (wt. part)	-	-	-	-	10	-
Composition of outer layer						
Copolyamide 6/66 resin-1 (wt. part)	100	95	100	90	100	90
Triazine-based flame retardant A (wt. part)	-	5	-	10	-	-
Triazine-based flame retardant B (wt. part)	-	-	-	-	-	10

Table 5 (continued)

	Examples		Comparative Examples			
Evaluation						
Multi-layer monofilament fineness (dtex)	2060	2060	2060	2060	*7	*7
Multi-layer monofilament diameter (mm)	0.48	0.48	0.48	0.48	-	-
Outer layer thickness (µm)	50	50	50	50	-	-
Average particle size of flame retardant (µm: inner layer)	0.8	0.8	0.8	0.8	-	-
Oxygen index (%)	27	28	24	36	-	-
Monofilament tensile strength (cN/dtex)	4.3	4.0	4.8	1.6	-	-
Netting ability for forming mesh sheet	Good	Good	Good	B	-	-
Fusibility at crossing portions of warp and weft filaments	Good	Good	Good	-	-	-
Note: *7: Ruptured upon stretching and failed to obtain a monofilament with fineness of 2,060 dtex B: Ruptured upon netting						

Table 6

	Example	Comparative Example
	13	25
Composition of inner layer		
Polyamide 6 resin-1 (wt. part)	90	99.5
Triazine-based flame retardant A (wt. part)	10	0.5
Composition of outer layer		
LLDPE (wt. part)	100	100
Evaluation		
Multi-layer monofilament fineness (dtex)	1980	1980
Multi-layer monofilament diameter (mm)	0.48	0.48
Outer layer thickness (µm)	30	30
Average particle size of flame retardant (µm: inner layer)	0.8	0.8
Oxygen index (%)	26	21
Monofilament tensile strength (cN/dtex)	3.8	3.8
Netting ability for forming mesh sheet	Good	Good
Fusibility at crossing portions of warp and weft filaments	Good	Good

[0088] According to the present invention, it is possible to obtain a polyamide filament having not only excellent flame retardancy but also excellent strength. In particular, even though no halogen-based flame retardant is used therein, the polyamide filament can exhibit the same flame retarding effect. Also, the polyamide filament in the form of a multi-filament is usable as raw yarn for carpets, and can provide safe BCF or carpets having an excellent flame retardancy. In addition, the polyamide filament in the form of a monofilament is suitably used in various applications such as guard nets for wire harness, meshes, etc. Further, the polyamide filament in the form of a multi-layer filament is suitably used for production of mesh sheets, etc.

Claims

1. A flame retardant polyamide filament comprising a polyamide resin composition which has a tensile strength of not less than 2.0 cN/dtex as measured according to JIS L1013 and comprises 98 to 80 parts by weight of a polyamide resin having a relative viscosity of 2.0 to 4.0 and 2 to 20 parts by weight of a triazine-based flame retardant which is dispersed in the polyamide filament and has an average particle size of less than 5 µm.

2. A flame retardant polyamide filament according to claim 1, wherein the polyamide filament contains no halogen compound.

3. A flame retardant polyamide filament according to claim 1 or 2, wherein the triazine-based flame retardant is a reaction product produced by reacting cyanuric acid with melamines at an equimolar ratio.

4. A flame retardant polyamide filament according to any of claims 1 to 3, wherein an oxygen index (LOI) of the polyamide filament is not less than 27 as measured according to JIS K7201.

5. A flame retardant polyamide filament according to any of claims 1 to 4, wherein the polyamide filament is in the form of a multi-filament comprising a plurality of monofilaments.

6. A flame retardant polyamide filament according to claim 5, wherein the monofilament has a fineness of 4 to 90 dtex.

7. A flame retardant polyamide filament according to any of claims 1 to 4, wherein the polyamide filament is in the form of a monofilament having a fineness of 300 to 56,500 dtex.

8. A flame retardant polyamide filament according to any of claims 1 to 4, wherein the polyamide filament is in the form of a monofilament having a fineness of 400 to 11,000 dtex.

9. A flame retardant polyamide BCF (bulked continuous filament) produced by subjecting the flame retardant polyamide filament as defined in claim 5 which is a multi-filament, to a crimping process.

10. A carpet using the flame retardant polyamide BCF as defined in claim 9.

11. A guard net for wire harness produced by knitting the flame retardant polyamide filament as defined in claim 7 into a tubular shape around an electric cable.

12. A mesh sheet produced by knitting the flame retardant polyamide filament as defined in claim 8 into a net, said mesh sheet having a porosity representing a mesh size, of 20 to 30%, and a basis weight of 100 to 600 g/m^2.

13. A flame retardant multi-layer filament which has said multi-layer filament having a tensile strength of no less than 2.0 cN/dtex as measured according to JIS L1013 and comprises an inner layer constituted of a flame retardant polyamide resin layer A comprising a polyamide resin composition comprising 98 to 80 parts by weight of a polyamide resin having a relative viscosity of 2.0 to 4.0 and 2 to 20 parts by weight of a triazine-based flame retardant which has an average particle size of less than 5 µm and is dispersed in the filament; and

a surface layer formed on the inner layer and constituted of any one of the flame retardant polyamide resin layer A, a polyamide resin layer B having a composition other than that of the flame retardant polyamide resin layer A and a polyolefin resin layer C.

14. A flame retardant multi-layer filament according to claim 13, wherein an oxygen index (LOI) of the multi-filament is not less than 27 as measured according to JIS K7201.

15. A flame retardant multi-layer filament according to claim 13 or 14, wherein a melting point of the polyamide resin contained in the polyamide resin layer A constituting the inner layer is higher by 5°C or more, than a melting point of the resin used in the surface layer.

16. A mesh sheet produced by interlacing the multi-layer filaments as defined in claim 15 into a net, and heat-fusing crossing portions of the warp and weft filaments at the surface layer thereof.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/08144

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 D01F6/90, D01F1/07, D01F8/12, D02G3/02, E04G21/32, F16L57/00,

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^7 D01F6/90, D01F1/07, D01F8/12, D02G3/02, E04G21/32, F16L57/00, C08L77/00-77/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2001
Kokai Jitsuyo Shinan Koho	1971-2001	Jitsuyo Shinan Toroku Koho	1996-2001

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI/L

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4321188 A (Snia Viscosa Societa Nazionale Industria Applicazioni Viscosa s.p.a.),	1-8
Y	23 March, 1982 (23.03.82), Claims 1 to 16; page 2, column 2, line 62 to page 3, column 3, line 2; examples 1 to 4	9-12
A	& NL 8000025 A & DE 3000074 A & GB 2039925 A & FR 2445844 A & BR 8000048 A & JP 55-149323 A & GB 2039925 A & IT 1109902 B	13-16
X	JP 56-107012 A (Asahi Chemical Industry Co., Ltd.),	1-8
Y	25 August, 1981 (25.08.81), Claims; page 3, working examples; page 5, table 1	9-12
A	(Family: none)	13-16

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 18 December, 2001 (18.12.01)	Date of mailing of the international search report 15 January, 2002 (15.01.02)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/08144

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5604007 A (BASF Corporation), 18 December, 1997 (18.02.97), Claims & AU 3400993 A & DE 69324947 C & CA 2078626 A & EP 559128 A & SK 15393 A & CZ 9300309 A & JP 6-10213 A & US 5618605 A & US 5626938 A	9,10
Y	JP 57-190990 U (Shinagawa Shoko K.K.), 03 December, 1982 (03.12.82), Full text (Family: none)	11
Y	JP 1-105863 A (Kuroda Henshoku K.K.), 24 April, 1989 (24.08.89), Claims of Utility Model (Family: none)	12
A	JP 48-91314 A (Mitsubishi Rayon Co., Ltd.), 28 November, 1973 (28.11.73), Full text (Family: none)	13-16
E,X	JP 2000-303257 A (Unitika Ltd.), 31 October, 2000 (31.10.00), Claims; page 4, Par. No. [0027] to page 5, Par. No. [0039] (Family: none)	1-8

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