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RESIN COMPOSITION, OPTICAL FIBER, METHOD FOR PRODUCING OPTICAL FIBER, OPTICAL FIBER RIBBON, AND OPTICAL FIBER CABLE

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A resin composition for primary coating of the optical fiber according to the present disclosure is a resin composition containing a photopolymerizable compound, a photopolymerizable initiator, and a polymerization inhibitor, wherein the photopolymerizable compound contains a photopolymerizable compound having a urethane bond and a photopolymerizable compound not having a urethane bond, the polymerization inhibitor contains 4-methoxyphenol, and the total content of the polymerization inhibitor is 200 ppm or more and 800 ppm or less.

TITLE

RESIN COMPOSITION, OPTICAL FIBER, METHOD FOR PRODUCING OPTICAL FIBER, OPTICAL FIBER RIBBON, AND OPTICAL FIBER CABLE

5 TECHNICAL FIELD

[0001] The present disclosure relates to a resin composition for primary coating of an optical fiber, the optical fiber, a method for producing the optical fiber, an optical fiber ribbon, and an optical fiber cable.

10 The present application claims the priority based on Japanese application No. 2022-006855, filed on January 20, 2022, and the content described in the Japanese application is incorporated herein in its entirety.

BACKGROUND

15 [0002] Demand for high-density cables, in which the packing densities of optical fibers are enhanced, is increasing in uses for data centers in recent years. An optical fiber commonly comprises a coating resin layer for protecting a glass fiber that is an optical transmission medium. For example, the coating resin layer comprises two layers that are a primary resin layer in contact with the glass fiber and a secondary resin layer formed on the outer layer of the primary resin layer. When the packing density of an optical fiber increases, external force (lateral pressure) is applied to the optical fiber, and the microbending loss easily increases. It is known that the Young's modulus of the primary resin layer is reduced, and the Young's modulus of the secondary resin layer is increased for improving the microbending resistance of an optical fiber. For example, resin compositions for primary coating containing urethane (meth)acrylates that are reaction products of polyols, 20 diisocyanates, and hydroxyl group-containing (meth)acrylates are described in Patent Literatures 1 to 5.

[0003] [Patent Literature 1] JP 2009-197163 A

[Patent Literature 2] JP 2012-111674 A

[Patent Literature 3] JP 2013-136783 A

[Patent Literature 4] JP 2013-501125 A

5 [Patent Literature 5] JP 2014-114208 A

SUMMARY

[0004] A resin composition for primary coating of an optical fiber according to one aspect of the present disclosure is a resin composition containing a photopolymerizable compound, a photopolymerizable initiator, and a polymerization inhibitor, wherein the photopolymerizable compound contains a photopolymerizable compound having a urethane bond and a photopolymerizable compound not having a urethane bond, the polymerization inhibitor contains 4-methoxyphenol, and the total content of the polymerization inhibitor is 200 ppm or more and 800 ppm or less.

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BRIEF DESCRIPTION OF THE DRAWINGS

15 [0005] FIG. 1 is a schematic sectional view showing one example of an optical fiber according to the present embodiment;

FIG. 2 is a schematic sectional view showing an optical fiber ribbon according to one embodiment;

20 FIG. 3 is a schematic sectional view showing an optical fiber ribbon according to one embodiment;

FIG. 4 is a plan view showing the appearance of an optical fiber ribbon according to one embodiment;

FIG. 5 is a schematic sectional view showing an optical fiber cable according to one embodiment; and

25 FIG. 6 is a schematic sectional view showing an optical fiber cable according to one embodiment.

DETAILED DESCRIPTION

[0006] [Problem to be solved by the Present Disclosure]

An increase in the production speed of an optical fiber is required from the viewpoint of improving the productivity of the optical fiber. When the production speed of the optical fiber increases, the dose of ultraviolet rays irradiated at the time of forming a primary resin layer and a secondary resin layer decreases. Since the primary resin layer has a low crosslinking density, the primary resin layer becomes uncured easily due to a decrease in the dose of ultraviolet rays, and defects (voids) are caused in the primary resin layer, and easily leads to an increase in transmission loss especially at low temperature. Meanwhile, when the enhancement of the ultraviolet curability of the resin composition for primary coating is attempted, the thermal stability of the resin composition easily decreases.

[0007] An object of the present disclosure is to provide a resin composition that can form a resin layer that is excellent in stability and suitable for primary coating of an optical fiber and an optical fiber that is excellent in microbending resistance and the low temperature characteristic.

[0008] [Advantageous Effects of the Present Disclosure]

According to the present disclosure, a resin composition that can form a resin layer that is excellent in stability and suitable for primary coating of an optical fiber and an optical fiber that is excellent in microbending resistance and the low temperature characteristic can be provided.

[0009] [Description of Embodiments of the Present Disclosure]

The contents of the embodiment of the present disclosure will be first enumerated and described.

The resin composition for primary coating of the optical fiber according to one aspect of the present disclosure is a resin composition containing a

photopolymerizable compound, a photopolymerizable initiator, and a polymerization inhibitor, the photopolymerizable compound contains a photopolymerizable compound having a urethane bond and a photopolymerizable compound not having a urethane bond, the polymerization inhibitor contains 4-methoxyphenol, and the total content of the polymerization inhibitor is 200 ppm or more and 800 ppm or less.

[0010] Such a resin composition can form a resin layer that is excellent in stability and suitable for primary coating of the optical fiber, and can improve the microbending resistance and the low temperature characteristic of the optical fiber.

[0011] The polymerization inhibitor may further contain 2,6-di-tert-butyl-p-cresol from the viewpoint of further improving the low temperature characteristic.

[0012] It is preferable that the Young's modulus of a resin film obtained by ultraviolet-curing the resin composition according to the present embodiment under the conditions of an accumulated amount of light of 10 mJ/cm² and an illumination of 100 mW/cm² be 0.10 MPa or more and 0.80 MPa or less at 23°C, and the Young's modulus may be 0.10 MPa or more and 0.60 MPa or less at 23°C from the viewpoint of further improving the microbending resistance.

[0013] The total content of the polymerization inhibitor in the resin composition may be 700 ppm or less, or may be 600 ppm or less from the viewpoint of further improving the low temperature characteristic.

[0014] The total content of the polymerization inhibitor in the resin composition may be 300 ppm or more from the viewpoint of further improving the stability of the resin composition.

[0015] The content of 4-methoxyphenol may be 80 ppm or more and 750 ppm or less from the viewpoint of further improving the stability of the resin composition.

[0016] The photopolymerizable compound not having a urethane bond contains an N-vinyl compound to improve the curing rate of the resin composition, and the content

of the N-vinyl compound may be 1 part by mass or more and 15 parts by mass or less based on 100 parts by mass of the total amount of the resin composition.

[0017] The N-vinyl compound may be N-vinyl caprolactam from the viewpoint of further improving the curing rate.

5 [0018] The resin composition according to the present embodiment further contains ϵ -caprolactam, and the content of ϵ -caprolactam in the resin composition may be 2000 ppm or less from the viewpoint of improving the fatigue characteristic.

[0019] The optical fiber according to one aspect of the present disclosure comprises: a glass fiber including a core and a cladding; a primary resin layer coating
10 the glass fiber in contact with the glass fiber; and a secondary resin layer coating the primary resin layer, and the primary resin layer contains a cured material of the above-mentioned resin composition. Such an optical fiber is excellent in microbending resistance and the low temperature characteristic without causing the defects of the primary resin layer.

15 [0020] A method for producing the optical fiber according to one aspect of the present disclosure comprises: an application step of applying the above-mentioned resin composition to the periphery of the glass fiber including the core and the cladding, and a curing step of curing the resin composition by irradiation with ultraviolet rays after the application step. The optical fiber that is excellent in
20 microbending resistance and the low temperature characteristic can be produced thereby.

[0021] In an optical fiber ribbon according to one aspect of the present disclosure, a plurality of the above-mentioned optical fibers are arranged in parallel and coated with a resin for a ribbon. Such an optical fiber ribbon is excellent in microbending
25 resistance and the low temperature characteristic, and can be highly densely packed in an optical fiber cable.

[0022] With respect to an optical fiber cable according to one aspect of the present disclosure, the above-mentioned optical fiber ribbon is accommodated in the cable. The optical fiber cable according to the present disclosure may be an aspect in which a plurality of the above-mentioned optical fibers are accommodated in the cable.

5 The optical fiber cable comprising the optical fiber or the optical fiber ribbon according to the present embodiment is excellent in microbending resistance and the low temperature characteristic.

[0023] [Details of the Embodiments of the Present Disclosure]

Specific examples of the resin composition and the optical fiber according to the present embodiment will be described with reference to a drawing if needed.

10 The present disclosure is not limited to this exemplification, is shown by the claims, and is intended to include all modifications in meanings and a scope equivalent to the claims. In the following descriptions, the same components are indicated with the same reference numeral, and the same descriptions are omitted in the description

15 of the drawing. A (meth)acrylate used herein means an acrylate or a methacrylate corresponding thereto. Other similar expressions such as (meth)acryloyl are in the same way. ppm indicates a mass ratio herein.

[0024] (Resin composition)

The resin composition according to the present embodiment contains a

20 photopolymerizable compound, a photopolymerizable initiator, and a polymerization inhibitor, the photopolymerizable compound contains a photopolymerizable compound having a urethane bond and a photopolymerizable compound not having a urethane bond, the polymerization inhibitor contains 4-methoxyphenol, and the total content of the polymerization inhibitor is 200 ppm or more and 800 ppm or less.

25 [0025] The polymerization inhibitor may be used at the time of the production of the photopolymerizable compound for preventing the gelation, and may be added at the

time of the preparation of the resin composition to enhance the storage stability of the resin composition. Examples of the polymerization inhibitor include hydroquinone, 4-methoxyphenol, 2,6-di-tert-butyl-p-cresol, p-benzoquinone, phenothiazine, catechol, and tert-butylcatechol.

5 [0026] The polymerization inhibitor according to the present embodiment contains 4-methoxyphenol, and may contain 4-methoxyphenol and 2,6-di-tert-butyl-p-cresol from the viewpoint of adjusting the balance between the storage stability and the photocurability of the resin composition.

10 [0027] The total content of the polymerization inhibitor in the resin composition (total content of the polymerization inhibitor based on the total mass of the resin composition) is 200 ppm or more and 800 ppm or less. When the total content of the polymerization inhibitor is less than 200 ppm, the storage stability of the resin composition easily decreases, and when the total content of the polymerization inhibitor exceeds 800 ppm, the primary resin layer is easily poorly cured at the time of the high-speed production of the optical fiber. When the primary resin layer is

15 poorly cured, the low temperature characteristic of the optical fiber may decrease.

[0028] It is preferable that the total content of the polymerization inhibitor in the resin composition be 700 ppm or less, it is more preferable that the total content be 650 ppm or less, and it is still more preferable that the total content be 600 ppm or less from the viewpoint of further improving the low temperature characteristic of the

20 optical fiber. It is preferable that the total content of the polymerization inhibitor in the resin composition be 250 ppm or more, it is more preferable that the total content be 280 ppm or more, and it is further preferable that the total content be 300 ppm or more from the viewpoint of further improving the storage stability of the resin composition. The content of 4-methoxyphenol may be 80 ppm or more and 750

25 ppm or less, 90 ppm or more and 700 ppm or less, or 110 ppm or more and 600 ppm

or less based on the total mass of the resin composition from the viewpoint of further improving the stability of the resin composition.

[0029] It is preferable that the Young's modulus of a resin film obtained by ultraviolet-curing the resin composition under the conditions of an accumulated amount of light of 10 mJ/cm² and an illumination of 100 mW/cm² be 0.10 MPa or more and 0.80 MPa or less at 23°C. When the Young's modulus of the resin film is 0.10 MPa or more, the low temperature characteristic of the optical fiber is easily improved, and when the Young's modulus of the resin film is 0.80 MPa or less, the microbending resistance of the optical fiber is easily improved. It is more preferable that the Young's modulus of the resin film be 0.10 MPa or more and 0.60 MPa or less, and it is further preferable that the Young's modulus be 0.10 MPa or more and 0.50 MPa or less from the viewpoint of improving the lateral pressure resistance.

[0030] The photopolymerizable compound according to the present embodiment contains the photopolymerizable compound having a urethane bond and a photopolymerizable compound not having a urethane bond. As the photopolymerizable compound having a urethane bond, a urethane (meth)acrylate that is a reaction product of a diol, a diisocyanate, and a hydroxyl group-containing (meth)acrylate (hereinafter occasionally referred to as a "urethane (meth)acrylate (A)") can be used.

[0031] Examples of the diol include polyether diols, polyester diols, polycaprolactone diols, polycarbonate diols, polybutadiene diols, and bisphenol A-ethylene oxide adduct diol. Examples of the polyether diols include polytetramethylene glycol (PTMG), polyethylene glycol (PEG), polypropylene glycol (PPG), a block copolymer of PTMG-PPG-PTMG, a block copolymer of PEG-PPG-PEG, a random copolymer of PTMG-PEG, and a random copolymer of PTMG-PPG. Since the Young's modulus of the resin layer is easily adjusted, it is preferable to use

polypropylene glycol as the diol.

[0032] The number average molecular weight (Mn) of the diol may be 1800 or more and 20000 or less, 2000 or more and 19000 or less, or 2500 or more and 18500 or less from the viewpoint of obtaining a Young's modulus suitable for the primary resin layer.

[0033] Examples of the diisocyanate include 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, isophorone diisocyanate, dicyclohexylmethane diisocyanate, diphenylmethane diisocyanate, hexamethylene diisocyanate, xylylene diisocyanate, hydrogenated xylylene diisocyanate, 1,5-naphthalene diisocyanate, norbornene diisocyanate, 1,5-pentamethylene diisocyanate, tetramethylxylylene diisocyanate, and trimethylhexamethylene diisocyanate.

[0034] Examples of the hydroxyl group-containing (meth)acrylate include 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, caprolactone (meth)acrylate, 2-hydroxy-3-phenoxypropyl (meth)acrylate, 2-(meth)acryloyloxyethyl-2-hydroxyethyl phthalic acid, 2-hydroxy-O-phenylphenolpropyl (meth)acrylate, 2-hydroxy-3-methacrylpropyl acrylate, trimethylolpropane di(meth)acrylate, and pentaerythritol tri(meth)acrylate. From the viewpoint of the reactivity, 2-hydroxyethyl acrylate is preferable.

[0035] Examples of a method for preparing the urethane (meth)acrylate (A) include a method for reacting the diol and the diisocyanate to synthesize an isocyanate group (NCO)-terminated prepolymer and then reacting the hydroxyl group-containing (meth)acrylate therewith; a method for reacting the diisocyanate and the hydroxyl group-containing (meth)acrylate and then reacting the diol therewith; and a method for reacting the diol, the diisocyanate, and the hydroxyl group-containing (meth)acrylate at the same time. When the urethane (meth)acrylate is prepared, the hydroxyl group-containing (meth)acrylate may be used as a mixture with a

monohydric alcohol or an active hydrogen-containing silane compound as needed.

[0036] The rate of (meth)acryloyl groups, which are a photopolymerizable groups, can be reduced, and the Young's modulus of the primary resin layer can be reduced by introducing groups based on the monohydric alcohol into the urethane (meth)acrylate (A).

[0037] Examples of the monohydric alcohol include methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, 2-methyl-2-propanol, 1-pentanol, 2-pentanol, 3-pentanol, 2-methyl-1-butanol, 3-methyl-1-butanol, 2-methyl-2-butanol, and 3-methyl-2-butanol.

[0038] The rate of (meth)acryloyl groups, which are a photopolymerizable groups, can be reduced, the Young's modulus of the primary resin layer can be reduced, and the adhesion to the glass fiber can be improved by introducing groups based on the active hydrogen-containing silane compound into the urethane (meth)acrylate (A).

[0039] Examples of the active hydrogen-containing silane compound include N-2-(aminoethyl)-3-aminopropylmethyldimethoxysilane, N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyltriethoxysilane, 3-triethoxysilyl-N-(1,3-dimethyl-butylidene)propylamine, N-phenyl-3-aminopropyltrimethoxysilane, 3-mercaptopropylmethyldimethoxysilane, and 3-mercaptopropyltrimethoxysilane.

[0040] It is preferable that the molar ratio of NCO to OH (NCO/OH) at the time of reacting the diol and the diisocyanate be 1.1 or more and 4.0 or less, it is preferable that the molar ratio be 1.2 or more and 3.5 or less, and it is preferable that the molar ratio be 1.4 or more and 3.0 or less. It is preferable that the molar ratio of the hydroxyl group-containing (meth)acrylate to the NCO of the NCO-terminated prepolymer be 1.00 or more and 1.15 or less, and it is more preferable that the molar ratio be 1.03 or more and 1.10 or less. When the hydroxyl group-containing

(meth)acrylate is used as a mixture with the active hydrogen-containing silane compound or the monohydric alcohol, it is preferable that the molar ratio of the total of the hydroxyl group-containing (meth)acrylate, the active hydrogen-containing silane compound, and the monohydric alcohol to the NCO of the NCO-terminated prepolymer be 1.00 or more and 1.15 or more, it is more preferable that the molar ratio be 1.03 or more and 1.10 or less, and it is preferable that the molar ratio of the total of the active hydrogen-containing silane compound and the monohydric alcohol to the NCO of the NCO-terminated prepolymer be 0.01 or more and 0.5 or less.

[0041] The resin composition according to the present embodiment may further contain the urethane (meth)acrylate that is a reaction product of a polyoxyalkylene monoalkyl ether, the diisocyanate, and the hydroxyl group-containing (meth)acrylate (hereinafter occasionally referred to as a "urethane (meth)acrylate (B)") as the photopolymerizable compound having a urethane bond.

[0042] The polyoxyalkylene monoalkyl ether is a compound having oxyalkylene groups, alkoxy groups, and hydroxyl groups. Examples of the polyoxyalkylene monoalkyl ether according to the present embodiment include polyoxyethylene oleyl ether, polyoxyethylene lauryl ether, polyoxyethylene cetyl ether, polyoxyethylene stearyl ether, polyoxyethylene alkyl (C₁₂ to C₁₄) ether, polyoxyethylene tridecyl ether, polyoxyethylene myristyl ether, polyoxyethylene isostearyl ether, polyoxyethylene octyldodecyl ether, polyoxyethylene cholesteryl ether, polyoxypropylene butyl ether, polyoxypropylene myristyl ether, polyoxypropylene cetyl ether, polyoxypropylene stearyl ether, polyoxypropylene lanolin alcohol ether, polyoxyethylene polyoxypropylene butyl ether, polyoxyethylene polyoxypropylene lauryl ether, polyoxyethylene polyoxypropylene cetyl ether, polyoxyethylene polyoxypropylene stearyl ether, and polyoxyethylene polyoxypropylene decyl tetradecyl ether.

[0043] It is preferable that the polyoxyalkylene monoalkyl ether be

polyoxypropylene monobutyl ether from the viewpoint of the compatibility of the primary resin composition.

[0044] It is preferable that the Mn of the polyoxyalkylene monoalkyl ether be 2000 or more and 10000 or less, and the Mn may be 2100 or more or 2200 or more, and 8000 or less or 7000 or less from the viewpoint of obtaining a Young's modulus suitable for the primary resin layer.

[0045] The Mn of the diol and the Mn of the polyoxyalkylene monoalkyl ether can be calculated from following expression (1) by measuring the hydroxyl values based on JIS K 0070. The functional group number of the diol is 2, and the functional group number of the polyoxyalkylene monoalkyl ether is 1.

$$Mn = 56.1 \times \text{functional group number} \times 1000 / \text{hydroxyl value (1)}$$

[0046] The Mn of the urethane (meth)acrylate (A) may be 6000 or more and 50000 or less, 8000 or more and 45000 or less, or 10000 or more and 40000 or less from the viewpoint of obtaining a Young's modulus suitable for the primary resin layer.

The Mn of the urethane (meth)acrylate (B) is 4000 or more and 20000 or less, 5000 or more and 18000 or less, or 6000 or more and 15000 or less. The Mn of urethane (meth)acrylate (A) and the Mn of the urethane (meth)acrylate (B) can be measured by gel permeation chromatography (GPC).

[0047] It is preferable that the content of the urethane (meth)acrylate (A) be 15 parts by mass or more and 80 parts by mass or less, it is more preferable that the content be 20 parts by mass or more and 75 parts by mass or less, and it is further preferable that the content be 25 parts by mass or more and 70 parts by mass or less based on 100 parts by mass of the total amount of the resin composition from the viewpoint of adjusting the Young's modulus of the primary resin layer.

[0048] The content of the urethane (meth)acrylate (B) may be 0 parts by mass or more and 70 parts by mass or less, 10 parts by mass or more and 50 parts by mass

or less, or 20 parts by mass or more and 45 parts by mass or less based on 100 parts by mass of the total amount of the resin composition.

[0049] The content of the photopolymerizable compound having a urethane bond may be 30 parts by mass or more and 90 parts by mass or less, 40 parts by mass or more and 80 parts by mass or less, or 45 parts by mass or more and 70 parts by mass or less based on the total amount of the resin composition.

[0050] As a catalyst when the photopolymerizable compound having a urethane bond is synthesized, an organotin compound or an amine compound is used. Examples of the organotin compound include dibutyltin dilaurate, dibutyltin diacetate, dibutyltin maleate, dibutyltin bis(2-ethylhexyl mercaptoacetate), dibutyltin bis(isooctyl mercaptoacetate), and dibutyltin oxide. It is preferable that the added amount of the catalyst be 100 ppm or more and 1000 ppm or less, and it is preferable that the added amount be 200 ppm or more and 800 ppm or less based on the total mass of the photopolymerizable compound having a urethane bond to be synthesized. It is preferable to use dibutyltin dilaurate or dibutyltin diacetate from the viewpoints of availability or catalyst performance as the catalyst.

[0051] It is preferable to use 4-methoxyphenol or 2,6-di-tert-butyl-p-cresol with respect to the polymerization inhibition performance as the polymerization inhibitor when the photopolymerizable compound having a urethane bond is synthesized. It is preferable that the added amount of the polymerization inhibitor be 150 ppm or more and 2000 ppm or less, it is more preferable that the added amount be 180 ppm or more and 1500 ppm or less, and it is further preferable that the added amount be 200 ppm or more and 1200 ppm or less based on the total mass of the photopolymerizable compound having a urethane bond to be synthesized.

[0052] The photopolymerizable compound according to the present embodiment contains a photopolymerizable compound not having a urethane bond (hereinafter

referred to as a "monomer"). Examples of the monomer include (meth)acrylic acid esters, N-vinyl compounds, and (meth)acrylamide compounds. The monomer may be a monofunctional monomer having one photopolymerizable ethylenic unsaturated group or a polyfunctional monomer having two or more ethylenic unsaturated groups.

[0053] Examples of the monofunctional (meth)acrylic acid ester include methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, n-butyl (meth)acrylate, s-butyl (meth)acrylate, t-butyl (meth)acrylate, isobutyl (meth)acrylate, n-pentyl (meth)acrylate, isopentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, isoamyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, n-octyl (meth)acrylate, isooctyl (meth)acrylate, isodecyl (meth)acrylate, lauryl (meth)acrylate, phenoxyethyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, benzyl (meth)acrylate, cyclic trimethylolpropane formal acrylate, dicyclopentenyl (meth)acrylate, dicyclopentenylloxyethyl (meth)acrylate, dicyclopentanyl (meth)acrylate, nonylphenol polyethylene glycol (meth)acrylate, nonylphenoxy polyethylene glycol (meth)acrylate, isobornyl (meth)acrylate, 3-phenoxybenzyl (meth)acrylate, methylphenoxyethyl (meth)acrylate, phenoxy diethylene glycol (meth)acrylate, phenoxy polyethylene glycol (meth)acrylate, m-phenoxybenzyl (meth)acrylate, 2-(2-ethoxyethoxy)ethyl (meth)acrylate, 2-hydroxy-3-phenoxypropyl acrylate, carboxyethyl (meth)acrylate, carboxypentyl (meth)acrylate, and ω -carboxypolycaprolactone (meth)acrylate.

[0054] Examples of the polyfunctional (meth)acrylic acid ester include difunctional monomers such as ethylene glycol di(meth)acrylate, polyethylene glycol di(meth)acrylate, polypropylene glycol di(meth)acrylate, neopentyl glycol di(meth)acrylate, tripropylene glycol di(meth)acrylate, triethylene glycol di(meth)acrylate, cyclohexanedimethanol di(meth)acrylate, dipropylene glycol di(meth)acrylate, tetraethylene glycol di(meth)acrylate, hydroxypivalate neopentyl

glycol di(meth)acrylate, 1,3-butylene glycol di(meth)acrylate, 1,4-butanediol di(meth)acrylate, diethylene glycol di(meth)acrylate, 1,6-hexanediol di(meth)acrylate, 1,9-nonanediol di(meth)acrylate, 1,12-dodecanediol di(meth)acrylate, 1,14-tetradecanediol di(meth)acrylate, 1,16-haxadecanediol di(meth)acrylate, 1,20-eicosanediol di(meth)acrylate, isopentyldiol di(meth)acrylate, 3-ethyl-1,8-octanediol di(meth)acrylate, tricyclodecanol di(meth)acrylate, 9,9-bis[4-(2-hydroxyethoxy)phenyl]fluorene di(meth)acrylate, bisphenol A epoxy di(meth)acrylate, bisphenol F epoxy di(meth)acrylate, an EO adduct of bisphenol A di(meth)acrylate, an EO adduct of bisphenol F di(meth)acrylate, a PO adduct of bisphenol A di(meth)acrylate, and a PO adduct of bisphenol F di(meth)acrylate; and tri- or more functional monomers such as trimethylolpropane tri(meth)acrylate, trimethyloloctane tri(meth)acrylate, trimethylolpropane polyethoxy tri(meth)acrylate, trimethylolpropane polypropoxy tri(meth)acrylate, trimethylolpropane polyethoxy polypropoxy tri(meth)acrylate, tris[(meth)acryloyloxyethyl] isocyanurate, pentaerythritol tri(meth)acrylate, pentaerythritol polyethoxy tetra(meth)acrylate, pentaerythritol polypropoxy tetra(meth)acrylate, pentaerythritol tetra(meth)acrylate, ditrimethylolpropane tetra(meth)acrylate, dipentaerythritol tetra(meth)acrylate, dipentaerythritol penta(meth)acrylate, dipentaerythritol hexa(meth)acrylate, and caprolactone-modified tris[(meth)acryloyloxyethyl] isocyanurate.

[0055] Examples of the (meth)acrylamide compound include dimethyl (meth)acrylamide, diethyl (meth)acrylamide, (meth)acryloyl morpholine, hydroxymethyl (meth)acrylamide, hydroxyethyl (meth)acrylamide, isopropyl (meth)acrylamide, dimethylaminopropyl (meth)acrylamide, dimethylaminopropyl acrylamide methyl chloride salt, diacetone acrylamide, (meth)acryloyl piperidine, (meth)acryloyl pyrrolidine, (meth)acrylamide, N-hexyl (meth)acrylamide, N-methyl (meth)acrylamide, N-butyl (meth)acrylamide, N-methylol (meth)acrylamide, and N-

methylolpropane (meth)acrylamide.

[0056] As a polymerization inhibitor, 4-methoxyphenol is commonly contained in a (meth)acrylic acid ester and a (meth)acrylamide compound. The amount of 4-methoxyphenol contained in each of a (meth)acrylic acid ester and a (meth)acrylamide compound may be 80 ppm or more and 1600 ppm or less, 90 ppm or more and 1400 ppm or less, or 100 ppm or more and 1000 ppm or less.

[0057] Examples of the N-vinyl compounds include N-vinylpyrrolidone, an N-vinyl caprolactam, N-vinyl methyl oxazolidinone, N-vinylimidazole, and N-vinyl-N-methylacetamide.

[0058] It is preferable that the content of the monomer be 5 parts by mass or more and 70 parts by mass or less, it is more preferable that the content be 10 parts by mass or more and 60 parts by mass or less, and it is further preferable that the content be 15 parts by mass or more and 50 parts by mass or less based on 100 parts by mass of the total amount of the resin composition.

[0059] When the photopolymerizable compound contains the N-vinyl compound, the curing rate of the resin composition can be improved. As the N-vinyl compound, especially N-vinyl caprolactam is preferable. N-vinyl caprolactam may contain ϵ -caprolactam as impurities. For example, the amount of the ϵ -caprolactam contained in N-vinyl caprolactam is around 5000 ppm to 25000 ppm. It is preferable that the content of ϵ -caprolactam contained in the resin composition be 2000 ppm or less, the content may be 1800 ppm or less, 1600 ppm or less, or 1400 ppm or less from the viewpoint of improving the fatigue characteristic of the optical fiber. It is believed that this is because ϵ -caprolactam is basic.

[0060] The content of the N-vinyl compound may be 1 part by mass or more and 15 parts by mass or less, 2 parts by mass or more and 14 parts by mass or less, or 3 parts by mass or more and 13 parts by mass or less based on 100 parts by mass

of the total amount of the resin composition.

[0061] The photopolymerization initiator can be suitably selected from well-known radical photopolymerization initiators and used. Examples of the photopolymerization initiator include 1-hydroxycyclohexyl phenyl ketone (Omnirad 184, produced by IGM Resins B.V.), 2,2-dimethoxy-2-phenyl acetophenone (Omnirad 651, produced by IGM Resins B.V.), 2,4,6-trimethylbenzoyl diphenylphosphine oxide (Omnirad TPO, produced by IGM Resins B.V.), ethyl(2,4,6-trimethylbenzoyl)-phenyl phosphinate (Omnirad TPO-L, produced by IGM Resins B.V.), 2-benzyl-2-dimethylamino-4'-morpholinobutyrophenone (Omnirad 369, produced by IGM Resins B.V.), 2-dimethylamino-2-(4-methylbenzyl)-1-(4-morpholin-4-yl-phenyl)-butan-1-one (Omnirad 379, produced by IGM Resins B.V.), bis(2,4,6-trimethylbenzoyl)phenylphosphine oxide (Omnirad 819, produced by IGM Resins B.V.), and 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one (Omnirad 907, produced by IGM Resins B.V.).

[0062] The photopolymerization initiator may be used as a mixture of two or more. It is preferable due to excellent rapid curability of the resin composition that the photopolymerization initiator contain 2,4,6-trimethylbenzoyldiphenylphosphine oxide.

[0063] It is preferable that the content of the photopolymerization initiator be 0.1 parts by mass or more and 5 parts by mass or less, it is more preferable that the content be 0.3 parts by mass or more and 4 parts by mass or less, and it is further preferable that the content be 0.4 parts by mass or more and 3 parts by mass or less based on the total amount of the resin composition.

[0064] The resin composition according to the present embodiment may further contain a sensitizer, a photoacid generator, a silane coupling agent, a leveling agent, an anti-foaming agent, an antioxidant, ultraviolet absorber, and the like.

[0065] Examples of the sensitizer include anthracene compounds such as 9,10-

dibutoxyanthracene, 9,10-diethoxyanthracene, 9,10-dipropoxyanthracene, and 9,10-bis(2-ethylhexyloxy)anthracene; thioxanthone compounds such as 2,4-diethylthioxanthone, 2,4-diethylthioxanthen-9-one, 2-isopropylthioxanthone, and 4-isopropylthioxanthone; amine compounds such as triethanolamine, methyl diethanolamine, and triisopropanolamine; benzoin compounds; anthraquinone compounds; ketal compounds; and benzophenone compounds.

[0066] An onium salt having a structure of A^+B^- may be used as the photoacid generator. Examples of the photoacid generator include sulfonium salts such as CPI-100P, 101A, 110P, 200K, 210S, 310B, and 410S (produced by San-Apro Ltd.) and Omnicat 270 and 290 (produced by IGM Resins B.V.); and iodonium salts such as CPI-IK-1 (produced by San-Apro Ltd.), Omnicat 250 (produced by IGM Resins B.V.), WPI-113, 116, 124, 169, and 170 (produced by FUJIFILM Wako Pure Chemical Corporation).

[0067] Examples of the silane coupling agents include tetramethyl silicate, tetraethyl silicate, mercaptopropyltrimethoxysilane, vinyl trichlorosilane, vinyltriethoxysilane, vinyl tris(β -methoxy-ethoxy)silane, β -(3,4-epoxycyclohexyl)-ethyltrimethoxysilane, dimethoxydimethylsilane, diethoxydimethylsilane, 3-(meth)acryloxypropyltrimethoxysilane, γ -glycidoxypropyltrimethoxysilane, γ -glycidoxypropylmethyldiethoxysilane, γ -methacryloxypropyltrimethoxysilane, N-(β -aminoethyl)- γ -aminopropyltrimethoxysilane, N-(β -aminoethyl)- γ -aminopropyltrimethyldimethoxysilane, N-phenyl- γ -aminopropyltrimethoxysilane, γ -chloropropyltrimethoxysilane, γ -mercaptopropyltrimethoxysilane, γ -aminopropyltrimethoxysilane, bis-[3-(triethoxysilyl)propyl]tetrasulfide, bis-[3-(triethoxysilyl)propyl]disulfide, γ -trimethoxysilylpropyldimethylthiocarbonyl tetrasulfide, and γ -trimethoxysilylpropylbenzothiazyl tetrasulfide.

[0068] It is preferable that the viscosity at 25°C of the resin composition according

to the present embodiment be 0.5 Pa·s or more and 20 Pa·s or less, it is more preferable that the viscosity be 0.8 Pa·s or more and 18 Pa·s or less, and it is further preferable that the viscosity be 1 Pa·s or more and 15 Pa·s or less from the viewpoint of the coatability. The viscosity at 25°C of the resin composition can be measured under the conditions of a cone plate of CP25-2 and a shear rate of 10 s⁻¹ using a rheometer ("MCR-102" manufactured by Anton Paar GmbH).

[0069] (Optical fiber)

Fig. 1 is a schematic sectional view showing one example of the optical fiber according to the present embodiment. An optical fiber 10 comprises a glass fiber 13 including a core 11 and a cladding 12 and a coating resin layer 16 including a primary resin layer 14 and a secondary resin layer 15 provided on the periphery of the glass fiber 13.

[0070] The cladding 12 surrounds the core 11. The core 11 and the cladding 12 mainly contain glass such as silica glass, and for example, germanium-added silica glass or pure silica glass can be used for the core 11, and pure silica glass or fluorine-added silica glass can be used for the cladding 12.

[0071] In Fig. 1, for example, the outer diameter of the glass fiber 13 (D2) is around 100 μm to 125 μm, and the diameter of the core 11 (D1), constituting the glass fiber 13, is around 7 μm to 15 μm. The thickness of the coating resin layer 16 is usually around 22 μm to 70 μm. The thickness of each layer of the primary resin layer 14 and the secondary resin layer 15 may be around 5 μm to 50 μm.

[0072] When the outer diameter of the glass fiber 13 is around 125 μm, and the thickness of the coating resin layer 16 is 60 μm or more and 70 μm or less, the thickness of each layer of the primary resin layer 14 and the secondary resin layer 15 may be around 10 μm to 50 μm, and, for example, the thickness of the primary resin layer 14 may be 35 μm, and the thickness of secondary resin layer 15 may be

25 μm . The outer diameter of the optical fiber 10 may be around 245 μm to 265 μm .

[0073] When the outer diameter of the glass fiber 13 is around 125 μm , and the thickness of the coating resin layer 16 is 20 μm or more and 48 μm or less, the thickness of each layer of the primary resin layer 14 and the secondary resin layer 15 may be around 8 μm to 38 μm , and, for example, the thickness of the primary resin layer 14 may be 25 μm , and the thickness of the secondary resin layer 15 may be 10 μm . The outer diameter of the optical fiber 10 may be around 165 μm to 221 μm .

[0074] When the outer diameter of the glass fiber 13 is around 100 μm , and the thickness of the coating resin layer 16 is 22 μm or more and 37 μm or less, the thickness of each layer of the primary resin layer 14 and the secondary resin layer 15 may be around 5 μm to 32 μm , and, for example, the thickness of the primary resin layer 14 may be 25 μm , and the thickness of the secondary resin layer 15 may be 10 μm . The outer diameter of the optical fiber 10 may be around 144 μm to 174 μm .

[0075] The optical fiber that is excellent in microbending resistance and the low temperature characteristic can be produced by applying the resin composition according to the present embodiment to the primary resin layer.

[0076] The method for producing the optical fiber according to the present embodiment comprises: an application step of applying the above-mentioned resin composition to the periphery of the glass fiber including the core and the cladding; and a curing step of curing the resin composition by irradiation with ultraviolet rays after the application step.

[0077] It is preferable that the Young's modulus of the primary resin layer be 0.80 MPa or less, it is more preferable that the Young's modulus be 0.70 MPa or less, it is further preferable that the Young's modulus be 0.60 MPa or less, it is still more

preferable that the Young's modulus be 0.50 MPa or less at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ from the viewpoint of improving the microbending resistance of the optical fiber. When the Young's modulus of the primary resin layer exceeds 0.80 MPa, external force is easily transmitted to the glass fiber, and the transmission loss increase due to microbending may increase. The Young's modulus of the primary resin layer may be 0.10 MPa or more, 0.15 MPa or more, or 0.20 MPa or more at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ from the viewpoint of improving the low temperature characteristic of the optical fiber.

[0078] The Young's modulus of the primary resin layer can be measured by the pullout modulus (POM) method at 23°C . Two places of the optical fiber are fixed with two chucking devices, the coating resin layer (the primary resin layer and the secondary resin layer) part between the two chucking devices is removed, one chucking device is subsequently fixed, and the other chucking device is slowly moved to the opposite direction to the fixed chucking device. When the length of the part held in the chucking device to be moved is defined as L, the movement of the chucking device is defined as Z, the outer diameter of the primary resin layer is defined as D_p , the outer diameter of the glass fiber is defined as D_f , the Poisson's ratio of the primary resin layer is defined as n, and the load at the time of moving the chucking device in the optical fiber is defined as W, the Young's modulus of the primary resin layer can be calculated from the following expression.

$$\text{Young's modulus (MPa)} = ((1+n)W/\pi LZ) \times \ln(D_p/D_f)$$

[0079] The secondary resin layer 15 can be formed, for example, by curing a resin composition containing a photopolymerizable compound containing the urethane (meth)acrylate, the photopolymerization initiator, and the like. The resin composition for forming the secondary resin layer has a composition different from that of the resin composition for primary coating. The resin composition for the secondary coating can be prepared using a conventionally well-known technique.

[0080] It is preferable that the Young's modulus of the secondary resin layer at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ be 800 MPa or more, it is more preferable that the Young's modulus be 1000 MPa or more, and it is further preferable that the Young's modulus be 1200 MPa or more from the viewpoint of improving the microbending resistance of the optical fiber.

5 Although the upper limit of the Young's modulus of the secondary resin layer is not particularly limited, the upper limit may be 3000 MPa or less, 2500 MPa or less, or 2000 MPa or less at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ from the viewpoint of imparting moderate toughness to the secondary resin layer.

[0081] The Young's modulus of the secondary resin layer can be measured by the
10 following method. First, the optical fiber is immersed in a mixed solvent of acetone and ethanol, and only the coating resin layer is extracted in a cylindrical shape. Although the primary resin layer and the secondary resin layer are united at this time, the Young's modulus of the primary resin layer is 1/1000 or more and 1/10000 or less of the Young's modulus of the secondary resin layer, the Young's modulus of the
15 primary resin layer is therefore negligible. Next, the solvent is removed from the coating resin layer by vacuum drying, a tensile test (the tensile speed is 1 mm/minute) can be performed at 23°C , and the Young's modulus can be calculated by a secant expression at 2.5% strain.

[0082] The method for producing the optical fiber according to the present
20 embodiment can produce an optical fiber that is excellent in microbending resistance and the low temperature characteristic using the resin composition according to the present embodiment as the resin composition for primary coating.

[0083] (Optical fiber ribbon)

25 An optical fiber ribbon can be produced using the optical fibers according to the present embodiment. In the optical fiber ribbon, a plurality of the above-mentioned optical fibers are arranged in parallel and coated with a resin for a ribbon.

[0084] FIG. 2 is a schematic sectional view showing the optical fiber ribbon according to one embodiment. An optical fiber ribbon 100 has a plurality of optical fibers 10 and a connective resin layer 40 through which the optical fibers 10 are (integrally) coated and connected with the resin for a ribbon. Although, in FIG. 2, four optical fibers 10 are shown as an example, the number thereof is not particularly limited.

[0085] The optical fibers 10 may be arranged in parallel in contact with each other and integrated, or some or all of the optical fibers 10 may be arranged in parallel at regular intervals and integrated. The distance between the centers of adjacent optical fibers 10 F may be 220 μm or more and 280 μm or less. When the distance between the centers is adjusted to 220 μm or more and 280 μm or less, the optical fibers are easily placed on the existing V-shaped grooves, and the optical fiber ribbon that is excellent in simultaneous fusibility can be obtained. Although the thickness of the optical fiber ribbon 100 T also depends on the outer diameter of the optical fibers 10, the thickness may be 164 μm or more and 285 μm or less.

[0086] FIG. 3 is a schematic sectional view showing one example of an optical fiber ribbon in which the optical fibers are arranged in parallel at regular intervals and integrated. In an optical fiber ribbon 100A shown in FIG. 3, pairs of optical fibers 10 are connected at regular intervals with a resin for a ribbon, thereby connecting a total of twelve optical fibers 10. The resin for a ribbon forms a connective resin layer 40.

[0087] When, as the resin for a ribbon, a resin material generally known as a ribbon material can be used. The resin for a ribbon may contain a thermosetting resin such as silicone resin, an epoxy resin, or a urethane resin or an ultraviolet-curable resin such as an epoxy acrylate, a urethane acrylate, or a polyester acrylate from the viewpoints of the damage preventing property and the ease of division of the optical fiber 10 and the like.

[0088] When the optical fibers 10 are arranged in parallel at regular intervals, namely when adjacent optical fibers 10 are united through the resin for a ribbon out of contact with each other, the thickness of the connected part at the center between the optical fibers 10 may be 150 μm or more and 220 μm or less. When the optical fiber ribbon is accommodated in a cable, the optical fiber ribbon is easily deformed, and the optical fiber ribbon may therefore have recesses in connected parts of the optical fibers. The recesses may be formed in a triangle shape having a narrow width on one surface of the connected parts.

[0089] The optical fiber ribbon according to the present embodiment may have connected parts and unconnected parts intermittently in the longitudinal direction and the width direction. FIG. 4 is a plan view showing the appearance of the optical fiber ribbon according to one embodiment. An optical fiber ribbon 100B has a plurality of optical fibers, a plurality of connected parts 20, and a plurality of unconnected parts (divided parts) 21. The unconnected parts 21 are intermittently formed in the longitudinal direction of the optical fiber ribbon. The optical fiber ribbon 100B is an intermittent connection type optical fiber ribbon, intermittently provided with the connected parts 20 and the unconnected parts 21 in the longitudinal direction between each of the pairs of optical fibers 10A. The "connected parts" refer to parts in which adjacent optical fibers are integrated through the connective resin layer, and the "unconnected parts" refer to parts in which adjacent optical fibers are not integrated through the connective resin layer, and gaps are between the optical fibers.

[0090] Since the connected parts 20 provided between each of the pairs of cores are intermittently provided with the unconnected parts 21 in the optical fiber ribbon having the above-mentioned configuration, the optical fiber ribbon is easily deformed. When the optical fiber ribbon is installed in an optical fiber cable, the optical fiber

ribbon can therefore be easily rounded and installed, the optical fiber ribbon can therefore be formed into an optical fiber ribbon suitable to be installed at high density. Since the connected parts 20 can be easily torn from the unconnected parts 21, the optical fibers 10 in the optical fiber ribbon are easily separated into single cores.

5 [0091] The optical fiber ribbon according to the present embodiment is excellent in microbending resistance and the low temperature characteristic, and can be packed in the optical fiber cable at high density using the above-mentioned optical fibers.

[0092] (Optical fiber cable)

10 With respect to an optical fiber cable according to the present embodiment, the above-mentioned optical fiber ribbons are accommodated in the cable. Examples of the optical fiber cable include a slot type optical fiber cable having a plurality of slots. The above-mentioned optical fiber ribbons can be installed in the slots so that the installation density in each slot is around 25% to 65%. The installation density means the ratio of the cross section of the optical fiber ribbons
15 installed in a slot to the cross section of the slot. The optical fiber cable according to the present embodiment may be an aspect in which the above-mentioned plurality of optical fibers are accommodated in a cable without being coated with the resin for a ribbon.

[0093] Examples of the optical fiber cable according to the present embodiment will
20 be described with reference to FIGS. 5 and 6. Although, in FIGS. 5 and 6, the intermittent connection type optical fiber ribbons are accommodated, the plurality of optical fibers not coated with the resin for a ribbon may be bundled and accommodated.

[0094] FIG. 5 is a schematic sectional view of a slotless type optical fiber cable 60
25 using the intermittent connection type optical fiber ribbons 100B, described above. The optical fiber cable 60 has a cylindrical tube 61 and a plurality of optical fiber

ribbons 100B. The plurality of optical fiber ribbons 100B may be bundled with an interposition 62 such as aramid fiber. The plurality of optical fiber ribbons 100B may have different markings, respectively. The optical fiber cables 60 is a structure formed by twisting the bundled plurality of optical fiber ribbons 100B, extruding a resin to be the tube 61 therearound, and coating the tube 61 together with tension members 63 with a jacket 64. When waterproofness is required, water-absorbing yarn may be inserted into the tube 61. For example, the tube 61 can be formed using a resin such as polybutylene terephthalate or high-density polyethylene. Tear cords 65 may be provided outside the tube 61.

[0095] FIG. 6 is a schematic sectional view of a slot type optical fiber cable 70 using the intermittent connection type optical fiber ribbons 100B, described above. The optical fiber cable 70 has a slot rod 72 having a plurality of slots 71 and a plurality of optical fiber ribbon 100B. The optical fiber cable 70 is a structure in which the slot rod 72 having a tension member 73 at the center is radially provided with the plurality of slots 71. The plurality of slots 71 may be provided in a shape twisted in a spiral form or an SZ form in a longitudinal direction of the optical fiber cable 70. A plurality of concentrated optical fiber ribbons 100B, into which the optical fiber ribbons 100B arranged in parallel are separated, are accommodated in the slots 71. The optical fiber ribbons 100B may be bundled with bundle materials for identification. A press-winding tape 74 is wound around the slot rod 72, and a jacket 75 is formed around the press-winding tape 74.

[0096] The optical fiber cables comprising the optical fibers or the optical fiber ribbons according to the present embodiment are excellent in microbending resistance and the low temperature characteristic. EXAMPLES

[0097] Hereinafter, the results of evaluation tests using Examples and Comparative Examples according to the present disclosure will be shown, and the present

disclosure will be described in further detail. The present disclosure is not limited to these Examples.

[0098] [Synthesis of urethane acrylate (A)]

(A-1)

5 Polypropylene glycol having an Mn of 3000 (trade name "SANNIX PP-3000" produced by Sanyo Chemical Industries, Ltd.) and 2,4-tolylene diisocyanate (TDI) were fed into a reaction kettle so that the molar ratio of NCO and OH (NCO/OH) was 1.5. Subsequently, 200 ppm dibutyltin dilaurate was added based on the final total fed amount as a catalyst, and 1000 ppm 2,6-di-tert-butyl-p-cresol (BHT) was added
10 based on the final total fed amount as a polymerization inhibitor. Then, the mixture was reacted at 60°C for 1 hour to prepare an NCO-terminated prepolymer. Next, 2-hydroxyethyl acrylate (HEA) was added so that the molar ratio of the OH of the HEA to the NCO of the NCO-terminated prepolymer was 1.05, and the mixture was reacted at 60°C for 1 hour to obtain a urethane acrylate having an Mn of 11100 (A-
15 1). The content of 4-methoxyphenol (MEHQ) that was a polymerization inhibitor derived from HEA in the urethane acrylate (A-1) was 18 ppm.

[0099] (A-2)

A urethane acrylate having an Mn of 11100 (A-2) was obtained in the same way as in the production of (A-1) except that the added amount of BHT was changed
20 to 500 ppm.

[0100] (A-3)

A urethane acrylate having an Mn of 11700 (A-3) was obtained in the same way as in the production of (A-1) except that the added amount of BHT was changed to 200 ppm.

25 [0101] (A-4)

A urethane acrylate having an Mn of 11200 (A-4) was obtained in the same

way as in the production of (A-1) except that the polymerization inhibitor was changed from BHT to MEHQ, the MEHQ was added so that the MEHQ and MEHQ derived from HEA totaled 1000 ppm based on the final total fed amount.

[0102] (A-5)

5 A urethane acrylate having an Mn of 11600 (A-5) was obtained in the same way as in the production of (A-1) except that the polymerization inhibitor was changed from BHT to MEHQ, the MEHQ was added so that the MEHQ and MEHQ derived from HEA totaled 500 ppm based on the final total fed amount.

[0103] (A-6)

10 Polypropylene glycol having an Mn of 18000 (trade name "PREMINOL S 4318F" produced by AGC Inc.) and TDI were fed into a reaction kettle so that the NCO/OH was 2.0. Subsequently, 200 ppm dibutyltin dilaurate was added based on the final total fed amount as a catalyst, and 500 ppm BHT was added based on the final total fed amount as a polymerization inhibitor. Then, the mixture was reacted
15 at 60°C for 1 hour to prepare an NCO-terminated prepolymer. Next, HEA was added so that the molar ratio of the OH of the HEA to the NCO of the NCO-terminated prepolymer was 1.05, and the mixture was reacted at 60°C for 1 hour to obtain a urethane acrylate having an Mn of 37100 (A-6). The content of MEHQ that was a polymerization inhibitor derived from HEA in the urethane acrylate (A-6) was 6 ppm.

20 [0104] [Synthesis of urethane acrylate (B)]

(B-1)

 Polyoxypropylene monobutyl ether having an Mn of 5000 (trade name "ACROBUTE MB-90" produced by NOF CORPORATION) and TDI were reacted at an NCO/OH of 2.0 at 60°C for 1 hour to prepare an NCO-terminated prepolymer.
25 Then, 200 ppm dibutyltin dilaurate was added based on the final total fed amount as a catalyst, and 500 ppm BHT was added based on the final total fed amount as a

polymerization inhibitor. Then, the mixture was reacted at 60°C for 1 hour to prepare an NCO-terminated prepolymer. Then, HEA was added so that the molar ratio of the OH of HEA to the NCO of the NCO-terminated prepolymer was 1.05, and the mixture was reacted at 60°C for one hour to obtain a urethane acrylate (B-1) having an Mn of 6400. The content of MEHQ derived from HEA in the urethane acrylate (B-1) was 18 ppm.

[0105] The Mn of the urethane acrylates (A) and the urethane acrylate (B) and the contents of the polymerization inhibitors are shown in Table 1.

[0106] [Table 1]

	A-1	A-2	A-3	A-4	A-5	A-6	B-1
Mn	11100	11100	11700	11200	11600	37100	6400
MEHQ [ppm]	18	18	18	1000	500	6	18
BHT [ppm]	1000	500	200	0	0	500	500

[0107] The Mn of polypropylene glycol and the polyoxypropylene monobutyl ether are values calculated from the hydroxyl values, and are values described in the catalogues of the products. The Mn of the urethane acrylate was measured using an ACQUITY APC RI system manufactured by Nihon Waters K.K. under the conditions of sample concentration: 0.2 % by mass THF solution, injection rate: 20 μ L, sample temperature: 15°C, mobile phase: THF, XT columns for organic solvent: particle size 2.5 μ m, pore size 450 Å, column inner diameter 4.6 $\times$ column length 150 mm + particle size 2.5 μ m, pore size 125 Å, column inner diameter 4.6 $\times$ column length 150 mm + particle size 1.7 μ m, pore size 45 Å, column inner diameter 4.6 $\times$ column length 150 mm, column temperature: 40°C, and flow velocity: 0.8 mL/minute.

[0108] As the monomers of the resin compositions for primary coating, nonylphenol polyethylene glycol acrylate (EO4NPA), neopentyl glycol diacrylate (NPGDA), acryloylmorpholine (ACMO), and N-vinyl caprolactam (NVCL), shown in Table 2, were provided. As the photopolymerization initiator, Omnirad TPO was provided. As the silane coupling agent, 3-acryloxypropyltrimethoxysilane (APTMS) was provided.

[0109] [Table 2]

Monomer		MEHQ [ppm]	ϵ -Caprolactam [ppm]
Acrylic acid ester	EO4NPA	1504	-
		1020	-
		681	-
		121	-
	NPGDA	598	-
		102	-
Acrylamide compound	ACMO	1010	-
		151	-
N-Vinyl compound	NVCL	-	7000
		-	19000
		-	24000

[0110] (Quantification of MEHQ)

The contents of MEHQ in the urethane acrylates (A), the urethane acrylate (B), the monomers, and the resin compositions were determined under the following measurement conditions using gas chromatography (trade name "GC2030" manufactured by SHIMADZU CORPORATION). First, an analytical curve was prepared using standard solutions of MEHQ in acetone (0 to 200 ppm). Next, the urethane acrylates (A), the urethane acrylate (B), the monomers, and resin compositions were diluted with acetone to suitable concentrations, respectively, and quantified by gas chromatography.

Column: UA-1, manufactured by Frontier Laboratories Ltd., (nonpolar, 0.25 mm in inner diameter $\times$ 30 m in length, film thickness: 0.25 μ m)

Column temperature: 50°C $\rightarrow$ 20°C/minute $\rightarrow$ 300°C (10 minutes)

Carrier: He gas, linear velocity 30.0 cm/second

Inlet temperature: 250°C

Detector temperature: 20°C (FID)

[0111] (Quantification of BHT)

An analytical curve was prepared from standard solutions of BHT in acetone (0 to 100 ppm) in the same procedure as in the quantification of MEHQ, the contents of BHT in the urethane acrylates (A), the urethane acrylate (B), and the resin compositions were determined by gas chromatography.

5 [0112] (Quantification of ϵ -caprolactam)

An analytical curve was prepared from standard solutions of ϵ -caprolactam in acetone (0 to 3000 ppm) in the same procedure as in the quantification of MEHQ, and the contents of ϵ -caprolactam in NVCL and the resin compositions were determined by gas chromatography.

10 [0113] [Resin compositions for primary coating]

The photopolymerizable compounds, the photopolymerization initiator, and the silane coupling agent were mixed in blended amounts (part by mass) shown in Table 3 or Table 4 to produce resin compositions for primary coating of the Test Examples. Test Examples 1 to 10 corresponds to Examples, and Test Examples 11 to 15 corresponds to Comparative Examples.

15 [0114] (Stability of resin composition)

The viscosity at 25°C of each resin composition was measured under the conditions of a cone plate of CP25-2 and a shear rate of 10 s⁻¹ using a rheometer ("MCR-102" manufactured by Anton Paar GmbH). Subsequently, the resin composition was stored at 60°C for 1 month, and the viscosity at 25°C of the resin composition was then measured under the same conditions. If the rate of change in the viscosity calculated with the following expression was less than 10%, the composition was evaluated as "A", if the rate of change was 10% or more and less than 30%, the composition was evaluated as "B", and if the rate of change was 30% or more, the composition was evaluated as "C".

$$\text{Rate of change [\%]} = (\text{Viscosity after storage} - \text{Viscosity before}) / \text{Viscosity before} \times 100$$

storage)/Viscosity before storage) $\times$ 100

[0115] [Resin films]

Each resin composition was applied to a polyethylene terephthalate (PET) film using a spin coater and cured under the conditions of 10 mJ/cm² and 100 mW/cm² using an electrodeless UV lamp system (D bulb, manufactured by Heraeus) to form a resin film having a thickness of 200 μ m on the PET film. A resin film was peeled from the PET film to obtain the resin film.

[0116] (Young's modulus)

The resin film was punched out in a dumb-bell shape of JIS K 7127 type 5, and the punched resin film was pulled under the conditions of $23 \pm 2^\circ\text{C}$ and $50 \pm 10\%$ RH under the conditions of a tensile speed of 1 mm/minute and a gauge length of 25 mm using a tensile tester to obtain a stress-strain curve. The Young's modulus of the resin film was calculated by dividing stress calculated with a secant expression of 2.5% strain by the cross section of the resin film.

[0117] [Resin composition for secondary coating]

Polypropylene glycol having an Mn of 600 (trade name "PP-600" produced by Sanyo Chemical Industries, Ltd.) and TDI were reacted at an NCO/OH of 2.0 to prepare an NCO-terminated prepolymer. Then, 200 ppm dibutyltin dilaurate was added based on the final total fed amount as a catalyst, and 500 ppm BHT was added based on the final total fed amount as a polymerization inhibitor. Next, HEA was added so that the molar ratio of the OH of HEA to the NCO of the NCO-terminated prepolymer was 1.05, and the mixture was reacted at 60°C for 1 hour to obtain a urethane acrylate having an Mn of 2300 (Z-1).

[0118] Then, 25 parts by mass of the urethane acrylate (Z-1), 36 parts by mass of tripropylene glycol diacrylate, 37 parts by mass of Viscoat#540 (product made by OSAKA ORGANIC CHEMICAL INDUSTRY LTD.), 1 part by mass of Omnirad TPO,

and 1 part by mass of Omnirad 184 were mixed to obtain a resin composition for secondary coating.

[0119] [Optical fibers]

The resin composition for primary coating and each resin composition for secondary coating were applied to the peripheral surface of the glass fiber 13 having a diameter of 125 μm . Subsequently, the resin compositions were cured by irradiation with ultraviolet rays, the coating resin layer 16 comprising the primary resin layer 14 and the secondary resin layer 15 was formed to produce the optical fiber 10. The thickness of the primary resin layer 14 was adjusted to 20 μm , and the thickness of the secondary resin layer 15 was adjusted to 15 μm to obtain an optical fiber having an outer diameter of 195 μm . The optical fiber was produced at a production speed of 3000 m/minute.

[0120] (Young's modulus of primary resin layer)

The Young's modulus of the primary resin layer of the optical fiber 10 was measured by the pullout modulus (POM) method.

[0121] (Dynamic fatigue characteristic)

The optical fiber 10 was subjected to 15 tensile tests under each of the four conditions that were tensile speeds of 0.5 mm/minute, 5 mm/minute, 50 mm/minute, and 500 mm/minute according to the testing method of IEC 60793-1-33 to determine the dynamic fatigue coefficient (Nd). If the Nd was 20 or more, the optical fiber was evaluated as "A", if the Nd was 18 or more and less than 20, the optical fiber was evaluated as "B", and if the Nd was less than 18, the optical fiber was evaluated as "C".

[0122] (Microbending resistance)

The transmission loss of light at a wavelength of 1550 nm when the optical fiber 10 was wound around a bobbin that had a diameter of 280 mm and the surface

of which was covered with sandpaper in a monolayer form was measured by the OTDR (optical time domain reflectometer) method. If the difference in transmission loss of light at a wavelength of 1550 nm when the optical fiber 10 was wound around a bobbin that had a diameter of 280 mm without sandpaper in a monolayer form was less than 0.5 dB/km, the optical fiber was evaluated as "A", if the difference was 0.5 dB/km or more and 1.0 dB/km or less, the optical fiber was evaluated as "B", and if the difference exceeded 1.0 dB/km, the optical fiber was evaluated as "C".

[0123] (Low temperature characteristic)

An optical fiber was wound around a glass bobbin at a tension of 50 g in monolayer winding, the transmission characteristics of signal light at a wavelength of 1550 nm were measured under temperature conditions of 23°C, -40°C, and -60°C, respectively, and the transmission loss was calculated. If the transmission loss difference obtained by subtracting the transmission loss at 23°C from the transmission loss at -40°C was less than 0 dB, the optical fiber was evaluated as "A", if the transmission loss difference was 0 dB or more and 0.01 dB/km or less, the optical fiber was evaluated as "B", and if the transmission loss difference was more than 0.01 dB/km, the optical fiber was evaluated as "C". Similarly, if the transmission loss difference obtained by subtracting the transmission loss at 23°C from the transmission loss at -60°C was less than 0 dB, the optical fiber was evaluated as "A", if the transmission loss difference was 0 dB or more and 0.01 dB/km or less, the optical fiber was evaluated as "B", and if the transmission loss difference was more than 0.01 dB/km, the optical fiber was evaluated as "C".

[0124] [Table 3]

Test Example		1	2	3	4	5	6	7	8	9	10
A-1		-	-	-	-	-	-	-	-	-	-
A-2		50	50	-	-	-	-	60	65	65	-
A-3		-	-	-	-	-	50	-	-	-	-
A-4		-	-	-	-	-	-	-	-	-	-
A-5		-	-	50	50	50	-	-	-	-	-
A-6		-	-	-	-	-	-	-	-	-	30
B-1		-	-	-	-	-	-	-	-	-	40
EO4NPA	1504 ppm	-	-	-	-	-	-	-	25	-	-
	1020 ppm	40	40	40	-	-	-	-	-	22	-
	681 ppm	-	-	-	40	-	-	27	-	-	-
	121 ppm	-	-	-	-	40	28	-	-	-	14
NPGDA	598 ppm	3	-	3	3	-	3	3	3	1	2
	102 ppm	-	3	-	-	3	-	-	-	-	-
ACMO	1010 ppm	5	-	5	5	-	5	5	5	-	5
	151 ppm	-	5	-	-	5	-	-	-	-	-
NVCL	7000 ppm	-	-	-	-	-	12	3	-	-	-
	19000 ppm	-	-	-	-	-	-	-	-	-	7
	24000 ppm	-	-	-	-	-	-	-	-	10	-
Omnirad TPO		1	1	1	1	1	1	1	1	1	1
APTMS [ppm]		1	1	1	1	1	1	1	1	1	1
MEHQ [ppm]		485	428	726	591	309	111	263	456	242	88
BHT [ppm]		250	250	0	0	0	100	300	325	425	350
MEHQ+BHT [ppm]		735	678	726	591	309	211	563	781	567	438
ϵ -Caprolactam [ppm]		0	0	0	0	0	840	210	0	2400	1330
Stability		A	A	A	A	A	B	A	A	A	A
Young's modulus [MPa]	Resin film	0.25	0.26	0.25	0.26	0.26	0.46	0.58	0.65	0.77	0.24
	Primary resin layer	0.19	0.21	0.19	0.25	0.25	0.44	0.55	0.61	0.76	0.24
Dynamic fatigue characteristic		A	A	A	A	A	A	A	A	B	A
Microbending resistance		A	A	A	A	A	A	A	B	B	A
Low temperature characteristic	-40°C	B	A	B	A	A	A	A	A	A	A
	-60°C	B	B	B	A	A	A	A	B	A	A

[0125] [Table 4]

Test Example		11	12	13	14	15
A-1		-	-	-	65	65
A-2		50	-	-	-	-
A-3		-	-	50	-	-
A-4		-	75	-	-	-
A-5		-	-	-	-	-
A-6		-	-	-	-	-
B-1		-	-	-	-	-
EO4NPA	1504 ppm	40	-	-	25	22
	1020 ppm	-	-	-	-	-
	681 ppm	-	12	-	-	-
	121 ppm	-	-	28	-	-
NPGDA	598 ppm	3	3	-	3	1
	102 ppm	-	-	3	-	-
ACMO	1010 ppm	5	5	-	5	-
	151 ppm	-	-	5	-	-
NVCL	7000 ppm	-	3	-	-	-
	19000 ppm	-	-	12	-	10
	24000 ppm	-	-	-	-	-
Omnirad TPO		1	1	1	1	1
APTMS [ppm]		1	1	1	1	1
MEHQ [ppm]		679	900	53	456	349
BHT [ppm]		250	0	100	650	650
MEHQ+BHT [ppm]		929	900	153	1106	999
ϵ -Caprolactam [ppm]		0	210	2280	0	1900
Stability		A	A	C	A	A
Young's modulus [MPa]	Resin film	0.25	0.85	0.46	0.64	0.75
	Primary resin layer	0.15	0.81	0.44	0.60	0.66
Dynamic fatigue characteristic		A	A	B	A	A
Microbending resistance		A	C	A	B	B
Low temperature characteristic	-40°C	C	B	A	C	B
	-60°C	C	B	A	C	C

CONCLUSIES

1. Een harssamenstelling voor primaire coating van een optische vezel, waarbij de
5 harssamenstelling een fotopolymeriseerbare verbinding, een fotopolymeriseerbare initiator en een polymerisatieremmer omvat,
 - waarbij de fotopolymeriseerbare verbinding een fotopolymeriseerbare verbinding met een urethaanbinding en een fotopolymeriseerbare verbinding zonder urethaanbinding omvat,
 - 10 • de polymerisatieremmer 4-methoxyfenol omvat, en
 - een totaal gehalte van de polymerisatieremmer is 200 ppm of meer en 800 ppm of minder.
2. Harssamenstelling volgens conclusie 1, waarbij de polymerisatieremmer verder 2,6-di-tert-butyl-p-cresol omvat.
- 15 3. Harssamenstelling volgens conclusie 1 of conclusie 2, met het kenmerk, dat een Young's modulus van een harsfilm dat verkregen is door ultravioletharding van de harssamenstelling onder condities van een geaccumuleerde hoeveelheid licht van 10 mJ/cm² en een belichting van 100 mW/cm² 0,10 MPa of meer en 0,80 MPa of minder is bij 23°C.
4. Harssamenstelling volgens conclusie 3, waarbij de Young's modulus van de harsfilm 0,10
20 MPa of meer en 0,60 MPa of minder is bij 23°C.
5. Harssamenstelling volgens een van de conclusies 1 tot 4, waarbij het totale gehalte van de polymerisatieremmer 700 ppm of minder is.
6. Harssamenstelling volgens een van de conclusies 1 tot 4, waarbij het totale gehalte van de polymerisatieremmer 600 ppm of minder is.
- 25 7. Harssamenstelling volgens een van de conclusies 1 tot 4, waarbij het totale gehalte van de polymerisatieremmer 300 ppm of meer is.
8. Harssamenstelling volgens een van de conclusies 1 tot 7, waarbij het gehalte aan 4-methoxyfenol 80 ppm of meer en 750 ppm of minder is.
9. Harssamenstelling volgens een van de conclusies 1 tot 8, waarbij de fotopolymeriseerbare
30 verbinding zonder urethaanbinding een N-vinylverbinding omvat, en een gehalte van de N-vinylverbinding 1 massadeel of meer en 15 massadelen of minder is gebaseerd op 100 massadelen van een totale hoeveelheid van de harssamenstelling.
10. Harssamenstelling volgens conclusie 9, waarbij de N-vinylverbinding N-vinylcaprolactam is.
- 35 11. Harssamenstelling volgens conclusie 10, verder omvattende ϵ -caprolactam, waarbij een gehalte aan ϵ -caprolactam 2000 ppm of minder is.
12. Een optische vezel, bestaande uit:

- een glasvezel bestaande uit een kern en een mantel;
 - een primaire harslaag die de glasvezel bekleedt in contact met de glasvezel; en
 - een secundaire harslaag die de primaire harslaag bedekt,
 - waarbij de primaire harslaag een uitgehard materiaal van de harssamenstelling
- 5 volgens een van de conclusies 1 tot 11 omvat.

13. Werkwijze voor het vervaardigen van een optische vezel, omvattende:

- een aanbrengstap van het aanbrengen van de harssamenstelling volgens een van de conclusies 1 tot 11 op een omtrek van een glasvezel omvattende een kern en een mantel; en
- 10 • een hardingsstap van het harden van de harssamenstelling door bestraling met ultraviolette stralen na de aanbrengstap.

14. Lint van optische vezels, waarbij een veelvoud van de optische vezels volgens conclusie 12 parallel zijn gerangschikt en zijn gecoat met een hars voor een lint.

15 15 Glasvezelkabel, waarbij het glasvezellint volgens conclusie 14 is opgenomen in een kabel.

16. Glasvezelkabel, waarbij meerdere van de optische vezels volgens conclusie 12 zijn opgenomen in een kabel.

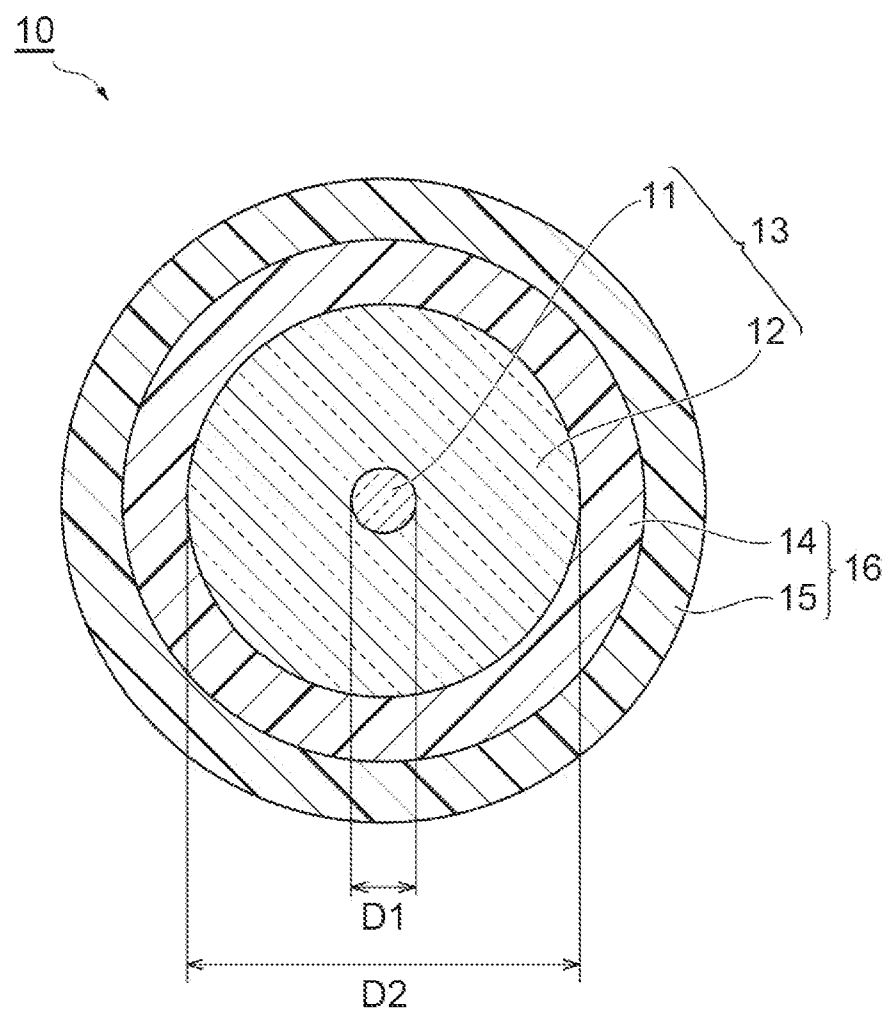
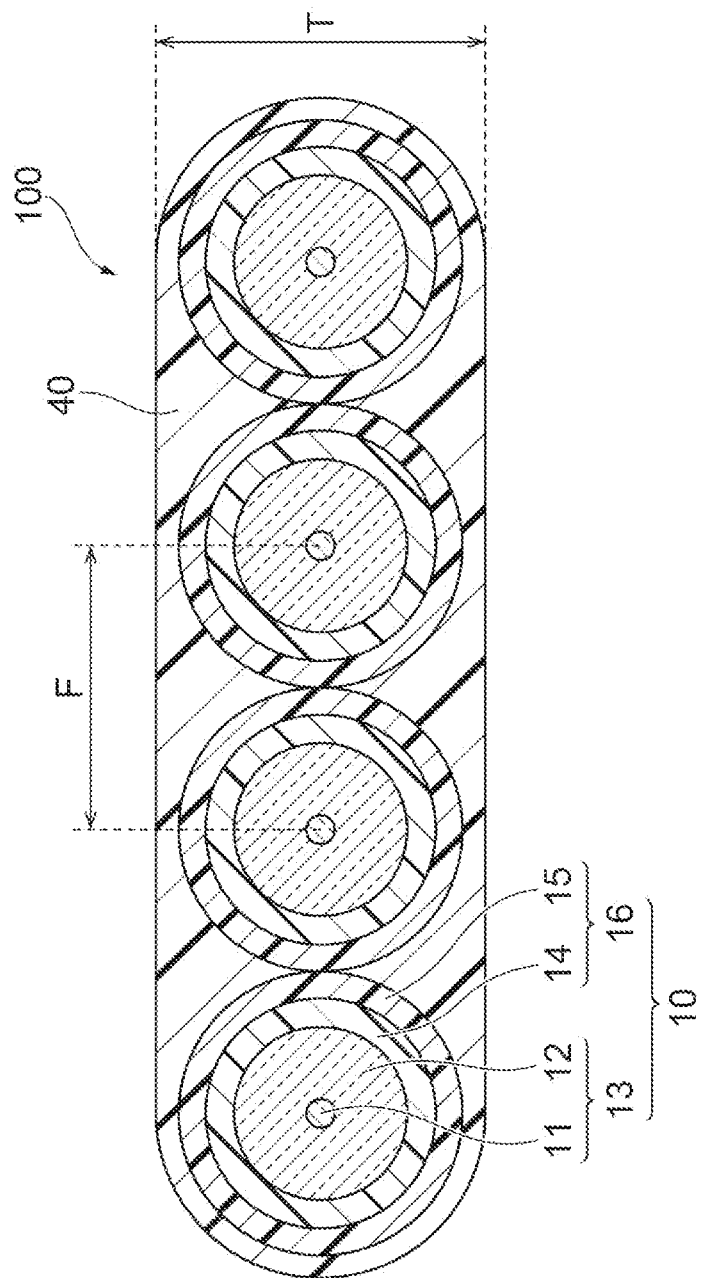
Fig.1

Fig.2

2 / 6



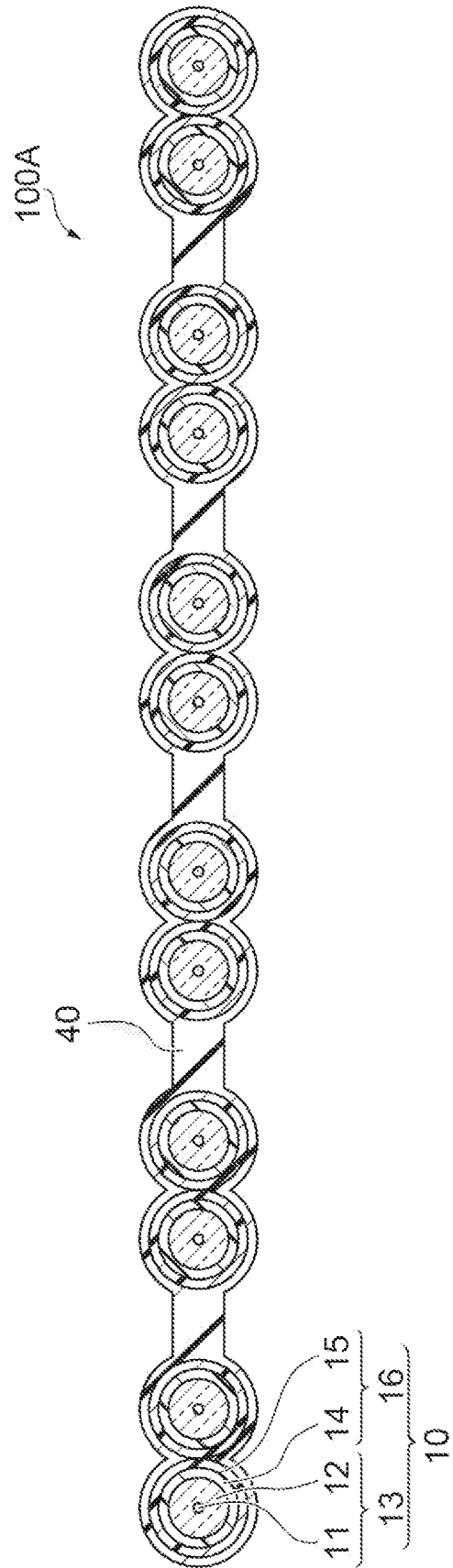


Fig. 3

Fig.4

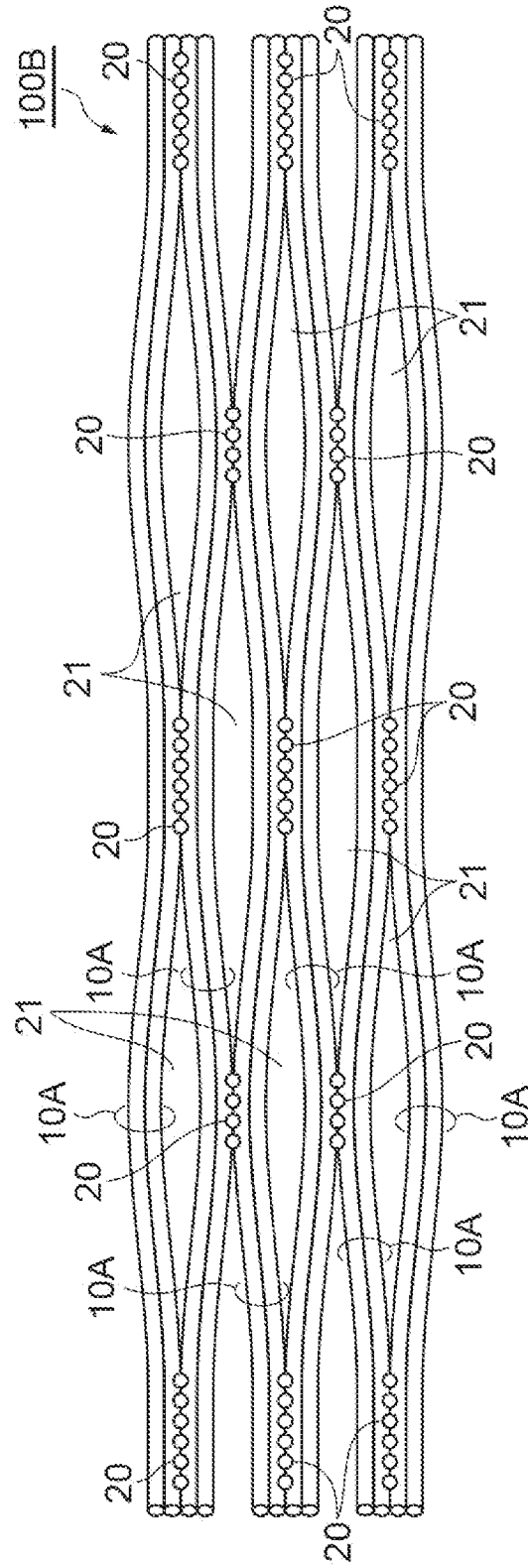


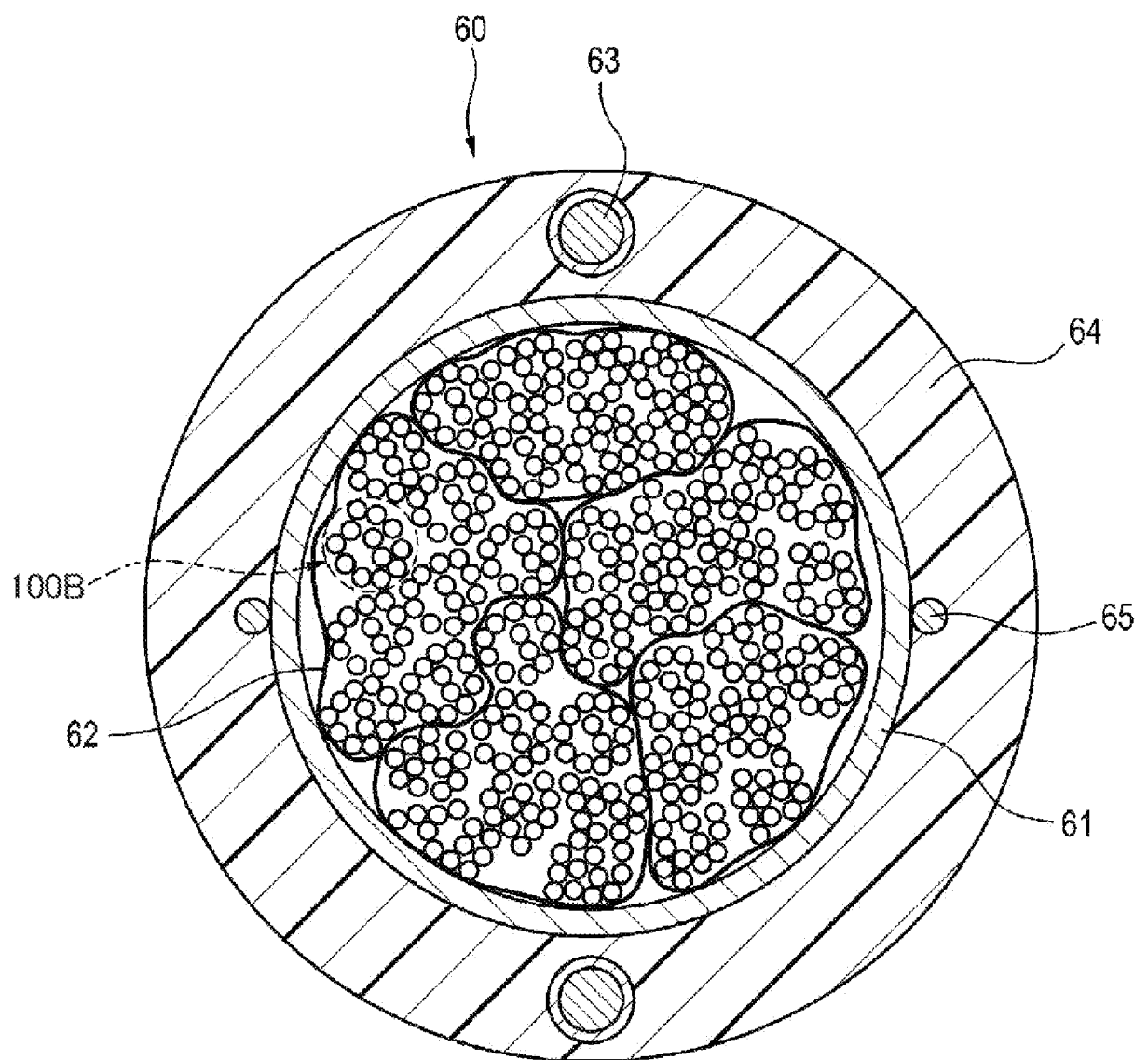
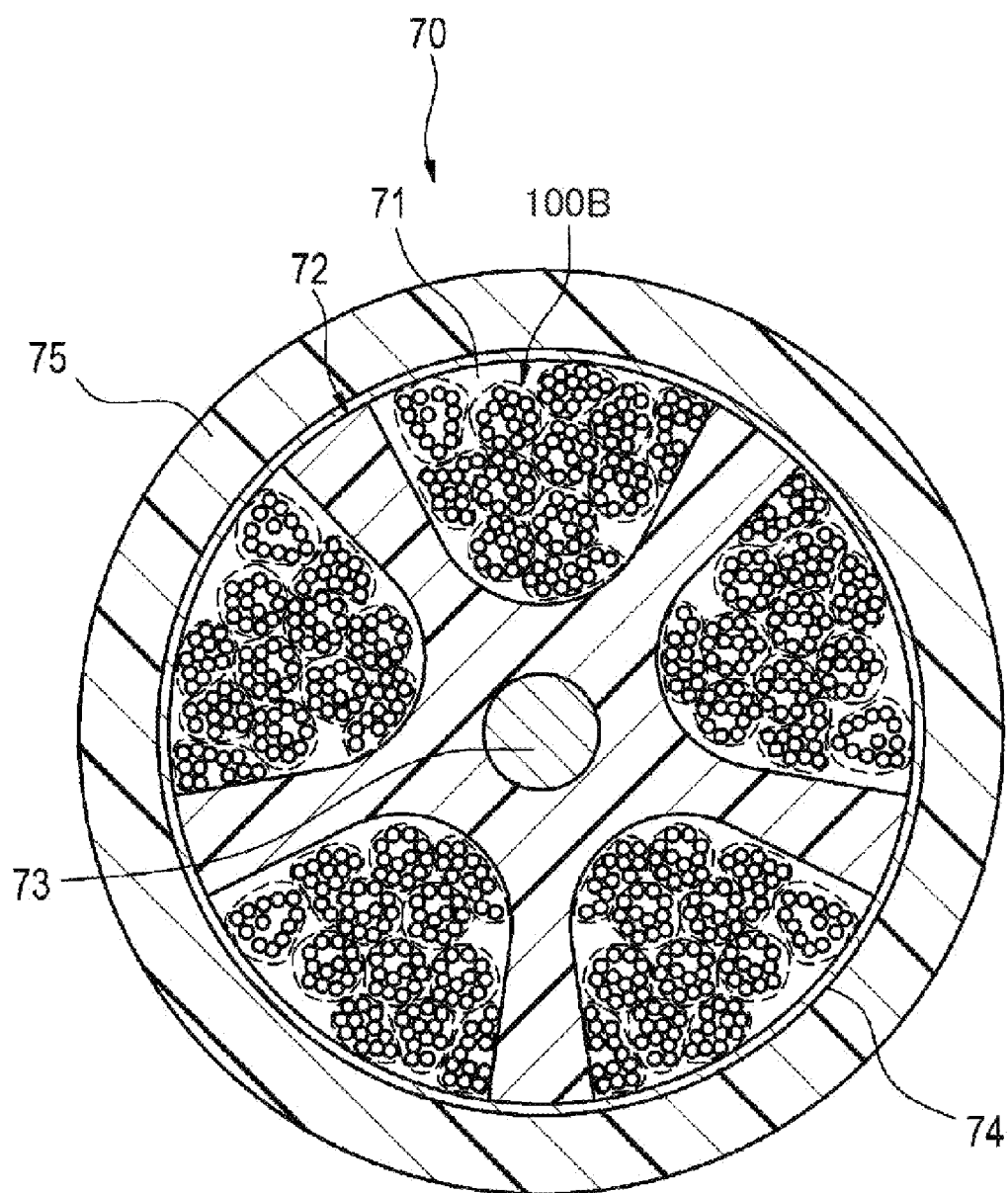
Fig.5

Fig.6



ONDERZOEKSRAPPORT

BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK

RELEVANTE LITERATUUR			
Categorie ¹	Literatuur met, voor zover nodig, aanduiding van speciaal van belang zijnde tekstgedeelten of figuren.	Van belang voor conclusie(s) nr:	Classificatie(IPC)
A	WO 2016/092971 A1 (DAINIPPON INK & CHEMICALS [JP]) 16 juni 2016 (2016-06-16) * voorbeelden *	1-16	INV. C03C25/106 C03C25/104 C03C25/24
A	WO 2020/239564 A1 (DSM IP ASSETS BV [NL]) 3 december 2020 (2020-12-03) * alinea [0115]; conclusie 1; voorbeelden *	1-16	
Indien gewijzigde conclusies zijn ingediend, heeft dit rapport betrekking op de conclusies ingediend op:			Onderzochte gebieden van de techniek
Plaats van onderzoek: München			Bevoegd ambtenaar: Pollio, Marco
Datum waarop het onderzoek werd voltooid: 26 mei 2023			
¹ NDERLINCATEGORIE VAN DE VERMELDE LITERATUUR			
X: de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur Y: de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht A: niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft O: niet-schriftelijke stand van de techniek P: tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur T: na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding E: eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven D: in de octrooiaanvraag vermeld L: om andere redenen vermelde literatuur &: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie			

**AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE
HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK,
UITGEVOERD IN DE OCTROOIAANVRAGE NR.**

**NO 142659
NL 2033985**

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octrooifamilie), die overeenkomen met octrooischriften genoemd in het rapport.

De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per
De juistheid en volledigheid van deze opgave wordt noch door het Europees Octrooibureau, noch door het Bureau voor de Industriële eigendom gegarandeerd;; de gegevens worden verstrekt voor informatiedoeleinden.

26-05-2023

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
WO 2016092971 A1	16-06-2016	CN 107001906 A	01-08-2017
		JP 5967340 B1	10-08-2016
		JP WO2016092971 A1	27-04-2017
		KR 20170092564 A	11-08-2017
		TW 201627457 A	01-08-2016
		WO 2016092971 A1	16-06-2016

WO 2020239564 A1	03-12-2020	CN 114144386 A	04-03-2022
		EP 3976544 A1	06-04-2022
		JP 2022533453 A	22-07-2022
		US 2020369822 A1	26-11-2020
		US 2022228023 A1	21-07-2022
		WO 2020239564 A1	03-12-2020

SCHRIFTELIJKE OPINIE

DOSSIER NUMMER NO142659	INDIENINGSDATUM 19.01.2023	VOORRANGSDATUM 20.01.2022	AANVRAAGNUMMER NL2033985
CLASSIFICATIE INV. C03C25/106 C03C25/104 C03C25/24			
AANVRAGER Sumitomo Electric Industries Ltd.			

Deze schriftelijke opinie bevat een toelichting op de volgende onderdelen:

- ☒ Onderdeel I Basis van de schriftelijke opinie
- ☐ Onderdeel II Voorrang
- ☐ Onderdeel III Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk
- ☐ Onderdeel IV De aanvraag heeft betrekking op meer dan één uitvinding
- ☒ Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid
- ☐ Onderdeel VI Andere geciteerde documenten
- ☐ Onderdeel VII Overige gebreken
- ☒ Onderdeel VIII Overige opmerkingen

	DE BEVOEGDE AMBTENAAR Pollio, Marco
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Onderdeel I Basis van de Schriftelijke Opinie

1. Deze schriftelijke opinie is opgesteld op basis van de meest recente conclusies ingediend voor aanvang van het onderzoek.
2. Deze motivering is opgesteld, met betrekking tot **nucleotide- en/of aminozuursequenties** die genoemd worden in de aanvraag, op basis van een sequentielijst die:
 - a. ☐ is opgenomen in de aanvraag zoals deze oorspronkelijk is ingediend
 - b. ☐ aangeleverd is na de indieningsdatum ten behoeve van het onderzoek

☐ en vergezeld ging van een verklaring dat de sequentielijst niet meer informatie bevat dan de aanvraag zoals deze oorspronkelijk is ingediend.
3. ☐ Deze motivering is opgesteld, met betrekking tot nucleotide- en/of aminozuursequenties die genoemd worden in de aanvraag, voor zover een zinvolle motivering gevormd kon worden zonder een sequentielijst die voldeed aan WIPO standaard ST.26.
4. Overige opmerkingen:

Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid

1. Verklaring

Nieuwheid	Ja: Conclusies 1-16 Nee: Conclusies
Inventiviteit	Ja: Conclusies 1-16 Nee: Conclusies
Industriële toepasbaarheid	Ja: Conclusies 1-16 Nee: Conclusies

2. Citaties en toelichting:

Zie aparte bladzijde

Onderdeel VIII Overige opmerkingen

De volgende opmerkingen met betrekking tot de duidelijkheid van de conclusies, beschrijving, en figuren, of met betrekking tot de vraag of de conclusies nawerkbaar zijn, worden gemaakt:

Zie aparte bladzijde

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1 WO 2016/092971 A1 (DAINIPPON INK & CHEMICALS [JP]) 16 juni 2016
(2016-06-16)
- D2 WO 2020/239564 A1 (DSM IP ASSETS BV [NL]) 3 december 2020
(2020-12-03)

1) D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses (see examples, claim 1) a resin composition for primary coating comprising a photopolymerizable compound having urethane bonds, a photopolymerizable compound having no urethane bonds, a photopolymerization initiator. In paragraph [0115] document D1 suggests that a polymerisation inhibitor can be added, in particular p-methoxyphenol.

The subject-matter of claim 1 therefore differs from this in that a quantity of inhibitor in the range from 200 ppm to 800 ppm is added.

Comparing examples and comparative examples a general improvement of the mechanical properties is observed. Therefore, the problem to be solved can be regarded as providing a primary coating composition providing a coating with improved mechanical properties. The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step. In fact there is no document suggesting to add a quantity of p-methoxyphenol in the claimed range to improve the mechanical properties.

The same reasoning applies mutatis mutandis to claims 12 - 16.

Claims 2-11 are dependent on claim 1 which subject-matter is considered as being new and inventive, as discussed above, and as such said dependent claims also meet the requirements of novelty and inventive step.

2) Document D2 (see examples) discloses the use of p-methoxyphenol as polymerisation inhibitor.

Re Item VIII

Certain observations on the application

Embodiments of the description (see for example paragraph [0025]) appear to be in contradiction with the scope of the claim. In fact in this paragraph polymerisation inhibitors are indicate different from m-methoxyphenol.