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(54) **RESIN COMPOSITION, OPTICAL FIBER, METHOD FOR PRODUCING OPTICAL FIBER, OPTICAL FIBER RIBBON, AND OPTICAL FIBER CABLE**

(57) A resin composition for primary coating of an optical fiber according to the present disclosure contains a photopolymerizable compound and a photopolymerization initiator, wherein the photopolymerizable compound contains a urethane (meth)acrylate and an ethylene oxide chain-containing (meth)acrylate, and the value obtained by dividing the formula weight of an ethylene oxide chain of the ethylene oxide chain-containing (meth)acrylate by the molecular weight of the ethylene oxide chain-containing (meth)acrylate is 0.50 or more and 0.93 or less.

TITLE

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

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.

The present application claims the priority based on Japanese application No. 2022-026878, filed on February 24, 2022, and the content described in the Japanese application is incorporated herein in its entirety.

BACKGROUND

[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, 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

[Patent Literature 5] JP 2014-114208 A

SUMMARY

[0004] A resin composition for primary coating of an optical fiber according to the one aspect of the present disclosure comprises a photopolymerizable compound and a photopolymerization initiator, wherein the photopolymerizable compound comprises a urethane (meth)acrylate and an ethylene oxide chain-containing (meth)acrylate, and the value obtained by dividing the formula weight of an ethylene oxide chain of the ethylene oxide chain-containing (meth)acrylate by the molecular weight of the ethylene oxide chain-containing (meth)acrylate is 0.50 or more and 0.93 or less.

BRIEF DESCRIPTION OF THE DRAWINGS

[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;

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

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]

A decrease in the Young's modulus of the primary resin layer may reduce the crosslinking density and make the water resistance inferior. When the optical fiber is immersed in water, foam is specifically formed in the primary resin layer, and the transmission loss easily increases.

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

[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 water resistance and suitable for primary coating of an optical fiber and an optical fiber that is excellent in water resistance 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. A resin composition for primary coating of an optical fiber according to the one aspect of the present disclosure comprises a photopolymerizable compound and a photopolymerization initiator, wherein the photopolymerizable compound comprises a urethane (meth)acrylate and an ethylene oxide

chain-containing (meth)acrylate, and the value obtained by dividing the formula weight of an ethylene oxide chain of the ethylene oxide chain-containing (meth)acrylate by the molecular weight of the ethylene oxide chain-containing (meth)acrylate is 0.50 or more and 0.93 or less. Hereinafter, the ethylene oxide chain is referred to as an "EO chain".

[0010] Such a resin composition can form the resin layer that is suitable for the primary coating of the optical fiber, and can improve the water resistance of the optical fiber.

[0011] The value obtained by dividing the formula weight of the EO chain by the molecular weight of the EO chain-containing (meth)acrylate may be 0.60 or more and 0.93 or less from the viewpoint of further improving the water resistance.

[0012] The content of the EO chain-containing (meth)acrylate may be 0.3 parts by mass or more and 25 parts by mass or less, or 0.5 parts by mass or more and 20 parts by mass or less based on 100 parts by mass of the total amount of the resin composition from the viewpoint of the balance between the water resistance and the oil resistance.

[0013] The EO chain-containing (meth)acrylate may contain at least one selected from the group consisting of methoxy polyethylene glycol acrylate, nonylphenoxy polyethylene glycol acrylate, polyethylene glycol diacrylate, ethoxylated bisphenol A diacrylate, and ethoxylated trimethylolpropane triacrylate from the viewpoint of further enhancing the water resistance.

[0014] The photopolymerizable compound further comprises 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.

[0015] 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/cm^2 and an illumination of 100 mW/cm^2 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 improving the microbending resistance of the optical fiber.

[0016] 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 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 water resistance.

[0017] 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 water resistance can be produced thereby.

[0018] 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 water resistance, and can be highly densely packed

in an optical fiber cable.

[0019] 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. The optical fiber cable comprising the optical fiber or the optical fiber ribbon according to the present embodiment is excellent in water resistance.

[0020] [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. 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 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.

[0021] (Resin composition)

The resin composition according to the present embodiment comprises a photopolymerizable compound and a photopolymerization initiator, wherein the photopolymerizable compound comprises a urethane (meth)acrylate and an EO chain-containing (meth)acrylate, and the value obtained by dividing the formula weight of the EO chain of the EO chain-containing (meth)acrylate by the molecular weight of the EO

chain-containing (meth)acrylate is 0.50 or more and 0.93 or less.

[0022] The urethane (meth)acrylate is a photopolymerizable compound having urethane bonds. As the urethane (meth)acrylate, a urethane (meth)acrylate that is a reaction product of, for example, a diol, a diisocyanate, and a hydroxyl group-containing (meth)acrylate (hereinafter occasionally referred to as a "urethane (meth)acrylate (A)") can be used.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] As a catalyst when the urethane (meth)acrylate is synthesized, an organotin 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 to use dibutyltin dilaurate or dibutyltin diacetate from the viewpoints of availability or catalyst performance as the catalyst.

[0028] When the urethane (meth)acrylate is synthesized, as the polymerization inhibitor, 4-methoxy phenol or 2,6-di-tert-butyl-p-cresol may be added.

[0029] 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.

[0030] 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).

[0031] 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.

[0032] 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).

[0033] 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.

[0034] 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.

[0035] The urethane (meth)acrylate may further contain a reaction product of a polyoxyalkylene monoalkyl ether, a diisocyanate, and a hydroxyl group-containing (meth)acrylate (hereinafter occasionally referred to as a "urethane (meth)acrylate (B)").

[0036] 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 (C_{12} to C_{14}) 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.

[0037] It is preferable that the polyoxyalkylene monoalkyl ether be polyoxypropylene monobutyl ether from the viewpoint of the compatibility of the primary resin composition.

[0038] 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.

[0039] 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.

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

[0040] The Mn of the urethane (meth)acrylate (A) may be 6000 or more and 50000 or less, 8000 or more and 45000 or less, 9000 or more and

40000 or less, or 10000 or more and 30000 or less from the viewpoint of obtaining a Young's modulus suitable for the primary resin layer. The weight average molecular weight (Mw) of the urethane (meth)acrylate (A) may be 6000 or more and 80000 or less, 8000 or more and 70000 or less, 10000 or more and 60000 or less, or 15000 or more and 40000 or less. 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 Mw of the urethane (meth)acrylate (B) may be 4000 or more and 30000 or less, 4500 or more and 25000 or less, or 5000 or more and 20000 or less.

[0041] The Mn and Mw of the urethane (meth)acrylate (A) and the urethane (meth)acrylate (B) can be measured by gel permeation chromatography (GPC).

[0042] It is preferable that the content of the urethane (meth)acrylate (A) be 15 parts by mass or more and 85 parts by mass or less, it is more preferable that the content be 20 parts by mass or more and 80 parts by mass or less, and it is further preferable that the content be 25 parts by mass or more and 75 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.

[0043] 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.

[0044] The content of the urethane (meth)acrylate 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 75 parts by mass or less based on 100 parts by mass of the total amount of the resin composition.

[0045] The EO chain-containing (meth)acrylate is a photopolymerizable compound having an EO chain and not having a urethane bond. In the EO chain-containing (meth)acrylate according to the present embodiment (hereinafter referred to as an "EO chain-containing (meth)acrylate (A)"), the value obtained by dividing the formula weight of the EO chain by the molecular weight of the EO chain-containing (meth)acrylate is 0.50 or more and 0.93 or less. When this value is 0.50 or more, the water resistance can be improved, and when the value is 0.93 or less, the EO chain-containing (meth)acrylate can be uniformly mixed in the resin composition.

[0046] The value obtained by dividing the formula weight of the EO chain in the EO chain-containing (meth)acrylate (A) by the molecular weight of the EO chain-containing (meth)acrylate may be 0.54 or more and 0.93 or less more, 0.58 or more and 0.93 or less, or 0.60 or more and 0.93 or less from the viewpoint of further improving the water resistance.

[0047] The structure of the EO chain can be represented by $(CH_2CH_2O)_n$. As an example of the EO chain-containing (meth)acrylate, CH_2=CHCOO-$(CH_2CH_2O)_8$-Ph-C_9H_{19} is mentioned for description. In this case, the number of CH_2CH_2O (molecular weight: 44) is 8, the formula weight of the EO chain is therefore 352 (= 44 × 8), and the value obtained by dividing the formula weight of the EO chain (352) by the molecular weight of the EO chain-containing (meth)acrylate (626) is 0.56.

[0048] Examples of the EO chain-containing (meth)acrylate (A) include methoxy polyethylene glycol (meth)acrylate, nonylphenoxy polyethylene glycol (meth)acrylate, polyethylene glycol di(meth)acrylate, ethoxylated bisphenol A di(meth)acrylate, ethoxylated trimethylolpropane tri(meth)acrylate, ethoxylated glycerol triacrylate, and ethoxylated pentaerythritol tetra(meth)acrylate.

[0049] The EO chain-containing (meth)acrylate (A) may contain at least one selected from the group consisting of methoxy polyethylene glycol acrylate, nonylphenoxy polyethylene glycol acrylate, polyethylene glycol diacrylate, ethoxylated bisphenol A diacrylate, and ethoxylated trimethylolpropane triacrylate from the viewpoint of further enhancing the water resistance.

[0050] For example, the number of oxyethylene groups (CH_2CH_2O) that methoxy polyethylene glycol acrylate has (n) may be 2 or more and 25 or less, 3 or more and 24 or less, or 4 or more and 23 or less. The number of oxyethylene groups that nonylphenoxy polyethylene glycol acrylate has may be 7 or more and 30 or less, 7 or more and 20 or less, or 8 or more and 10 or less. The number of oxyethylene groups that polyethylene glycol diacrylate has may be 4 or more and 30 or less, 4 or more and 20 or less, or 4 or more and 15 or less. The number of oxyethylene groups that ethoxylated bisphenol A diacrylate has may be 8 or more and 50 or less, 9 or more and 40 or less, or 10 or more and 30 or less. The number of oxyethylene groups that ethoxylated trimethylolpropane triacrylate has may be 6 or more and 50 or less, 9 or more and 40 or less, or 10 or more and 30 or less. The number of oxyethylene groups that ethoxylated glycerol triacrylate has may be 6 or

more and 50 or less, 9 or more and 40 or less, or 10 or more and 30 or less. The number of oxyethylene groups that ethoxylated pentaerythritol tetraacrylate has may be 8 or more and 50 or less, 9 or more and 40 or less, or 10 or more and 35 or less.

[0051] The content of the EO chain-containing (meth)acrylate (A) may be 0.3 parts by mass or more from the viewpoint of further improving the water resistance, and the content may be 25 parts by mass or less from the viewpoint of improving the oil resistance. It is preferable that the content of the EO chain-containing (meth)acrylate (A) be 0.3 parts by mass or more and 25 parts by mass or less, it is more preferable that the content be 0.5 parts by mass or more and 20 parts by mass or less, and it is further preferable that the content be 0.8 parts 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.

[0052] The resin composition according to the present embodiment may further contain an EO chain-containing (meth)acrylate wherein the value obtained by dividing the formula weight of the EO chain by the molecular weight of the EO chain-containing (meth)acrylate is less than 0.50 (hereinafter referred to as an "EO chain-containing (meth)acrylate (B)"). The value obtained by dividing the formula weight of the EO chain in the EO chain-containing (meth)acrylate (B) by the molecular weight of the EO chain-containing (meth)acrylate may be 0.25 or more and 0.48 or less, 0.30 or more and 0.45 or less, and 0.35 or more and 0.42 or less more.

[0053] Examples of the EO chain-containing (meth)acrylate (B) include CH_2=CHCOO-$(CH_2CH_2O)_n$-Ph-C_9H_{19} (n: 1 to 6), CH_2=CHCOO-$(CH_2CH_2O)_n$-Ph (n: 1 or 2), CH_2=CHCOO-CH_2CH_2O-CH_3,

CH_2=CHCOO-$(CH_2CH_2O)_n$-CH_2CH_3 (n: 1 or 2), CH_2=CHCOO-$(CH_2CH_2O)_n$-OOC-CH=CH_2 (n: 1 or 2), an EO(n) adduct of bisphenol A di(meth)acrylate (n: 2 to 7), an EO(n) adduct of trimethylolpropane tri(meth)acrylate (n: 3 to 6), and an EO(n) adduct of pentaerythritol tetra(meth)acrylate (n: 4 to 7).

[0054] The photopolymerizable compound according to the present embodiment may further contain a photopolymerizable compound other than the urethane (meth)acrylate and the EO chain-containing (meth)acrylate (hereinafter referred to merely 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.

[0055] 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-ethylhexy (meth)acrylate, n-octyl (meth)acrylate, isooctyl (meth)acrylate, isodecyl (meth)acrylate, lauryl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, benzyl (meth)acrylate, cyclic trimethylolpropane formal acrylate, dicyclopentenyl (meth)acrylate, dicyclopentenyloxyethyl (meth)acrylate, dicyclopentanyl (meth)acrylate, isobornyl (meth)acrylate, 3-phenoxybenzyl (meth)acrylate, 2-hydroxy-3-phenoxypropyl acrylate, carboxyethyl (meth)acrylate, carboxypentyl

(meth)acrylate, and ω-carboxy-polycaprolactone (meth)acrylate.

[0056] Examples of the polyfunctional (meth)acrylic acid ester include difunctional monomers such as polypropylene glycol di(meth)acrylate, neopentyl glycol di(meth)acrylate, tripropylene glycol di(meth)acrylate, cyclohexanedimethanol di(meth)acrylate, dipropylene glycol di(meth)acrylate, hydroxypivalate neopentyl glycol di(meth)acrylate, 1,3-butylene glycol di(meth)acrylate, 1,4-butanediol 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, bispenol A epoxy di(meth)acrylate, bisphenol F epoxy di(meth)acrylate, a PO adduct of bispenol 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 polypropoxy tri(meth)acrylate, tris[(meth)acryloyloxyethyl] isocyanurate, pentaerythritol tri(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.

[0057] 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.

[0058] Examples of the N-vinyl compounds include N-vinylpyrrolidone, an N-vinyl caprolactam, N-vinyl methyl oxazolidinone, N-vinylimidazole, and N-vinyl-N-methylacetamide.

[0059] When the photopolymerizable compound contains an N-vinyl compound, the curing rate of the resin composition can be improved. As an N-vinyl compound, especially N-vinyl caprolactam and N-vinyl methyl oxazolidinone are preferable. 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.

[0060] 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.).

[0061] 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.

[0062] 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 100 parts by mass of the total amount of the resin composition.

[0063] 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.

[0064] 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.

[0065] 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).

[0066] 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-trimethoxysilylpropyldimethylthiocarbamyl tetrasulfide, and γ-trimethoxysilylpropylbenzothiazyl tetrasulfide.

[0067] 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).

[0068] 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/cm^2 and an illumination of 100 mW/cm^2 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.

[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 resin composition according to the present embodiment can produce an optical fiber that is excellent in microbending resistance and water resistance by applying 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°C ± 2°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°C ± 2°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 Dp, the outer diameter of the glass fiber is defined as Df, 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.

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

[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°C ± 2°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. 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°C ± 2°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 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 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 embodiment can produce an optical fiber that is excellent in microbending resistance and water resistance using the resin composition according to the present embodiment as the resin composition for primary coating.

[0083] (Optical fiber ribbon)

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.

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

[0092] (Optical fiber cable)

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 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 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 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 cable comprising the optical fiber or the optical fiber ribbon according to the present embodiment is excellent in microbending resistance and water resistance.

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)

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 500 ppm 2,6-di-tert-butyl-p-cresol (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. Next, methanol was added so that the molar ratio of the OH of the methanol to the NCO of the NCO-terminated prepolymer (MeOH/NCO) was 0.2, and 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 0.85, and the mixture was reacted at 60°C for 1 hour to obtain a urethane acrylate (A-1). The urethane acrylate (A-1) had an Mn of 13100 and an Mw of 17700.

[0099] (A-2)

Polypropylene glycol having an Mn of 4000 (trade name "SANNIX PP-4000" produced by Sanyo Chemical Industries, Ltd.) and TDI were fed into a reaction kettle so that the NCO/OH was 1.5. 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 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 (A-2). The urethane acrylate (A-2) had an Mn of 18100 and an Mw of 23400.

[0100] The Mn of polypropylene glycol are values calculated from the

hydroxyl values, and are values described in the catalogues of the products. The Mn and Mw of the urethane acrylate were 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 μL, sample temperature: 15°C, mobile phase: THF, XT columns for organic solvent: particle size 2.5 μm, pore size 450 Å, column inner diameter 4.6 × column length 150 mm + particle size 2.5 μm, pore size 125 Å, column inner diameter 4.6 × column length 150 mm + particle size 1.7 μm, pore size 45 Å, column inner diameter 4.6 × column length 150 mm, column temperature: 40°C, and flow velocity: 0.8 mL/minute.

[0101] As the EO chain-containing (meth)acrylate, EO-1 to EO-15, shown in Table 1, were provided.

[0102] [Table 1]

	Compound name	Company name	Product name	Formula weight of EO chain/molecular weight of acrylate
EO-1(n≈8)	Nonylphenoxy polyethylene glycol acrylate	Miwon Specialty Chemical Co., Ltd.	Miramer M166	0.56
EO-2(n≈3)	Methoxy triethylene glycol acrylate	Kyoeisha Chemical Co., Ltd.	Light Acrylate MTG-A	0.61
EO-3(n≈9)	Methoxy polyethylene glycol acrylate		Light Acrylate 130A	0.82
EO-4(n≈13)	Methoxy polyethylene glycol acrylate	SHIN-NAKAMURA CHEMICAL Co, Ltd.	AM-130G	0.87
EO-5(n≈23)	Methoxy polyethylene glycol acrylate		AM-230G	0.92
EO-6(n≈4)	Polyethylene glycol diacrylate	Miwon Specialty Chemical Co., Ltd.	Miramer M282	0.55
EO-7(n≈13)	Polyethylene glycol diacrylate		Miramer M286	0.80
EO-8(n≈15)	Ethoxylated trimethylolpropane triacrylate		Miramer M3150	0.69
EO-9(n≈10)	Ethoxylated bisphenol A diacrylate		Miramer M2100	0.57
EO-10(n≈30)	Ethoxylated bisphenol A diacrylate		Miramer M2300	0.80
EO-11(n≈4)	Nonylphenoxy polyethylene glycol acrylate		Miramer M164	0.39
EO-12(n=1)	Phenoxyethyl acrylate		Miramer M140	0.23
EO-13(n≈2)	Ethoxy polyethylene glycol acrylate		Miramer M170	0.47
EO-14(n≈3)	Ethoxylated trimethylolpropane triacrylate		Miramer M3130	0.31
EO-15(n≈4)	Ethoxylated bisphenol A diacrylate		Miramer M240	0.34

[0103] As the monomers of the resin compositions for primary coating, N-vinyl caprolactam (NVCL), were provided. As the photopolymerization initiator, Omnirad TPO was provided. As the silane coupling agent, 3-acryloxypropyltrimethoxysilane (APTMS) was provided.

[0104] [Resin compositions for primary coating]

A urethane acrylates, an EO chain-containing (meth)acrylates, a monomer, a photopolymerization initiator, and a silane coupling agent were mixed in blended amounts (part by mass) shown in Table 2 or Table 3 to produce the resin compositions for primary coating of Test Examples. Test Examples 1 to 12 correspond to Examples, and Test Examples 13 to 18 correspond to Comparative Examples.

[0105] [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/cm^2 and 100 mW/cm^2 using an electrodeless UV lamp system (D bulb, manufactured by Heraeus) to form a resin film having a thickness of 200 μm on the PET film. A resin film was peeled from the PET film to obtain the resin film.

[0106] (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 ± 2°C and 50 ± 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.

[0107] [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 (Z-1). The urethane acrylate (Z-1) had an Mn of 2300, and an Mw of 2700.

[0108] 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.

[0109] [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.

[0110] (Water resistance)

The optical fiber 10 was immersed in water at 23°C so that the whole coating resin layer 16 was completely soaked, and the transmission loss of light at a wavelength of 1550 nm was measured. After immersion for 120 days, the transmission loss of light at a wavelength of 1550 nm was then measured. If an increase in transmission loss was less than 0.03 dB/km, the optical fiber was evaluated as "A", if the increase in transmission loss was 0.03 dB/km or more and less than 0.05 dB/km, the optical fiber was evaluated as "B", and if the increase in transmission loss was 0.05 dB/km or more, the optical fiber was evaluated as "C".

[0111] (Oil resistance)

The optical fiber 10 was immersed in jelly heated to 85°C for 120 days so that the whole coating resin layer 16 was completely soaked. Mineral oil that had an Mn of around 300 to 600 and to which a thickener was added was used as the jelly. The transmission loss of light at a wavelength of 1550 nm was measured under the temperature conditions of 23°C and -40°C. If a difference obtained by subtracting the transmission loss at 23°C from the transmission loss at -40°C (transmission loss difference) was less than 0 dB/km (the transmission loss at -40°C was smaller), the optical fiber was evaluated as "A", if the difference was 0 dB/km or more and less than 0.01 dB/km, the optical fiber was evaluated as "B", and if the difference was 0.01 dB/km or more, the optical fiber was evaluated as "C".

[0112] (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".

[0113] [Table 2]

Test Example	1	2	3	4	5	6	7	8	9	10	11	12
A-1	-	-	-	-	-	-	-	-	-	-	75	75
A-2	75	75	75	75	75	75	75	75	75	75	-	-
EO-1	18	-	-	-	-	-	-	-	-	-	23	-
EO-2	-	12	-	-	-	-	-	-	-	-	-	-
EO-3	-	-	6	-	-	-	-	-	-	-	-	23
EO-4	-	-	-	2	-	-	-	-	-	-	-	-
EO-5	-	-	-	-	1	-	-	-	-	-	-	-
EO-6	-	-	-	-	-	5	-	-	-	-	-	-
EO-7	-	-	-	-	-	-	5	-	-	-	-	-
EO-8	-	-	-	-	-	-	-	3	-	-	-	-
EO-9	-	-	-	-	-	-	-	-	5	-	-	-
EO-10	-	-	-	-	-	-	-	-	-	5	-	-
EO-11	-	6	12	16	17	13	13	15	13	13	-	-
NVCL	5	5	5	5	5	5	5	5	5	5	-	-
Omnirad TPO	1	1	1	1	1	1	1	1	1	1	1	1
APTMS	1	1	1	1	1	1	1	1	1	1	1	1
Young's modulus [MPa]	0.33	0.29	0.36	0.35	0.35	0.58	0.47	0.44	0.76	0.45	0.41	0.39
Water resistance	B	A	A	A	A	B	A	A	B	A	B	A
Oil resistance	A	A	A	A	A	A	A	A	A	A	B	B
Microbending resistance	A	A	A	A	A	B	A	A	B	A	A	A

[0114] [Table 3]

Test Example	13	14	15	16	17	18
A-1	-	-	-	-	-	75
A-2	75	75	75	75	75	-
EO-11	18	-	-	15	15	23
EO-12	-	18	-	-	-	-
EO-13	-	-	18	-	-	-
EO-14	-	-	-	3	-	-
EO-15	-	-	-	-	3	-
NVCL	5	5	5	5	5	-
Omnirad TPO	1	1	1	1	1	1
APTMS	1	1	1	1	1	1
Young's modulus [MPa]	0.36	0.52	0.18	0.74	0.66	0.45
Water resistance	C	C	C	C	C	C
Oil resistance	A	A	A	A	A	A
Microbending resistance	A	B	A	B	B	A

GEWIJZIGDE CONCLUSIES

1. Een harssamenstelling voor primaire coating van een optische vezel, waarbij de harssamenstelling een fotopolymeriseerbare verbinding en een fotopolymerisatie-initiator omvat,
waarbij de fotopolymeriseerbare verbinding een urethaan(meth)acrylaat en een ethyleenoxideketenbevattend (meth)acrylaat omvat, en
een waarde verkregen door het delen van een formulegewicht van een ethyleenoxideketen van het ethyleenoxideketenbevattende (meth)acrylaat door een molecuulgewicht van het ethyleenoxideketenbevattende (meth)acrylaat is 0,50 of meer en 0,93 of minder, en
waarbij een gehalte van het ethyleenoxideketenbevattende (meth)acrylaat 0,3 massadelen of meer is en 25 massadelen of minder gebaseerd op 100 massadelen van een totaal hoeveelheid harssamenstelling.

2. Harssamenstelling volgens conclusie 1, waarbij de waarde verkregen door het formulegewicht van de ethyleenoxideketen te delen door het molecuulgewicht van het ethyleenoxideketenbevattende (meth)acrylaat 0,60 of meer en 0,93 of minder is.

3. Harssamenstelling volgens conclusie 1 of conclusie 2, waarbij het gehalte van het ethyleenoxideketenbevattende (meth)acrylaat 0,5 massadelen of meer en 20 massadelen of minder gebaseerd op 100 massadelen is. van de totale hoeveelheid harssamenstelling.

4. Harssamenstelling volgens een van de conclusies 1 tot 3, waarbij het ethyleenoxideketenbevattende (meth)acrylaat er ten minste een omvat gekozen uit de groep bestaande uit methoxypolyethyleenglycolacrylaat, nonylfenoxypolyethyleenglycolacrylaat, polyethyleenglycoldiacrylaat , geëthoxyleerd bisfenol A-diacrylaat en geëthoxyleerd trimethylolpropaantriacrylaat.

5. Harssamenstelling volgens een van de conclusies 1 tot 4, waarbij de fotopolymeriseerbare verbinding verder een N-vinylverbinding omvat, en een gehalte van de N-vinylverbinding 1 massadeel of meer is en 15 massadelen of minder gebaseerd op 100 massadelen van de totale hoeveelheid harssamenstelling.

6. Harssamenstelling volgens een van de conclusies 1 tot 5, waarbij een Young's modulus van een harsfilm verkregen door het ultraviolet uitharden van de harssamenstelling onder omstandigheden van een geaccumuleerde hoeveelheid licht van 10 mJ/cm^2 en een belichting van 100 mW/cm^2 is 0,10 MPa of meer en 0,80 MPa of minder bij 23°C.

7. Harssamenstelling volgens conclusie 6, waarbij de Young-modulus van de harsfilm 0,10 MPa of meer en 0,60 MPa of minder is bij 23°C.

8. 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 volgens een van de conclusies 1 tot 7 omvat.

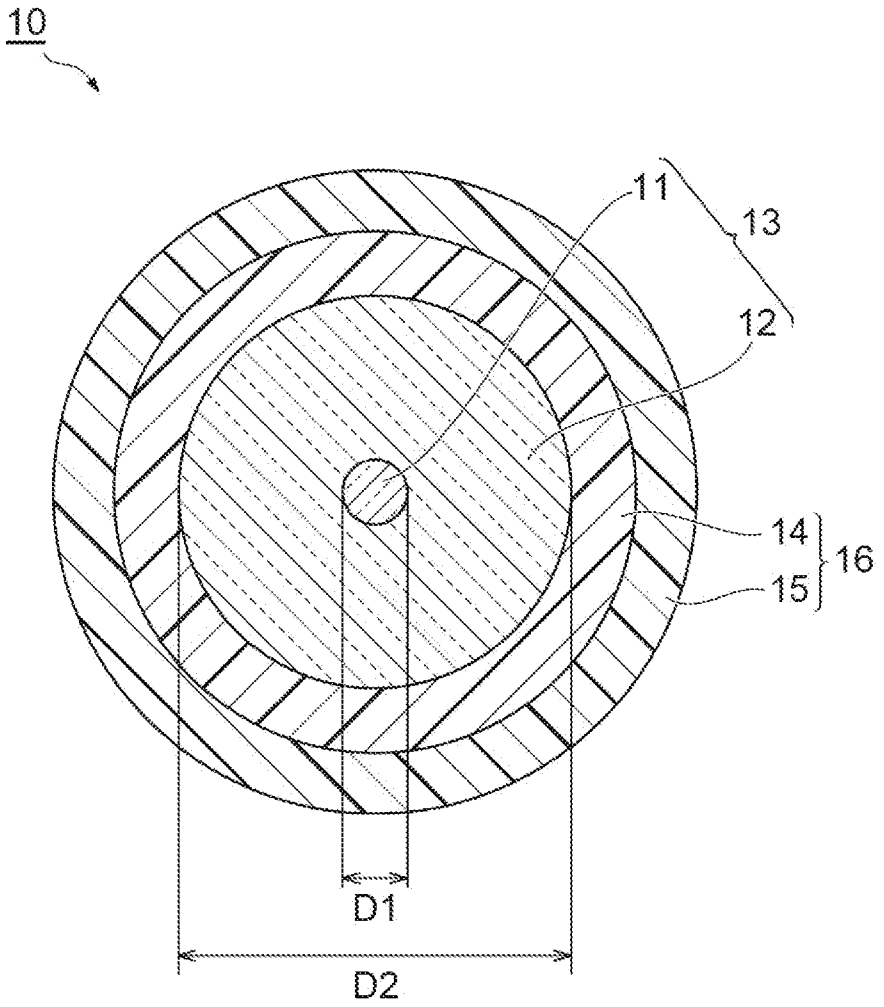
9. Werkwijze voor het vervaardigen van een optische vezel, omvattende:
   - een aanbrengstap van het aanbrengen van de harssamenstelling volgens een van de conclusies 1 tot 7 op een omtrek van een glasvezel omvattende een kern en een bekleding; en
   - een hardingsstap van het harden van de harssamenstelling door bestraling met ultraviolette stralen na de aanbrengstap.

10. Lint van optische vezels, waarbij een veelvoud van de optische vezels volgens conclusie 8 parallel zijn gerangschikt en zijn bekleed met een hars voor een lint.

11. Glasvezelkabel, waarbij het glasvezellint volgens conclusie 10 is opgenomen in een kabel.

12. Glasvezelkabel, waarbij meerdere van de optische vezels volgens conclusie 8 in een kabel zijn opgenomen.

Fig.1



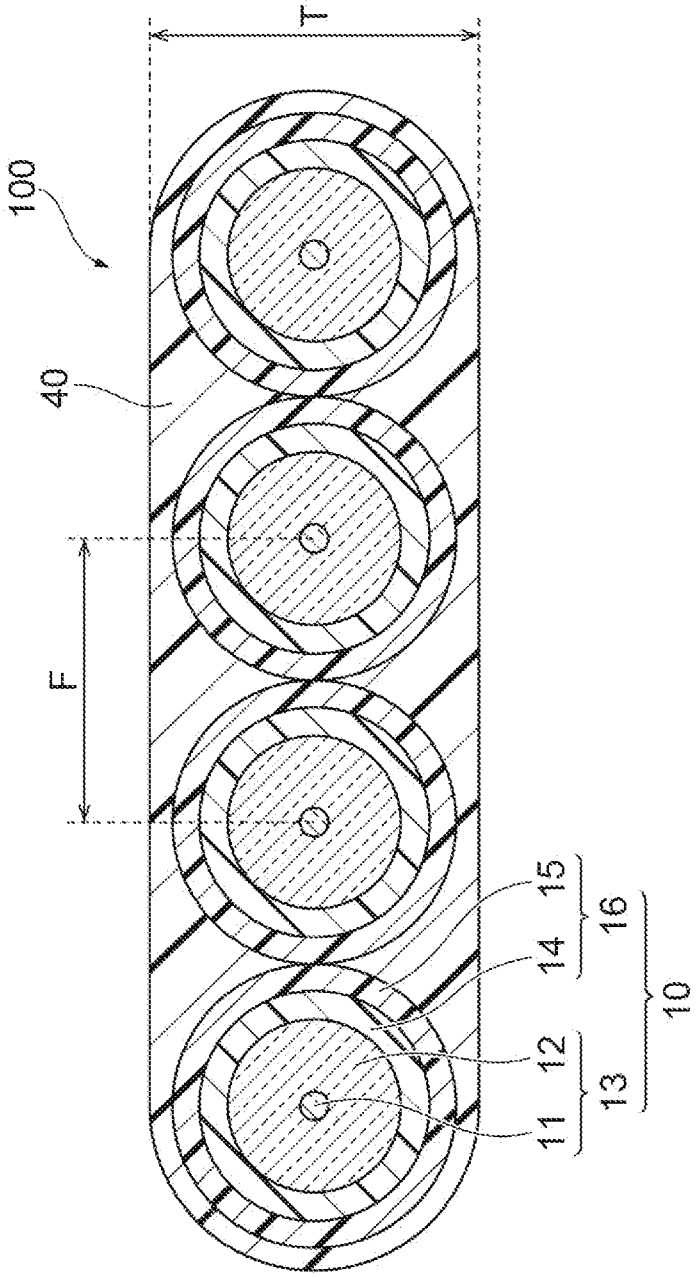
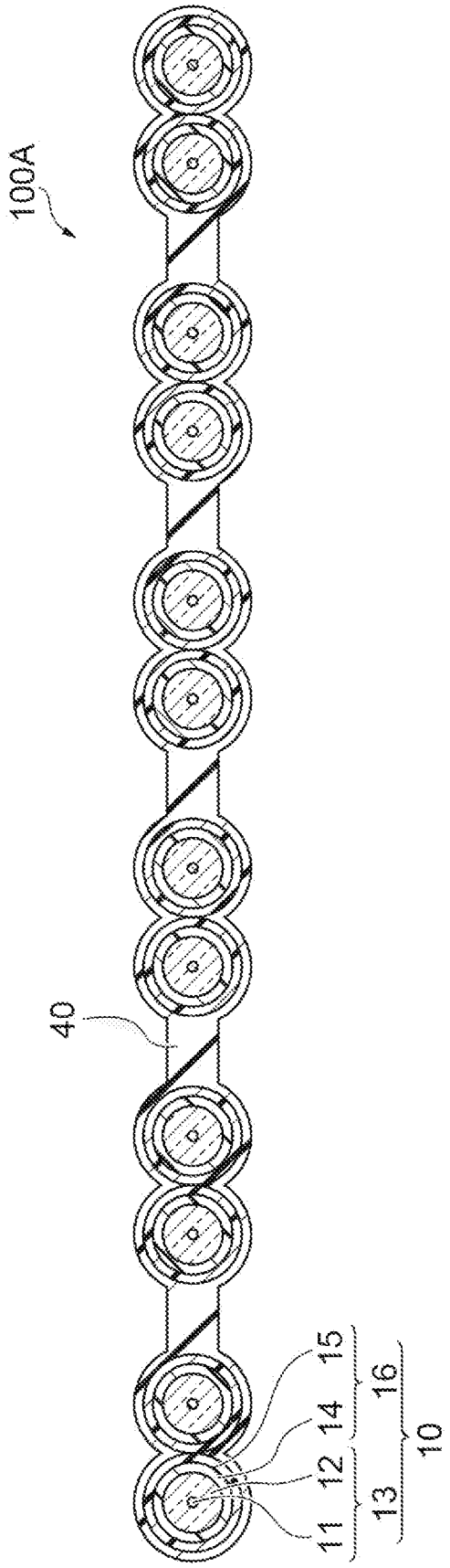


Fig.2

Fig.3



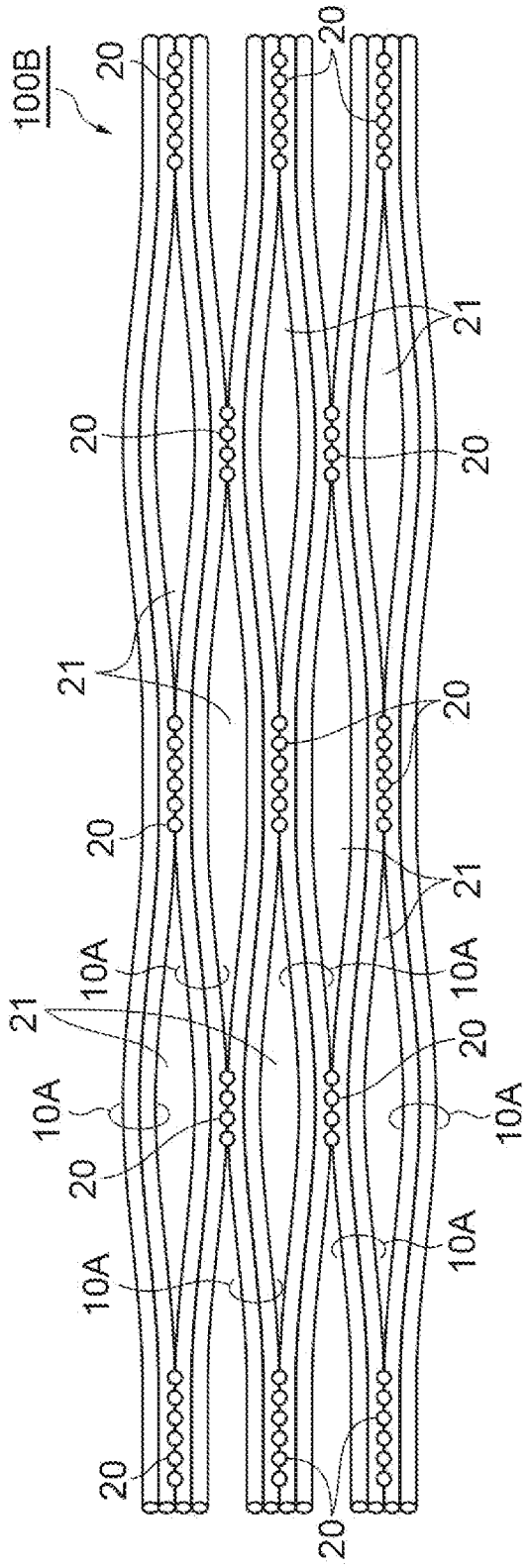


Fig.4

Fig.5

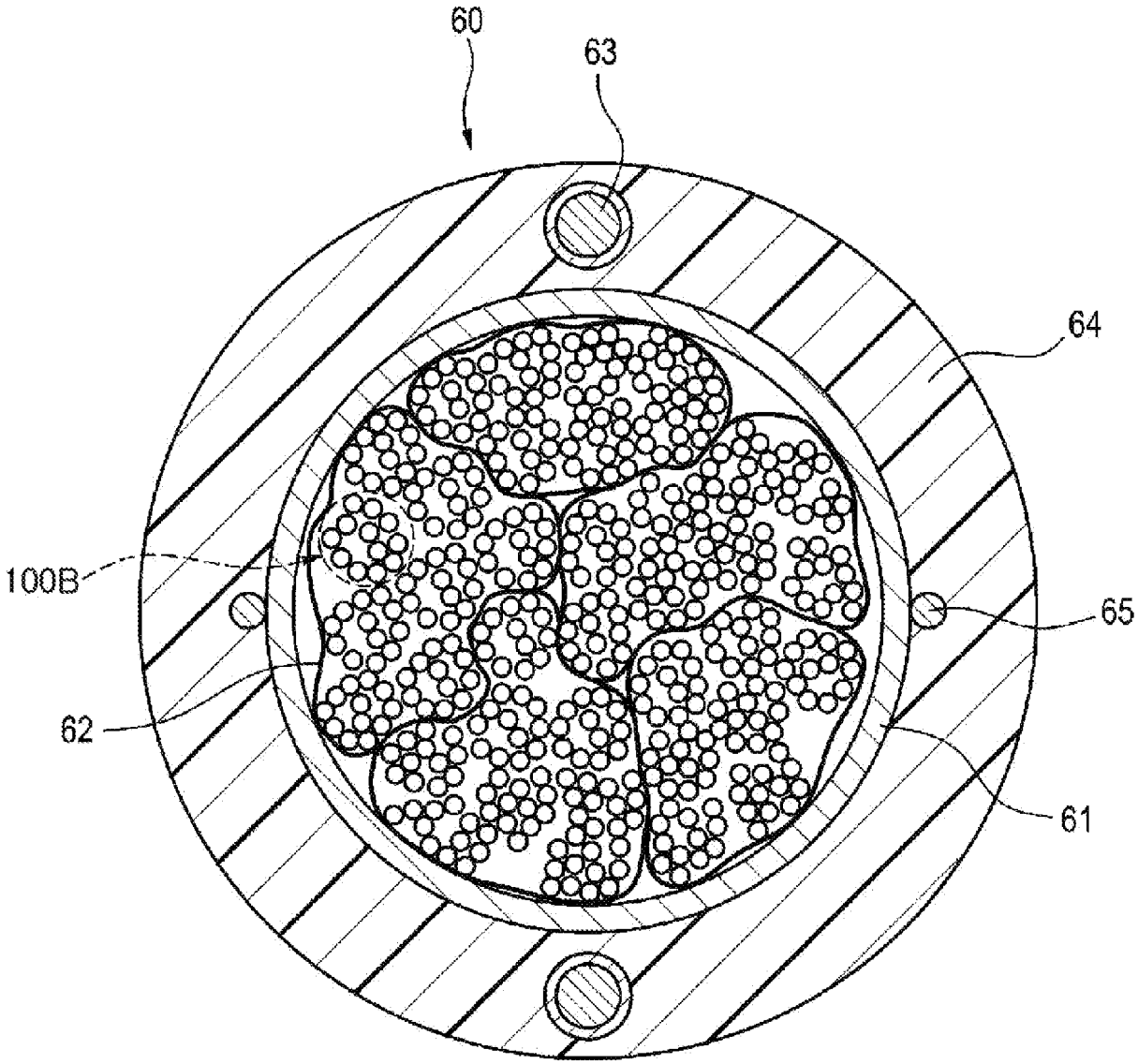
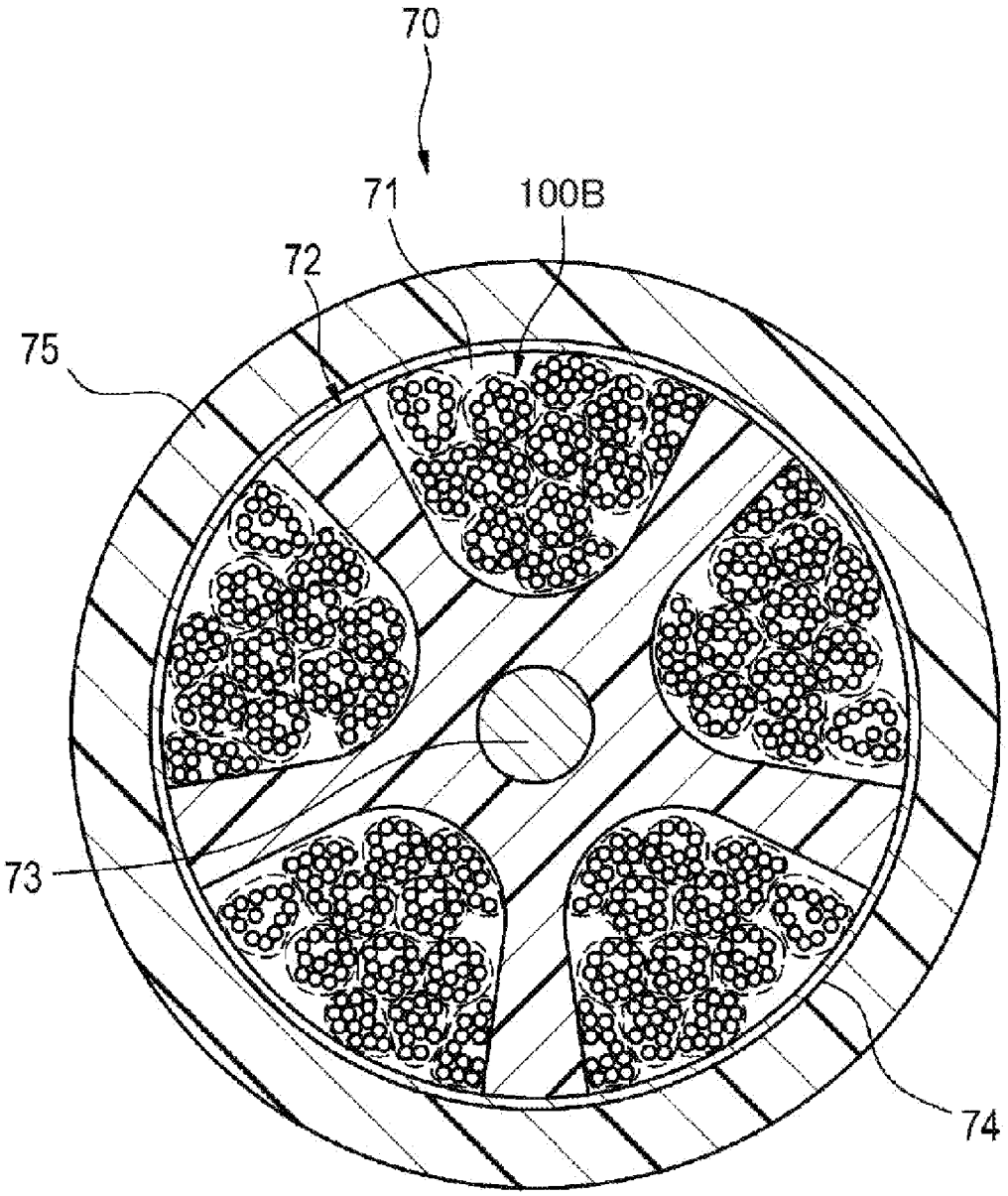


Fig.6



Rijksdienst voor Ondernemend Nederland

OCTROOIAANVRAAG NR.:
NO 142856
NL 2034194

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)
X	WO 01/49624 A2 (CORNING INC [US]) 12 juli 2001 (2001-07-12)	1,2,5,7,	INV.
A	* voorbeelden *	8,10 3,4,6,9, 11-13	C03C25/1065 C03C25/285 G02B6/02
	-----		C03C25/106
A	WO 2021/145103 A1 (SUMITOMO ELECTRIC INDUSTRIES [JP]) 22 juli 2021 (2021-07-22) * alinea [0074] * -----	1-13	C08F222/10 C09D4/00

Onderzochte gebieden van de techniek

C03C
C09J
C09D
G02B
C08F

Indien gewijzigde conclusies zijn ingediend, heeft dit rapport betrekking op de conclusies ingediend op:

Plaats van onderzoek:	Datum waarop het onderzoek werd voltooid:	Bevoegd ambtenaar:
München	18 september 2023	Pollio, Marco

[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 octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding
E: eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven
D: in de octrooiaanvrage vermeld
L: om andere redenen vermelde literatuur
&: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

EOB FORM 02.83 (P0414B)

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

NO 142856
NL 2034194

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.

18-09-2023

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
WO 0149624 A2	12-07-2001	AU 4502101 A	16-07-2001
		CA 2395531 A1	12-07-2001
		CN 1437621 A	20-08-2003
		DE 60032944 T2	18-10-2007
		EP 1263823 A2	11-12-2002
		JP 4958360 B2	20-06-2012
		JP 2003519076 A	17-06-2003
		KR 20020067061 A	21-08-2002
		WO 0149624 A2	12-07-2001
WO 2021145103 A1	22-07-2021	CN 114845968 A	02-08-2022
		EP 4092001 A1	23-11-2022
		JP WO2021145103 A1	22-07-2021
		US 2023049256 A1	16-02-2023
		WO 2021145103 A1	22-07-2021

Algemene informatie over dit aanhangsel is gepubliceerd in de 'Official Journal' van het Europees Octrooibureau nr 12/82 blz 448 ev

SCHRIFTELIJKE OPINIE

DOSSIER NUMMER	INDIENINGSDATUM	VOORRANGSDATUM	AANVRAAGNUMMER
NO142856	21.02.2023	24.02.2022	NL2034194

CLASSIFICATIE
INV. C03C25/1065 C03C25/285 G02B6/02 C03C25/106 C08F222/10 C09D4/00

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

Aanvraag nr.:

SCHRIFTELIJKE OPINIE

NL2034194

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	3, 4, 6, 9, 11-13
	Nee:	Conclusies	1, 2, 5, 7, 8, 10
Inventiviteit	Ja:	Conclusies	3, 4, 6, 9, 11-13
	Nee:	Conclusies	1, 2, 5, 7, 8, 10
Industriële toepasbaarheid	Ja:	Conclusies	1-13
	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 01/49624 A2 (CORNING INC [US]) 12 juli 2001 (2001-07-12)
D2	WO 2021/145103 A1 (SUMITOMO ELECTRIC INDUSTRIES [JP]) 22 juli 2021 (2021-07-22)

The present application does not meet the criteria of patentability, because the subject-matter of claims 1, 2, 5, 7, 8 and 10 is not new.

1) Document D1 discloses (see examples R, S, T, U) a composition comprising a resin composition suitable for primary coating of an optical fiber, comprising a photopolymerization initiator, a urethane (meth)acrylate and an ethylene oxide chain-containing (meth)acrylate, namely SR 602, an ethoxylated bisphenol A di-acrylate. The value obtained by dividing the weight of the ethylene oxide chain of the ethylene oxide chain-containing (meth)acrylate by a molecular weight of the ethylene oxide chain-containing (meth)acrylate is 0.72.
Document D1 discloses a method of coating optical fiber adding the composition and curing it.
Fulfilling the claimed composition the properties of claims 7 and 8 are regarded as being fulfilled.
Therefore, claims 1, 2, 5, 7, 8 and 10 are not new over document D1.

2) Document D2 discloses (see paragraph [0074]) a coating composition comprising a photopolymerization initiator, a urethane (meth)acrylate and an ethylene oxide chain-containing (meth)acrylate. The value obtained by dividing the weight of the ethylene oxide chain of the ethylene oxide chain-containing (meth)acrylate by a molecular weight of the ethylene oxide chain-containing (meth)acrylate is below 0.50.

3) It is reminded that in order to positively asses the presence of an inventive step over the whole claimed scope, it shall be proven or at least made credible that the technical problem is solved over the whole claimed scope. In cases where a composition is claimed, it is unlikely that the problem is solved over the whole claimed scope if the quantities of the components is not claimed.

Re Item VIII

Certain observations on the application

1) Claim 1 is characterised by a ratio of the molecular weight of a part of a component over the molecular weight of the whole component. At a first glance one would understand that an homopolymeric ethylene oxide chain is meant. Nevertheless, taking into account claim 5 it is understood that also copolymers of ethylene oxide are meant. Furthermore, it is not clear how the parameter is exactly defined. In fact it is not clear whether one shall divide the whole weight of the ethylene oxide containing chain or only the ethylene oxide part. Additionally, it is not clear which atoms shall be regarded as belonging to the ethylenoxide chain. It remains unclear whether the oxygen derived from the acrylate shall be calculated with the ethylene oxide chain or not.

2) Claims 7 and 8 are characterised by parameters, which also represent results to be achieved.

3) It is noticed that claim 10 is not limited by providing a primary coating when using the composition.