

DESCRIPTION

PHOTOCURABLE COMPOSITION, ARTIFICIAL NAIL, METHOD FOR GENERATING SHAPING DATA, METHOD FOR PRODUCING ARTIFICIAL NAIL, AND SYSTEM FOR PRODUCING ARTIFICIAL NAIL

Technical Field

[0001] The present invention relates to a photocurable composition, an artificial nail, a method of generating shaping data of an artificial nail, a method of producing an artificial nail, and a system for producing an artificial nail.

Background Art

[0002] Nail arts for performing a nail care, a care of a fingernail and a toenail such as a manicure and a pedicure, makeup, and decoration are spreading. In recent years, a nail art such as a nail tip, sculpture, and a tip overlay using a decorated artificial nail (that is, artificial nail) is becoming popular.

[0003] Nail arts refer to making up and decorating a fingernail and a toenail. A store which performs nail arts is referred to as nail salon, and a technician who performs the nail art is referred to as a manicurist. Various nail art products are on the market, and many women are performing professional-level nail art on their own.

In the 19th century, a lacquer paint for automobiles was invented in the United States, and a manicure currently in use was developed by applying the invented lacquer paint.

However, although the manicure to which the lacquer paint is applied is still widely spread, there is a problem in that the manicure has poor adhesion with a natural nail and is peeled off and detached in a short period after treatment. For this reason, an artificial nail material to which a room temperature curing resin for dental use is applied have been developed.

[0004] The artificial nail material is excellent in strength and durability compared with the manicure to which the lacquer paint is applied and as a result, accepted by some manicurists, but the artificial nail material has bad treatment operability in addition to irritation, irritating odor, and the like derived from an acrylic monomer and as a result, is not widely available to common manicurists.

In recent years, however, a gel nail which has improved the irritating odor and the treatment operability of the artificial nail material is emerging in the market. A gel nail currently marketed is a high-viscosity liquid material containing a (meth)acrylic monomer and a photopolymerization initiator as a main component, and the high-viscosity liquid material is

applied to a bare nail and cured by being irradiated with ultraviolet light. The commercially available gel nail has less odor irritation and skin irritation, and has excellent treatment operability as compared with the artificial nail material at the beginning of development, and therefore is accepted by the majority of common manicurists.

Japanese Patent Application Laid-Open (JP-A) No. 2010-37330 discloses an artificial nail composition characterized in that a specific photopolymerization initiator is used for an artificial nail composition having improved curability.

[0005] JP-A No. 2010-110451 discloses, as an artificial nail having a natural appearance matching individual nails as well as having excellent fitting property, an artificial nail including an outer layer having a nail shape and an inner layer directly or indirectly attached to the outer layer and having a multilayered structure in which a cross section perpendicular to a center axis in a longitudinal direction of the artificial nail as a whole is formed in a desired bent state by cooperation of the outer layer and the inner layer.

In addition, JP-A No. 2015-209375 discloses an artificial nail raw material composition cured by light irradiation as an artificial nail raw material composition capable of easily removing an artificial nail from a natural nail.

[0006] In recent years, a three-dimensional shaping device called a so-called three-dimensional (3D) printer has been developed, and used in various fields. In a case in which the 3D printer is applied to the field of nail art, a certain degree of hardness is required for the produced artificial nail, and a curing step is required to produce the artificial nail. However, the artificial nail is deformed due to curing contraction while curing. For this reason, there is a problem in that production accuracy is reduced and high fitting feeling is not obtained in a case in which the artificial nail is mounted.

SUMMARY OF INVENTION

Technical Problem

[0007] An object of the present invention is to provide a photocurable composition, an artificial nail, a method of generating shaping data capable of producing an artificial nail with high accuracy, a method of producing an artificial nail, and a system for producing an artificial nail.

[0008] In recent years, a three-dimensional printer (that is, 3D printer) has been developed and applied to various fields. In a case in which a 3D printer is applied to the field of nail art, an ordinary curable resin for a gel nail is considered to be used by being directly applied to a bare nail and cured, is not suitable for application of nail tip preparation by an optical shaping method, and has a problem in a flexural strength, a flexural modulus, a bending resistance, a

tensile strength, an elongation rate, and the like of a cured product.

In a case in which an optically shaped product, preferably, an artificial nail is produced using the 3D printer, excellent flexural strength (that is, flexural strength), flexural modulus, flexural resistance, tensile strength, and elongation rate are required for the photocurable composition photocured.

[0009] That is, an object of an embodiment of the invention is to provide a photocurable composition which is used for optical shaping and which is excellent in flexural strength and flexural modulus, and furthermore excellent in bending resistance, tensile strength, and elongation rate after photocuring.

Another object of an embodiment of the invention is to provide an artificial nail which is a cured product of the photocurable composition and is excellent in flexural strength and flexural modulus, and furthermore excellent in bending resistance, tensile strength, and elongation rate.

Solution to Problem

[0010] As a result of intensive studies, the present inventors found that a photocurable composition containing a combination of specific monomer species is excellent in flexural strength and flexural modulus, and furthermore excellent in bending resistance, tensile strength, and elongation rate after photocuring, and is particularly suitable for producing an artificial nail by optical shaping, and completed the invention.

That is, specific means for solving the above problems are as follows.

[0011] [1] A photocurable composition used for optical shaping, comprising:

a (meth)acrylic monomer (X) which is at least one selected from di(meth)acrylic monomers that have no hydroxyl group and no carboxy group and that have two aromatic rings and two (meth)acryloyloxy groups in one molecule, and which has a weight average molecular weight of 400 or more and 800 or less;

a (meth)acrylic monomer (D) which is at least one selected from (meth)acrylic monomers that have at least one ring structure and one (meth)acryloyloxy group in one molecule, and which has a weight average molecular weight of 130 or more and 350 or less; and

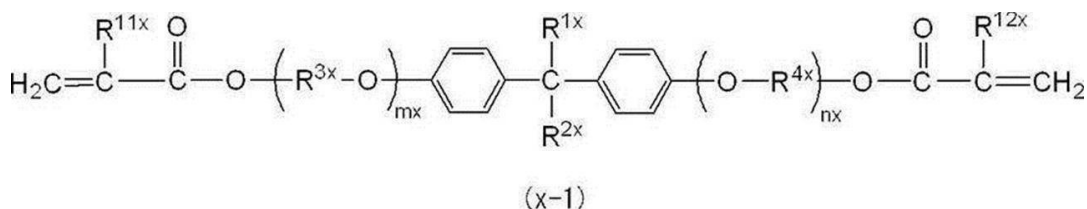
a photopolymerization initiator.

[2] The photocurable composition described in [1], in which at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) has an ether bond in one molecule.

[3] The photocurable composition described in [1] or [2], in which at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) has 1 or more 10 or

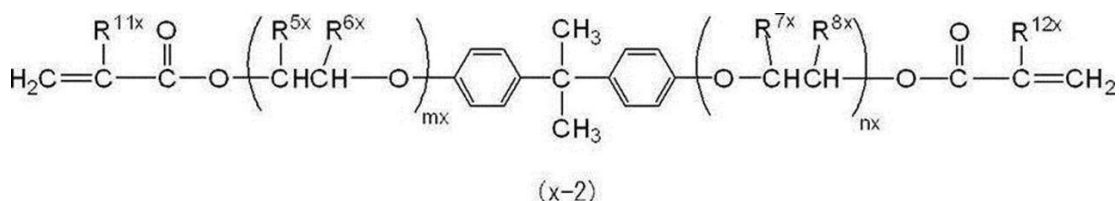
less ether bonds in one molecule.

[0012] [4] The photocurable composition according to any one of [1] to [3], wherein at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) is a compound represented by the following Formula (x-1):



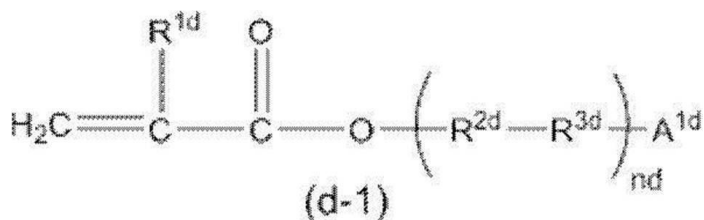
wherein, in Formula (x-1), each of $\text{R}^{1\text{x}}$, $\text{R}^{2\text{x}}$, $\text{R}^{11\text{x}}$, and $\text{R}^{12\text{x}}$ independently represents a hydrogen atom or a methyl group, each of $\text{R}^{3\text{x}}$ and $\text{R}^{4\text{x}}$ independently represents a linear or branched alkylene group having from 2 to 4 carbon atoms, each of mx and nx independently represents from 0 to 10, and satisfies a relationship of $1 \leq (\text{mx} + \text{nx}) \leq 10$.

[0013] [5] The photocurable composition according to any one of [1] to [4], wherein at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) is a compound represented by the following Formula (x-2):



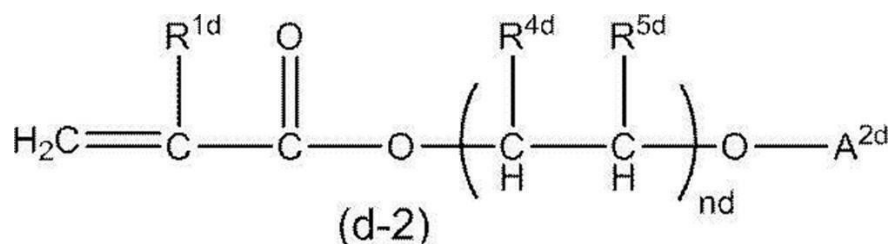
wherein, in Formula (x-2), each of $\text{R}^{5\text{x}}$, $\text{R}^{6\text{x}}$, $\text{R}^{7\text{x}}$, $\text{R}^{8\text{x}}$, $\text{R}^{11\text{x}}$, and $\text{R}^{12\text{x}}$ independently represents a hydrogen atom or a methyl group, each of mx and nx independently represents from 0 to 10, and satisfies a relationship of $1 \leq (\text{mx} + \text{nx}) \leq 10$.

[0014] [6] The photocurable composition according to any one of [1] to [5], wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a compound represented by the following Formula (d-1):



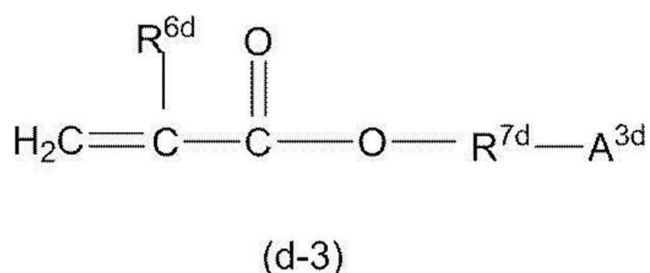
wherein, in Formula (d-1), $\text{R}^{1\text{d}}$ represents a hydrogen atom or a methyl group, $\text{R}^{2\text{d}}$ represents a single bond or a linear or branched alkylene group having from 1 to 5 carbon atoms, $\text{R}^{3\text{d}}$ represents a single bond, an ether bond ($-\text{O}-$), an ester bond ($-\text{O}-\text{C}(=\text{O})-$), or $-\text{C}_6\text{H}_4-\text{O}-$, $\text{A}^{1\text{d}}$ represents an aromatic ring which may have a substituent, and nd represents 1 or 2.

[0015] [7] The photocurable composition according to [6], wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a compound represented by the following Formula (d-2):



wherein, in Formula (d-2), each of $\text{R}^{1\text{d}}$, $\text{R}^{4\text{d}}$, and $\text{R}^{5\text{d}}$ independently represents a hydrogen atom or a methyl group, $\text{A}^{2\text{d}}$ represents an aromatic ring which may have a substituent, and nd represents 1 or 2.

[0016] [8] The photocurable composition according to any one of [1] to [5], wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a compound represented by the following Formula (d-3):



wherein, in Formula (d-3), $\text{R}^{6\text{d}}$ represents a hydrogen atom or a methyl group, $\text{R}^{7\text{d}}$ represents a single bond or a methylene group, and $\text{A}^{3\text{d}}$ represents a ring structure other than an aromatic ring.

[0017] [9] The photocurable composition according to [8], wherein the ring structure other than an aromatic ring is a ring structure having a dicyclopentenyl skeleton, a ring structure having a dicyclopentanyl skeleton, a ring structure having a cyclohexane skeleton, a ring structure having a tetrahydrofuran skeleton, a ring structure having a morpholine skeleton, a ring structure having an isobornyl skeleton, a ring structure having a norbornyl skeleton, a ring structure having a dioxolane skeleton, or a ring structure having a dioxane skeleton.

[10] The photocurable composition according to any one of [1] to [5], wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a (meth)acrylic monomer which has at least one ring structure, one hydroxyl group, and one (meth)acryloyloxy group in one molecule.

[11] The photocurable composition according to any one of [1] to [6], wherein the (meth)acrylic monomer (D) is o-phenylphenol EO-modified acrylate.

[12] The photocurable composition according to any one of [1] to [6], wherein the (meth)acrylic monomer (D) is 3-phenoxybenzyl acrylate.

[0018] [13] The photocurable composition according to any one of [1] to [12], wherein a content of the acrylic monomer (X) is 200 parts by mass or more with respect to 1000 parts by mass of a total content of (meth)acrylic monomers.

[14] The photocurable composition according to any one of [1] to [13], wherein a content of the acrylic monomer (D) is from 30 parts by mass to 800 parts by mass with respect to 1000 parts by mass of a total content of (meth)acrylic monomers.

[15] The photocurable composition according to any one of [1] to [14], wherein the photopolymerization initiator is at least one selected from an alkylphenone-based compound or an acylphosphine oxide-based compound.

[16] The photocurable composition according to any one of [1] to [15], wherein a content of the photopolymerization initiator is from 1 part by mass to 50 parts by mass with respect to 1000 parts by mass of a total content of (meth)acrylic monomers.

[0019] [17] The photocurable composition according to any one of [1] to [16], wherein a viscosity at 25°C and 50 rpm, which is measured using an E-type viscometer, is from 20 mPa·s to 3000 mPa·s.

[18] The photocurable composition according to any one of [1] to [17], wherein the photocurable composition is used for producing an artificial nail by optical shaping.

[19] An artificial nail comprising a cured product of the photocurable composition according to [18].

[0020] In addition, specific aspects of a method of generating shaping data capable of producing an artificial nail with high accuracy, a method of producing an artificial nail, and a system for producing an artificial nail are as follows.

<1> A method of generating shaping data, comprising:

- a receiving step of receiving shape information specifying a three-dimensional external shape of an artificial nail to be formed;

- a predicting step of predicting, based on predetermined prediction information, a contraction state of a shaped product which is optically shaped by a three-dimensional shaping device based on three-dimensional shaping data and predetermined shaping information and then is photocured by a curing device under a predetermined curing condition;

- a generating step of generating the three-dimensional shaping data to optically shape the shaped product of the artificial nail to be formed by the three-dimensional shaping device by correcting three-dimensional shape data, of the artificial nail to be formed, obtained from

the shape information based on a prediction result obtained in the predicting step; and

an outputting step of outputting the shaping data generated in the generating step.

[0021] <2> The method of generating shaping data according to <1>, wherein the prediction information includes shaping information indicating a shaping condition including the three-dimensional shaping device and an optical shaping material used for optical shaping in the three-dimensional shaping device and curing information indicating the curing condition.

<3> The method of generating shaping data according to <1> or <2>, wherein the prediction information includes shape data of the artificial nail produced in advance, shaping data generated from the shape data, and three-dimensional post-curing data representing an external shape after the curing of the shaped product which is optically shaped and photocured based on the shaping data.

[0022] <4> The method of generating shaping data according to any one of claims <1> to <3>, comprising:

an acquiring step of acquiring three-dimensional post-curing data representing the external shape of the shaped and cured product which is optically shaped and photocured based on the shaping data; and

an updating step of updating the prediction information based on the post-curing data acquired in the acquiring step, the shape data of the formed artificial nail for the post-curing data, the prediction result predicted for the shape data in the predicting step, and the shaping data which are generated based on the prediction result.

[0023] <5> The method of generating shaping data according to any one of claims <1> to <4>, comprising: a combining step of combining the shaping data of a plurality of artificial nails to be formed, such that the plurality of artificial nails to be formed are arranged on a base plate and integrally formed by the three-dimensional shaping device.

<6> The method of generating shaping data according to claim <5>, wherein the combining step includes providing data, in which identification information, specifying each of the plurality of artificial nails to be formed, is formed on the base plate.

<7> The method of generating shaping data according to claim <5> or <6>, wherein in the combining step, the shaping data is combined such that each of a plurality of base plates, on which the plurality of artificial nails to be formed are arranged, is optically shaped in parallel by the three-dimensional shaping device.

[0024] <8> A method of producing an artificial nail, comprising:

a receiving step of receiving shape information specifying a three-dimensional external shape of an artificial nail to be formed;

a predicting step of predicting, based on predetermined prediction information, a

contraction state of a shaped product which is optically shaped by a three-dimensional shaping device based on three-dimensional shaping data and predetermined shaping information and then is photocured by a curing device under a predetermined curing condition;

a generating step of generating the three-dimensional shaping data to optically shape the shaped product of the artificial nail to be formed by the three-dimensional shaping device by correcting three-dimensional shape data, of the artificial nail to be formed, obtained from the shape information based on a prediction result obtained in the predicting step;

a shaping step of generating the shaped product by the three-dimensional shaping device based on the shaping data generated in the generating step; and

a curing step of further photocuring the shaped product shaped in the shaping step.

[0025] <9> The method of producing an artificial nail according to <8>, comprising:

an acquiring step of acquiring three-dimensional post-curing data, representing the external shape of the shaped product, from the post-curing shaped product photocured in the curing step; and

an evaluating step of evaluating the post-curing shaped product by comparing the post-curing data with the shape data of the artificial nail to be formed.

<10> The method of producing an artificial nail according to <8> or <9>, comprising:

an updating step of updating the prediction information based on an evaluation result obtained in the evaluating step.

<11> The method of producing an artificial nail according to any one of claims <8> to <10>, comprising: a washing step of removing excess optical shaping material, used for optically shaping the shaped product, from the shaped product optically shaped in the shaping step, prior to the curing step.

[0026] <12> A system for producing an artificial nail, comprising:

a three-dimensional shaping device which optically shapes a three-dimensional shaped product based on three-dimensional shaping data to be input;

a curing device which photocures the shaped product optically shaped by the three-dimensional shaping device; and

a shaping design device which includes a receiving unit receiving shape information specifying a three-dimensional external shape of an artificial nail to be formed, a prediction unit predicting, based on predetermined stored prediction information, a contraction state of a shaped product which is optically shaped by the three-dimensional shaping device based on the three-dimensional shaping data and predetermined shaping information and then is photocured by the curing device under a predetermined curing condition, a generation unit

generating three-dimensional shaping data to optically shape the shaped product of the artificial nail to be formed by the three-dimensional shaping device by correcting three-dimensional shape data of the formed artificial nail obtained from the shape information based on a prediction result obtained from the prediction unit, and an output unit outputting the shaping data to the three-dimensional shaping device.

[0027] <13> The system for producing an artificial nail according to <12>, wherein the prediction information includes shaping information indicating a shaping condition including the three-dimensional shaping device and an optical shaping material used for shaping in the three-dimensional shaping device and curing information indicating the curing condition.

<14> The system for producing an artificial nail according to <12> or <13>, wherein the prediction information stored in the shaping design device includes shape data of the artificial nail produced in advance, shaping data generated from the shape data, and three-dimensional post-curing data representing an external shape after the curing of the shaped product which is optically shaped and photocured based on the shaping data.

<15> The system for producing an artificial nail according to any one of <12> to <14>, wherein the shaping design device includes:

an acquisition unit which acquires three-dimensional post-curing data representing the post-curing external shape of the shaped product which is optically shaped and photocured based on the shaping data; and

an updating unit which updates the post-curing data acquired in the acquiring unit, the shape data of the formed artificial nail for the post-curing data, the prediction result predicted for the shape data in the prediction unit, and the prediction information based on the shaping data which is generated based on the prediction result.

[0028] <16> The system for producing an artificial nail according to any one of <12> to <15>, wherein the shaping design device includes a combination unit that combines the shaping data of a plurality of artificial nails to be formed such that the plurality of artificial nails to be formed are arranged on a base plate and integrally formed by the three-dimensional shaping device.

<17> The system for producing an artificial nail according to <16>, wherein the combination unit of the shaping design device provides data including identification information specifying each of the plurality of artificial nails formed on the base plate.

<18> The system for producing an artificial nail according to <16> or <17>, wherein the combination unit of the shaping design device combines the shaping data such that each of a plurality of base plates, on which the plurality of artificial nails to be formed are arranged, is shaped in parallel by the three-dimensional shaping device.

[0029] <19> The system for producing an artificial nail according to any one of <12> to <18>, comprising:

an acquisition unit which acquires three-dimensional post-curing data representing the external shape of the shaped product, from the post-curing shaped product photocured by the curing device; and

an evaluation device that includes an evaluation unit which evaluates the post-curing shaped product by comparing the post-curing data with the shape data of the formed artificial nail.

<20> The system for producing an artificial nail according to <19>, wherein the shaping design device includes an updating unit that updates the prediction information based on an evaluation result of the evaluation unit of the evaluation device.

Advantageous Effects of Invention

[0030] As described above, according to an embodiment of the invention, it is possible to obtain a shaping data capable of producing an artificial nail with high accuracy. Also, according to an embodiment of the invention, it is possible to produce an artificial nail with high accuracy.

[0031] According to an embodiment of the invention, there is provided a photocurable composition which is used for optical shaping and which is excellent in flexural strength and flexural modulus, and furthermore excellent in bending resistance and elongation rate.

In addition, according to an embodiment of the invention, there is provided an artificial nail which is a cured product of a photocurable composition and is excellent in flexural strength and flexural modulus, and furthermore excellent in bending resistance and elongation rate.

BRIEF DESCRIPTION OF DRAWINGS

[0032] Fig. 1 is a flowchart showing a method of producing an artificial nail according to the present embodiment.

Fig. 2 is a perspective view schematically showing an artificial nail to be formed and an artificial nail cured.

Fig. 3 is a block diagram showing a configuration of a shaping design system according to the embodiment.

Fig. 4 is a flowchart showing a step of producing an artificial nail.

Fig. 5 is a perspective view showing an example of a shaped product which is optically shaped.

DESCRIPTION OF EMBODIMENTS

[0033] In the present specification, a numerical range represented using “to” means a range including numerical values described before and after “to” as a lower limit value and an upper limit.

Further, in the present specification, an “ether bond” is usually defined, and refers to a bond (that is, a bond represented by -O-) connecting between two hydrocarbon groups by an oxygen atom. Accordingly, “-O-” in an ester bond (that is, -C(=O)-O-) does not correspond to the “ether bond”.

In addition, in the present specification, a “(meth)acrylic monomer” is a concept including both an acrylic monomer and a methacrylic monomer.

In addition, in the present specification, “(meth)acrylate” is a concept including both acrylate and methacrylate.

In addition, in the present specification, a “(meth)acryloyloxy group” is a concept including both an acryloyloxy group and a methacryloyloxy group.

[0034] [Photocurable Composition]

A photocurable composition according to an embodiment of the invention is a photocurable composition used for optical shaping and contains a (meth)acrylic monomer (X) which is at least one selected from di(meth)acrylic monomers which have no hydroxyl group and carboxy group and have two aromatic rings and two (meth)acryloyloxy groups in one molecule, and has a weight average molecular weight of 400 or more and 800 or less, a (meth)acrylic monomer (D) which is at least one selected from (meth)acrylic monomers which have at least one ring structure and one (meth)acryloyloxy group in one molecule, and has a weight average molecular weight of 130 or more and 350 or less, and a photopolymerization initiator.

[0035] The photocurable composition according to an embodiment of the invention contains a combination of the acrylic monomer (X) and the (meth)acrylic monomer (D) to improve flexural strength and flexural modulus, and furthermore bending resistance and elongation rate after photocuring.

Accordingly, an optically shaped product, preferably, an artificial nail which is produced by optical shaping using the photocurable composition of the embodiment is also excellent in both flexural strength and flexural modulus, and furthermore excellent in bending resistance and elongation rate. In addition, the photocurable composition according to the embodiment has a viscosity suitable for producing an artificial nail or the like (that is, an example of a preferred form of the optically shaped product, which shall apply hereinafter) by

the optical shaping. In this case, the viscosity is in a range in which the flexural strength, the flexible modulus, the bending resistance, the tensile strength, and the elongation rate after photocuring are suitable for the artificial nail. That is, the photocurable composition according to the embodiment can be a photocurable artificial nail composition.

[0036] In the present specification, a “(meth)acrylic monomer component” refers to the entire (meth)acrylic monomer contained in the photocurable composition.

The “(meth)acrylic monomer component” includes at least a (meth)acrylic monomer (X) and a (meth)acrylic monomer (D).

The “(meth)acrylic monomer component” may contain other (meth)acrylic monomers.

[0037] The photocurable composition according to the embodiment includes the (meth)acrylic monomer (X) to increase the flexural strength and the flexural modulus after photocuring, as compared with a case of containing a (meth)acrylic monomer which has no hydroxyl group and carboxy group and has one aromatic ring and one (meth)acryloyloxy groups in one molecule instead of the (meth)acrylic monomer (X).

[0038] The photocurable composition according to the embodiment includes the (meth)acrylic monomer (X) to suppress the phenomenon that crystallinity of a monomer becomes too high and to reduce a viscosity of the photocurable composition, as compared with a case of using a (meth)acrylic monomer which has no hydroxyl group and carboxy group and has one aromatic ring and two (meth)acryloyloxy groups in one molecule instead of the (meth)acrylic monomer (X).

[0039] The photocurable composition according to the embodiment includes the (meth)acrylic monomer (X) to reduce the viscosity of the photocurable composition, as compared with a case of using a (meth)acrylic monomer which has no hydroxyl group and carboxy group and has three or more aromatic rings in one molecule instead of the (meth)acrylic monomer (X).

[0040] The photocurable composition includes the (meth)acrylic monomer (X) to improve the bending resistance, the tensile strength, and the elongation rate after photocuring, as compared with a case of using a (meth)acrylic monomer which has no hydroxyl group and carboxy group and has three or more (meth)acryloyloxy groups in one molecule instead of the (meth)acrylic monomer (X).

[0041] The upper limit of a weight average molecular weight of the (meth)acrylic monomer (X) of 800 is an upper limit is set from the viewpoint of the flexural strength and the flexural modulus after photocuring.

In addition, the lower limit of the weight average molecular weight of the

(meth)acrylic monomer (X) of 400 is set from the viewpoint of ease of production or availability of a monomer.

[0042] The photocurable composition according to the embodiment includes the (meth)acrylic monomer (D) to improve the bending resistance after photocuring. In addition, the photocurable composition includes the (meth)acrylic monomer (D) to improve the flexural strength, the flexural modulus, the bending resistance, the tensile strength, and the elongation rate in a well-balanced manner after photocuring.

Although the reason is not clear, it is considered that the (meth)acrylic monomer (D) includes at least one ring structure to make an intermolecular force between a ring structure of the (meth)acrylic monomer (X) and a ring structure of the (meth)acrylic monomer (D) and an intermolecular force between the ring structures of the (meth)acrylic monomer (D) strong, thereby improving the bending resistance.

The upper limit of a weight average molecular weight of the (meth)acrylic monomer (D) of 350 is an upper limit is set from the viewpoint of the flexural strength and the flexural modulus after photocuring.

The lower limit of the weight average molecular weight of the (meth)acrylic monomer (D) of 130 is set from the viewpoint of ease of production or availability of a monomer.

[0043] The photocurable composition according to the embodiment preferably satisfies the following flexural strength and flexural modulus after photocuring, from the viewpoint of practicality of the obtained artificial nail and the like.

That is, the photocurable composition according to the embodiment is shaped to have a size of 80 mm × 10 mm × 4 mm thickness to obtain a shaped product, the resulting shaped product is irradiated with ultraviolet light under a condition of 5 J/cm² and photocured to obtain an optically shaped product (that is, a cured product, which shall apply hereinafter). In a case in which the flexural strength of the optically shaped product is measured in accordance with ISO178 (or JIS K7171), the flexural strength of the optically shaped product is preferably 10 MPa or more, more preferably 40 MPa or more, and still more preferably 60 MPa or more.

In addition, the photocurable composition according to the embodiment is shaped to have a size of 80 mm × 10 mm × 4 mm thickness to obtain a shaped product, the resulting shaped product is irradiated with ultraviolet light under a condition of 5 J/cm² and photocured to obtain an optically shaped product. In a case in which the flexural modulus of the optically shaped product is measured in accordance with ISO178 (or JIS K7171), the flexural modulus of the optically shaped product is preferably 400 MPa or more, more preferably 1500

MPa or more, and still more preferably 2000 MPa or more.

[0044] The photocurable composition according to the embodiment preferably satisfies the following bending resistance after photocuring, from the viewpoint of practicality of the obtained artificial nail and the like.

That is, a photocurable resin composition is shaped to have an outer diameter of 8 mm, an inner diameter of 7.5 mm (thickness of 0.5 mm), a circumference of 90°, and a length of 15 mm using a 3D printer, and is photocured by being irradiated with ultraviolet light having a wavelength of 365 nm under the condition of 5 J/cm² to obtain an optically shaped product, five pieces of the resulting shaped product are placed under one metal cube having a size of 50 mm long, 50 mm wide, and 50 mm high, and the metal cube is applied with a load of 20 kg weight from above, and it is preferable that the five pieces of the shaped product maintain the shape without breaking in a case in which it is visually checked.

[0045] The photocurable resin composition according to the embodiment is shaped to have an outer diameter of 8 mm, an inner diameter of 7 mm (thickness of 1.0 mm), a circumference of 90°, and a length of 15 mm using a 3D printer, and is photocured by being irradiated with ultraviolet light having a wavelength of 365 nm under the condition of 5 J/cm² to obtain an optically shaped product, five pieces of the resulting shaped product are placed under one metal cube having a size of 50 mm long, 50 mm wide, and 50 mm high, and the metal cube is applied with a load of 20 kg weight from above, and it is preferable that the five pieces of the shaped product maintain the shape without breaking in a case in which it is visually checked.

[0046] The photocurable composition according to the embodiment preferably satisfies the following tensile strength and the elongation rate after photocuring, from the viewpoint of practicality of the obtained artificial nail and the like.

That is, the photocurable resin composition is shaped to have a size of 30 mm × 10 mm × 0.5 mm thickness using a 3D printer and is photocured by being irradiated with ultraviolet light having a wavelength of 365 nm under the condition of 5 J/cm² to obtain an optically shaped product, and the resulting shaped product (that is, a tensile test piece) is measured using a tensile test device under the condition of an inter-chip distance of 20 mm and a tension rate of 5 mm/min in accordance with the method described in ISO527-1 (or JIS K7161). The tensile test piece preferably has a tensile strength of 15 MPa or more and more preferably 40 MPa or more in a case in which the tensile test piece is fractured. In addition, the elongation rate is preferably 10% or more and more preferably 20% or more in a case in which the tensile test piece is fractured.

[0047] A glass transition temperature (T_g) after the photocuring of the photocurable composition according to the embodiment is not particularly limited, and the glass transition

temperature (T_g) after the photocuring is preferably from 20 to 100°C and more preferably from 40 to 80°C from the viewpoint of the balance of the flexural strength, the flexural modulus, the bending resistance, the tensile strength, and the elongation rate.

[0048] In the embodiment, the “optical shaping” is one of three-dimensional shaping methods using a 3D printer.

Examples of the optical shaping method include a stereo lithography apparatus (SLA) method, a digital light processing (DLP) method, an ink jet method, and the like.

The photocurable composition according to the embodiment is particularly suitable for the optical shaping of the SLA method or the DLP method.

[0049] In the embodiment of the invention, the “optical shaping” refers to shaping (production of a shaped product) using an optical shaping material as a shaping material in shaping a three-dimensional image using a shaping material. In the embodiment, the “photocuring” refers to further curing the shaped product, which is obtained by the photocuring, with light.

In the embodiment, the optical shaping is a type of three-dimensional shaping methods using a three-dimensional shaping device (hereinafter, referred to as a 3D printer). Specific examples of the optical shaping method include a stereo lithography apparatus (SLA) method, a digital light processing (DLP) method, an ink jet method, and the like.

[0050] Examples of the SLA method include a method of obtaining a three-dimensional shaped product by irradiating spot-like ultraviolet laser light to a photocurable composition.

In the case in which the artificial nail or the like is produced by the SLA method, for example, it is preferable to repeatedly perform a lamination operation of obtaining a continuous cured layer by storing a liquid photocurable composition in a container, selectively irradiating spot-like ultraviolet laser light to the liquid photocurable composition to obtain a desired pattern on a liquid surface of the liquid photocurable composition and cure the liquid photocurable composition, forming a cured layer having a desired thickness on a shaping table, and then moving (that is, moving upward or downward) the shaping table to supply the liquid photocurable composition corresponding to one layer onto the cured layer and cure the liquid photocurable composition as well.

[0051] Examples of the DLP method include a method of obtaining a three-dimensional shaped product by irradiating surface-like light to a photocurable composition. For the method of obtaining a three-dimensional shaped product by the DLP method, for example, the descriptions of Japanese Patent No. 5111880 and Japanese Patent No. 5235056 can be referred to as appropriate.

In the case in which an artificial nail, a dental prosthesis, and the like as a shaped

product are produced by the DLP method, by using lamps such as a high pressure mercury lamp, a super high pressure mercury lamp, a low pressure mercury lamp as a light source, LEDs, and the like which emit light other than laser light, a planar drawing mask having a plurality of digital micro mirror shutters disposed in a planar form is disposed between a light source and a shaped surface of a photocurable composition, and light is irradiated to the shaped surface of the photocurable composition via the planar drawing mask, whereby cured layers having a predetermined shape pattern may be sequentially layered.

[0052] Examples of the ink jet method include a method of a three-dimensional shaped product by continuously discharging droplets of a photocurable composition from an ink jet nozzle to a base plate and irradiating light to the droplets attached to the base plate.

In the case of producing an artificial nail or the like by the ink jet method, cured layers may be formed by discharging a photocurable composition from an ink jet nozzle to a base plate while scanning a head including, for example, the ink jet nozzle and a light source in a plane and irradiating light to the discharged photocurable composition, and the cured layers may be sequentially layered by repeating these operations.

[0053] The photocurable composition according to the embodiment preferably has a viscosity of from 20 mPa·s to 3000 mPa·s, more preferably from 20 mPa·s to 1500 mPa·s, and particularly preferably from 20 to 1200 mPa·s at 25°C and 50 rpm, which is measured using an E-type viscometer from the viewpoint of suitability for production of an artificial nail by optical shaping. A lower limit of the viscosity range is more preferably 30 mPa·s and particularly preferably 40 mPa·s.

[0054] The viscosity of the photocurable composition at 25°C and 50 rpm may also be adjusted according to the optical shaping method.

For example, in the case of producing the artificial nail using the SLA method, the viscosity is preferably from 20 mPa·s to 3000 mPa·s, more preferably from 20 mPa·s to 1500 mPa·s, and particularly preferably from 30 mPa·s to 1200 mPa·s.

For example, in the case of producing the artificial nail by the DLP method, the viscosity is preferably from 50 mPa·s to 500 mPa·s, and more preferably from 50 mPa·s to 250 mPa·s.

For example, in the case of producing the artificial nail and the like by the ink jet method, the viscosity is preferably from 20 mPa·s to 500 mPa·s, and preferably from 20 mPa·s to 100 mPa·s.

[0055] Next, the components of the photocurable composition according to the embodiment will be described.

[0056] <(Meth)acrylic Monomer (X)>

A (meth)acrylic monomer component in the photocurable composition according to the embodiment contains a (meth)acrylic monomer (X).

The (meth)acrylic monomer (X) is at least one selected from di(meth)acrylic monomers which have no hydroxyl group and carboxy group and have two aromatic rings and two (meth)acryloyloxy groups in one molecule, and has a weight average molecular weight of 400 or more and 800 or less.

In the photocurable composition according to the embodiment, the (meth)acrylic monomer (X) mainly contributes to improving flexural strength and flexural modulus after photocuring.

[0057] The (meth)acrylic monomer (X) may be only one selected from di(meth)acrylic monomers which have no hydroxyl group and carboxy group and have two aromatic rings and two (meth)acryloyloxy groups in one molecule, and may be a mixture of two or more of the di(meth)acrylic monomers.

[0058] At least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) preferably has an ether bond in one molecule from the viewpoint of further improving the fracture toughness after photocuring.

In detail, since at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) has the ether bond in one molecule, the degree of freedom of molecular motion is increased, and the toughness of the cured product photocured is improved, whereby the fracture toughness of the cured product (that is, the fracture toughness after the photocuring of the photocurable composition) is improved.

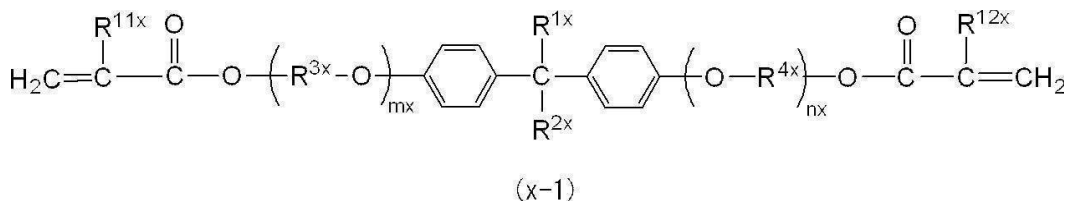
[0059] It is more preferable that at least one of the di(meth)acrylic monomers has ether bonds of 1 or more and 10 or less in one molecule.

In at least one of the di(meth)acrylic monomers, in a case in which the number of ether bonds in one molecule is 10 or less, the flexural strength and the flexural modulus after photocuring are further improved.

The number of ether bonds in one molecule is more preferably 2 or more and 6 or less particularly preferably 2 or more and 4 or less from the viewpoint of improving the flexural strength and the flexural modulus after photocuring.

[0060] At least one of the di(meth)acrylic monomers is more preferably a compound represented by the following Formula (x-1) from the viewpoint of reducing the viscosity of the photocurable composition and further improving the fracture toughness, the flexural strength, and the flexural modulus after photocuring.

[0061]



[0062] [In Formula (x-1), each of R^{1x} , R^{2x} , R^{11x} , and R^{12x} independently represents a hydrogen atom or a methyl group. Each of R^{3x} and R^{4x} independently represents a linear or branched alkylene group having from 2 to 4 carbon atoms. Each of the mx and nx independently represents from 0 to 10. However, $1 \leq (mx + nx) \leq 10$.]

[0063] In the case in which there are a plurality of R^{3x} in Formula (x-1), the plurality of R^{3x} may be the same or different. The same also goes for R^{4x} .

[0064] In Formula (x-1), R^{1x} and R^{2x} are preferably a methyl group.

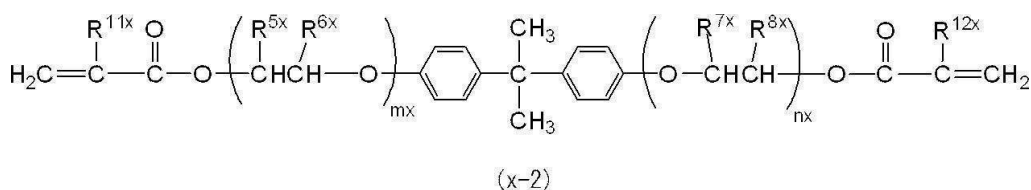
Each of R^{3x} and R^{4x} independently is preferably an ethylene group, a trimethylene group, a tetramethylene group, a 1-methylethylene group, a 1-ethylethylene group, or a 2-methyltrimethylene group, and more preferably an ethylene group or a 1-methylethylene group.

Both R^{3x} and R^{4x} are preferably an ethylene group, a trimethylene group, a tetramethylene group, a 1-methylethylene group, or a 2-methyltrimethylene group, and more preferably an ethylene group or a 1-methylethylene group.

$mx + nx$ is from 1 to 10, and particularly preferably from 2 to 6 from the viewpoint of further improving the flexural strength and the flexural modulus.

[0065] At least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) is more preferably a compound represented by the following Formula (x-2) from the viewpoint of reducing the viscosity of the photocurable composition and further improving the fracture toughness, the flexural strength, and the flexural modulus after photocuring.

[0066]



[0067] In Formula (x-2), each of R^{5x} , R^{6x} , R^{7x} , R^{8x} , R^{11x} , and R^{12x} independently represents a hydrogen atom or a methyl group. Each of the mx and nx independently represents from 0 to 10. However, $1 \leq (mx + nx) \leq 10$.

[0068] In the case in which there are a plurality of R^{5x} in Formula (x-2), the plurality of R^{5x} may be the same or different. The same also goes for each of R^{6x} , R^{7x} , and R^{8x} .

[0069] In Formula (x-2), one of R^{5x} and R^{6x} is preferably a methyl group, the other of R^{5x} and R^{6x} is preferably a hydrogen atom, and one of R^{7x} and R^{8x} is preferably a methyl group and the other of R^{7x} and R^{8x} is preferably a hydrogen atom.

In Formula (x-2), particularly preferably, both R^{5x} and R^{8x} are a methyl group, and both R^{6x} and R^{7x} are a hydrogen atom.

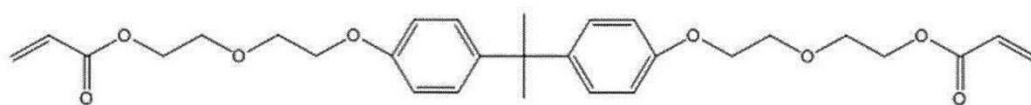
[0070] $mx + nx$ is from 1 to 10, and particularly preferably from 2 to 6 from the viewpoint of further improving the flexural strength and the flexural modulus.

[0071] Specific examples of the (meth)acrylic monomers (X) include ethoxylated bisphenol A di(meth)acrylate (EO = 2 mol, 2.2 mol, 2.6 mol, 3 mol, 4 mol, or 10 mol), propoxylated bisphenol A di(meth)acrylate (PO = 2 mol, 3 mol, 4 mol, or 8 mol), ethoxylated bisphenol F di(meth)acrylate (EO = 2 mol, 2.2 mol, 2.6 mol, 3 mol, 4 mol, or 10 mol), and the like.

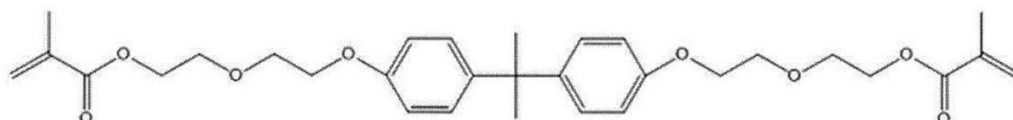
As an example, structural formulas of the ethoxylated bisphenol A di(meth)acrylate and the ethoxylated bisphenol A dimethacrylate are shown below.

[0072]

Ethoxylated bisphenol A diacrylate



Ethoxylated bisphenol A dimethacrylate



[0073] In the photocurable composition according to the embodiment, a content of the (meth)acrylic monomer (X) is preferably 200 parts by mass or more, more preferably 300 parts by mass or more, still more preferably 400 parts by mass or more, further preferably 500 parts by mass or more, and further still more preferably 550 parts by mass or more with respect to a total content of 1000 parts by mass of (meth)acrylic monomer component from the viewpoint of reducing the viscosity of the composition and improving the flexural and the flexural modulus after photocuring.

The content of the (meth)acrylic monomer (X) is not particularly limited as long as it is less than 1000 parts by mass with respect to a total content of 1000 parts by mass of (meth)acrylic monomer component, and is preferably 950 parts by mass or less, more preferably 900 parts by mass or less, and still more preferably 850 parts by mass or less from

the viewpoint of the fracture toughness after photocuring.

[0074] <(Meth)acrylic Monomer (D)>

The photocurable composition according to the embodiment includes a (meth)acrylic monomer (D).

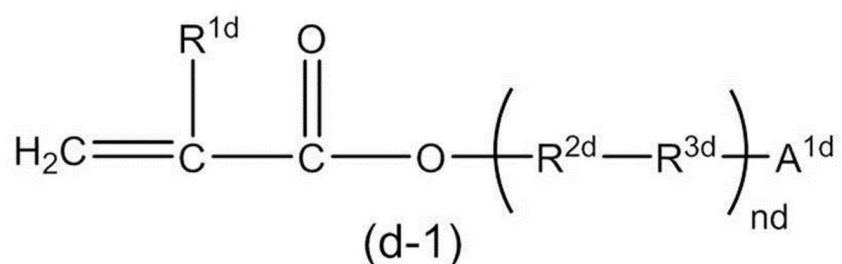
The (meth)acrylic monomer (D) is at least one selected from (meth)acrylic monomers which have at least one ring structure and one (meth)acryloyloxy group in one molecule and has a weight average molecular weight by 130 or more and 350 or less.

The (meth)acrylic monomer component contains the (meth)acrylic monomer (D), whereby the bending resistance after photocuring is significantly improved.

The (meth)acrylic monomer (D) may contain at least one selected from the (meth)acrylic monomers which have at least one ring structure and one (meth)acryloyloxy group in one molecule, and may be a mixture of two or more of the (meth)acrylic monomers.

[0075] At least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is preferably a compound represented by the following Formula (d-1) from the viewpoint of further improving the bending resistance after photocuring.

[0076]



[0077] In Formula (d-1), $\text{R}^{1\text{d}}$ represents a hydrogen atom or a methyl group. $\text{R}^{2\text{d}}$ represents a single bond or a linear or branched alkylene group having from 1 to 5 carbon atoms. $\text{R}^{3\text{d}}$ represents a single bond, an ether bond (-O-), an ester bond (-O-(C=O)-), or -C₆H₄-O-. $\text{A}^{1\text{d}}$ represents an aromatic ring which has a substituent. nd represents 1 or 2. In Formula (d-1), it is preferable to include one or two ether bonds or ester bonds (except those contained in an acryloyloxy group).

[0078] Examples of the substituent of the aromatic ring in $\text{A}^{1\text{d}}$ include an alkyl group (for example, a methyl group, an ethyl group, a propyl group or a butyl group), an aryl group, an alkylaryl group, an aryloxy group, and the like.

Examples of the aromatic ring which may have a substituent in $\text{A}^{1\text{d}}$ include, for example, a phenyl group, a phenyl ether group, a biphenyl group, a terphenyl group, a benzhydryl group, a diphenylamino group, a benzophenone group, a naphthyl group, an

anthracenyl group, a phenanthrenyl group, a tolyl group, a xylyl group, a mesityl group, a cumyl group, a styryl group, or a nonylphenyl group.

Example of the aromatic ring in A^{1d} preferably include a phenyl group, a phenylether group, a biphenyl group, a naphthyl group, a cumyl group, or a nonylphenyl group.

[0079] Examples of the linear or branched alkylene group having from 1 to 5 carbon atoms in R^{2d} include a methylene group, an ethylene group, an n-propylene group, an isopropylene group, an n-butylene group, an isobutylene group, a sec-butylene group, a tert-butylene group, an n-pentylene group, an isopentylene group, a neopentylene group, a sec-pentylene group, a tert-pentylene group, or 3-pentylene group. R^{2d} is preferably a single bond, a methylene group, or an ethylene group.

R^{3d} is preferably an ether bond or an ester bond.

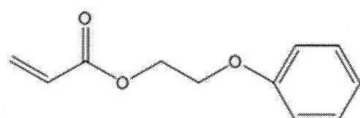
[0080] Specific examples of the (meth)acrylic monomer represented by the Formula (d-1) include phenoxy ethylene glycol (meth)acrylate, 3-phenoxybenzyl (meth)acrylate, o-phenylphenol EO-modified (meth)acrylate, o-phenylphenol (meth)acrylate, p-cumylphenol (meth)acrylate, p-nonylphenol (meth)acrylate, p-methylphenol (meth)acrylate, neopentyl glycol-(meth)acrylic acid-benzoic acid ester, benzyl (meth)acrylate, phenyl (meth)acrylate, phenyl glycidyl ether (meth)acrylic acid adduct, phenoxy ethylene glycol (meth)acrylate, phenoxy diethylene glycol (meth)acrylate, neopentylglycol (meth)acrylic acid-benzoic acid ester, naphthoxy EO-modified (meth)acrylate, 2-hydroxyethyl methacrylate, EO-modified p-cumylphenol (meth)acrylate, or nonylphenol EO-modified (meth)acrylate (preferably EO = from 1 to 2 mol).

Among them, the (meth)acrylic monomer represented by the above Formula (d-1) is particularly preferably o-phenylphenol EO-modified (meth)acrylate or 3-phenoxybenzyl (meth)acrylate. Here, the “EO-modified” means having a structure of an ethylene oxide unit (that is, -CH₂-CH₂-O-).

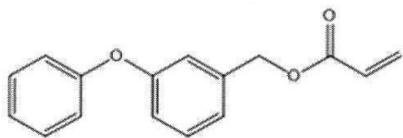
Structure Formulas of the phenoxy ethylene glycol (meth)acrylate, the 3-phenoxybenzyl (meth)acrylate, the o-phenylphenol EO-modified (meth)acrylate (EO = 1 mol), the phenyl glycidyl ether (meth)acrylic acid adduct, and the 2-hydroxyethyl methacrylate are shown below.

[0081]

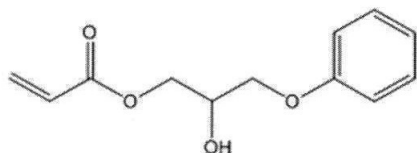
Phenoxy ethylene glycol acrylate



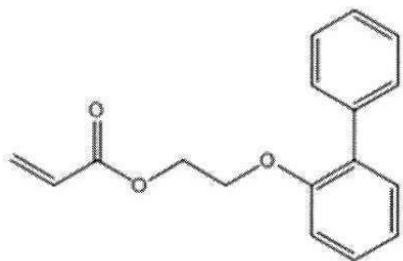
3-Phenoxybenzyl acrylate



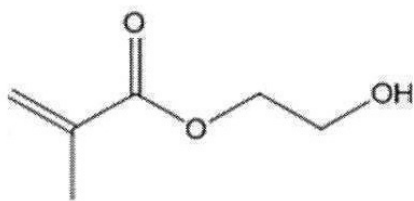
Phenyl glycidyl ether acrylic acid adduct



o-Phenylphenol EO-modified acrylate

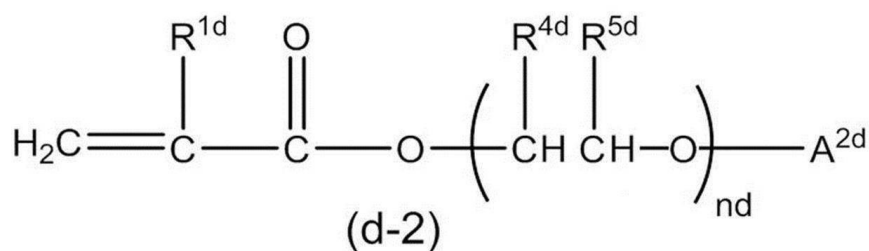


2-Hydroxyethyl methacrylate



[0082] At least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is preferably a compound represented by the following Formula (d-2) from the viewpoint of further improving the bending resistance, the tensile strength, and the elongation rate after photocuring.

[0083]



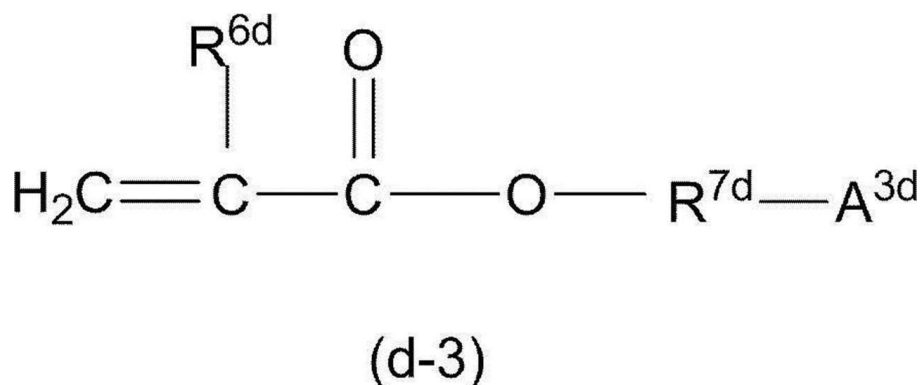
[0084] In Formula (d-2), each of R^{1d} , R^{4d} , and R^{5d} independently represents a hydrogen atom or a methyl group. A^{2d} represents one aromatic ring which may have a substituent. nd represents 1 or 2. As examples of the aromatic ring in A^{2d} and preferred examples of the aromatic ring, those exemplified in A^{1d} can be applied as they are.

[0085] In the case in which there are a plurality of R^{4d} in Formula (d-2), the plurality of R^{4d} may be the same or different. The same also goes for R^{5d} .

The weight average molecular weight of the (meth)acrylic monomer (D) is 130 or more and 350 or less, and is preferably 150 or more and 300 or less and more preferably 150 or more and 280 or less.

[0086] At least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is preferably a compound represented by the following Formula (d-3) from the viewpoint of further improving the bending resistance and the elongation rate after photocuring.

[0087]



[0088] In Formula (d-3), R^{6d} represents a hydrogen atom or a methyl group, and R^{7d} represents a single bond or a methylene group. A^{3d} represents ring structures other than at least one aromatic ring.

The ring structures other than the aromatic ring are not particularly limited, and may be a single ring structure or a polycyclic structure. The number of ring members of the ring structures other than the aromatic ring is not limited, and is preferably from 5 to 12 membered rings. In addition, the ring structures other than the aromatic ring is preferably an alicyclic structure or a heterocyclic structure. Examples of the hetero atom in the heterocyclic

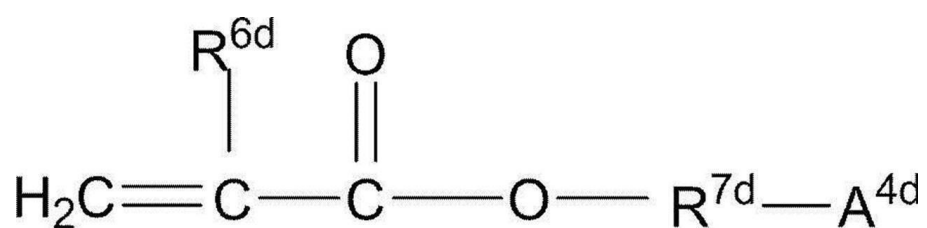
structure includes O, S and/or N.

[0089] Examples of the ring structures other than the aromatic ring include a dicyclopentenyl skeleton, a dicyclopentanyl skeleton, a cyclohexane skeleton, a tetrahydrofuran skeleton, a morpholine skeleton, an isobornyl skeleton, a norbornyl skeleton, a dioxolane skeleton or a dioxane skeleton, a cyclopropane skeleton, a cyclobutane skeleton, a cyclopentane skeleton, a cycloheptane skeleton, a cyclooctane skeleton, a cyclopropene skeleton, a cyclobutene skeleton, a cyclopentene skeleton, a cyclohexene skeleton, a cycloheptene skeleton, a cyclooctene skeleton, a cyclohexadiene skeleton, a cyclooctadiene skeleton, a norbornene skeleton, a norbornadiene skeleton, a norbornane skeleton, an ethyleneimine skeleton, an ethylene oxide skeleton, an ethylene sulfide skeleton, an azacyclobutane skeleton, an oxetane skeleton, a thietane skeleton, a pyrrolidine skeleton, an imidazolidine skeleton, a pyrazolidine skeleton, a tetrahydrothiophene skeleton, a piperidine skeleton, a piperazine skeleton, a tetrahydropyran skeleton, a tetrahydrothiopyran skeleton, an azepane skeleton, an oxepane skeleton, a thiepane skeleton, or an imidazoline skeleton.

[0090] In addition, at least one of the (meth)acrylic monomers represented by the Formula (d-3) is preferably a compound containing no imide structure from the viewpoint of suppressing water absorption.

That is, the (meth)acrylic monomer represented by the Formula (d-3) is more preferably a compound represented by the following Formula (d-4) from the viewpoint of further improving the flexural strength and the flexural modulus after photocuring.

[0091]



(d-4)

[0092] In Formula (d-4), R^{6d} represents a hydrogen atom or a methyl group. R^{7d} represents a single bond or a methylene group. A^{4d} represents a ring structure having a dicyclopentenyl skeleton, a dicyclopentanyl skeleton, a cyclohexane skeleton, a tetrahydrofuran skeleton, a morpholine skeleton, an isobornyl skeleton, a norbornyl skeleton, a dioxolane skeleton, or a dioxane skeleton.

In Formula (d-4), the ring structure represented by A^{4d} may have a substituent such as

an alkyl group (a methyl group, an ethyl group, a propyl group, a butyl group, and the like).

[0093] The weight average molecular weight of the (meth)acrylic monomer represented by the above Formula (d-4) is 130 or more and 350 or less, and is preferably 150 or more and 240 or less and more preferably 180 or more and 230 or less.

[0094] Examples of the (meth)acrylic monomer represented by the above Formula (d-4) include isobornyl (meth)acrylate, norbornyl (meth)acrylate, dicyclopentenyl (meth)acrylate, dicyclopentanyl (meth)acrylate, cyclohexyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, (meth)acryloyl morpholine, 4-tert-butylcyclohexanol (meth)acrylate, cyclohexane dimethanol di(meth)acrylate, (2-methyl-2-ethyl-1,3-dioxolan-4-yl) methyl acrylate, cyclic trimethylolpropane formal acrylate, and the like.

[0095] In the photocurable composition according to the embodiment, the content of the (meth)acrylic monomer (D) is preferably from 30 parts by mass to 800 parts by mass and from 50 parts by mass to 700 parts by mass with respect to a total content of 1000 parts by mass of (meth)acrylic monomer component.

[0096] The (meth)acrylic monomer component in the photocurable composition according to the embodiment may contain at least one of other (meth)acrylic monomers other than (meth)acrylic monomer (X) and the (meth)acrylic monomer (D) described above in the range where the effects of the invention are exhibited.

However, a total content of (meth)acrylic monomer (X) and (meth)acrylic monomer (D) in the (meth)acrylic monomer component is preferably 60% by mass or more, more preferably 80% by mass or more, and still more preferably 90% by mass or more with respect to the total amount of the (meth)acrylic monomer component. In addition, the total content may be 100% by mass with respect to the total amount of (meth)acrylic monomer component.

[0097] <Photopolymerization Initiator>

The photocurable composition according to the embodiment contains a photopolymerization initiator.

The photopolymerization initiator is not particularly limited as long as it generates a radical by being irradiated with light, and preferably generates the radical at a wavelength of light used for optical shaping.

The wavelength of light used for the optical shaping is generally from 365 nm to 500 nm, and is preferably from 365 nm to 430 nm and more preferably from 365 nm to 420 nm for practical use.

[0098] Examples of the photopolymerization initiator which generate the radical by the wavelength of light used for the optical shaping include an alkyl phenone-based compound, an acyl phosphine oxide-based compound, a titanocene-based compound, an oxime

ester-based compound, a benzoin-based compound, an acetophenone-based compound, a benzophenone-based compound, a thioxanthone-based compound, an α -acyloxime ester-based compound, a phenyl glyoxylate-based compound, a benzyl-based compound, an azo-based compound, a diphenyl sulfide-based compound, an organic coloring matter-based compound, an iron-phthalocyanine-based compound, a benzoin ether-based compound, an anthraquinone-based compound, and the like.

Among them, from the viewpoint of reactivity, and the like, the alkylphenone-based compounds and the acyl phosphine-based oxide compounds are preferable.

[0099] Examples of the alkylphenone-based compounds include

1-hydroxy-cyclohexyl-phenyl-ketone (Irgacure 184: manufactured by BASF).

Examples of the acyl phosphine oxide-based compound include

bis(2,4,6-trimethylbenzoyl)-phenyl phosphine oxide (Irgacure 819: manufactured by BASF),

2,4,6-trimethylbenzoyl-diphenyl-phosphine oxide (Irgacure TPO: manufactured by BASF),

and the like.

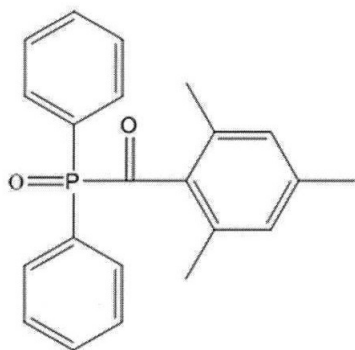
Structure Formulas of the bis(2,4,6-trimethylbenzoyl)-phenyl phosphine oxide

(Irgacure 819: manufactured by BASF) and 2,4,6-trimethylbenzoyl-diphenyl-phosphine oxide

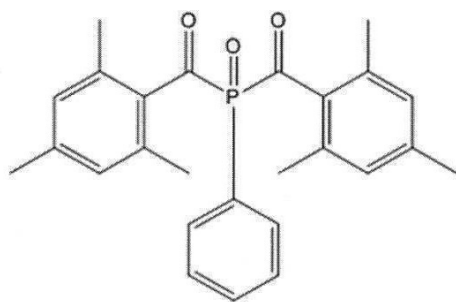
(Irgacure TPO: manufactured by BASF) are shown below.

[0100]

2,4,6-Trimethylbenzoyl diphenyl phosphine oxide (TPO)



Bis(2,4,6-trimethylbenzoyl)-phenyl phosphine oxide (Ir 819)



[0101] The photocurable composition according to the embodiment may contain only one type of photopolymerization initiator, or may contain two or more types thereof.

The content (total content in the case of two or more types) of the photopolymerization initiator in the photocurable composition according to the embodiment is preferably from 1 part by mass to 50 parts by mass, more preferably from 2 parts by mass to 30 parts by mass, and still more preferably from 3 parts by mass to 25 parts by mass with respect to a total content of 1000 parts by mass of (meth)acrylic monomer component.

[0102] [Other Components]

The photocurable composition according to the embodiment may optionally contain at least one of other components other than the (meth)acrylic monomer component and the photopolymerization initiator.

However, a total content of (meth)acrylic monomer component and photopolymerization initiator is preferably 60% by mass or more, more preferably 80% by mass or more, and more preferably 90% by mass or more with respect to the total amount of photocurable composition.

[0103] Other components include a coloring material.

For example, in the case in which the photocurable composition according to the present embodiment is used to produce the artificial nail, from the viewpoint of esthetics, the

photocurable composition contains the coloring material, and as a result may be colored to a desired color tone.

Examples of the coloring material include a pigment, a dye, a coloring matter, and the like. More specifically, examples of the coloring material include a synthetic tar coloring matter, aluminum lake of the synthetic tar coloring matter, an inorganic pigment, a natural coloring matter, and the like.

[0104] In addition, examples of other components also include curable resins (for example, other curable monomers other than the (meth)acrylic monomer component, and the like) other than the (meth)acrylic monomer component.

[0105] Other components include a thermal polymerization initiator.

In the case in which the photocurable composition according to the embodiment contains a thermal polymerization initiator, combined use of photocuring and thermal curing becomes possible. Examples of the thermal polymerization initiator include a thermal radical generating agent, an amine compound, and the like.

[0106] Examples of the other components include a coupling agent such as a silane coupling agent (for example, 3-acryloxypropyltrimethoxysilane), additives such as a rubber agent, an ion trap agent, an ion exchange agent, a leveling agent, a plasticizer, and an antifoaming agent, and the like.

[0107] A method of preparing a photocurable composition according to the embodiment is not particularly limited, and include a method of mixing an acrylic monomer (X), a (meth)acrylic monomer (D), and a photopolymerization initiator (and other components, if necessary).

Means for mixing the respective components is not particularly limited, and includes, for example, means such as dissolution by ultrasonic waves, a double-armed stirrer, a roll kneader, a twin screw extruder, a ball mill kneader, and a planetary stirrer.

The photocurable composition according to the embodiment may be prepared by mixing the respective components, filtering the mixture by a filter to remove impurities, and further performing vacuum degassing treatment.

[0108] [Photocured Product]

Performing the photocuring using the photocurable composition according to the embodiment is not particularly limited, and all the well-known methods and devices can be used. For example, a method of layering a plurality of cured layers and preparing a photocured product having a desired shape by repeating a step of forming a thin film made of the photocurable composition according to the embodiment and a step of irradiating light to the thin film to obtain a cured layer plural times can be used. The resulting photocured

product may be used as it is, or furthermore may be used after mechanical property, shape stability, and the like of the resulting photocured product are improved by performing the post-curing by heating and the like.

[0109] [Artificial Nail]

An artificial nail is particularly preferable as a cured product (that is, optically shaped product) of the photocurable composition according to the embodiment. The artificial nail, which is the cured product of the photocurable composition according to the embodiment is excellent in the flexural strength, the flexural modulus, the bending resistance, the tensile strength and the elongation rate.

A size of the artificial nail according to the embodiment is not particularly limited, and the artificial nail having a desired size can be produced. In addition, the artificial nail according to the embodiment may be a set.

Only some of the artificial nails according to the embodiment may be produced using the photocurable composition according to the embodiment, or all of the artificial nails may be produced using the photocurable composition according to the embodiment.

[0110] Hereinafter, an example of the embodiment of the invention will be described in detail with reference to the drawings. In the following description, an “apparatus” (that is, device) may be a device having a predetermined function, and may exist as an independent device, or as part of a device having other functions. For example, a three-dimensional shaping device, a curing device, a photocuring device, a shaping design device, a three-dimensional shape measuring device, and an evaluation device exist in any form as long as they each have the functions described in locations described. For example, the photocuring device may be a device having a light irradiation function incorporated in a 3D printer, or may be a device independent of the 3D printer.

Fig. 1 shows an outline of the process of producing the artificial nail according to the embodiment. The process of producing the artificial nail according to the embodiment includes a shape acquiring step 80 as a receiving unit, a design step 82 as a design unit, a shaping step 84 as a shaping unit, a washing step 86, and a curing step 88 as a curing unit. The artificial nail is produced as a plain unprinted artificial nail having no decoration and the like by passing through the shape acquiring step 80, the design step 82, the shaping step 84, the washing step 86, and the curing step 88. In the embodiment, the washing step 86 may be included in the shaping step 84 as post-processing of the shaping step 84, and the washing step 86 may be included in the curing step 88 as pre-processing of the curing step 88.

[0111] In the embodiment, a rapid prototype method is applied to create a three-dimensional image of an artificial nail (that is, a three-dimensional model, hereinafter, also referred to as

shaped product) based on three-dimensional data (hereinafter, also referred to as shaping data). As the shaping method, any of a binder injection method, a directional energy volume method, a material extraction method, a material injection method, a powder bed fusion bonding method, a sheet lamination method, a liquid tank photopolymerization method, a lamination shaping method, an optical shaping method, a powder shaping method, a hot melt lamination method, an ink jet method, and the like may be applied.

[0112] In the shaping step 84 according to the embodiment, the shaped product is produced as the artificial nail by the optical shaping using the photocurable composition as an optical shaping material. The optical shaping method and the viscosity of the photocurable composition are as described above.

[0113] In the shaping step 84 according to the embodiment, a 3D printer to which any of an SLA method, a DLP method, or an ink jet method is applied is used, and the 3D printer operates by the three-dimensional data (hereinafter, referred to as shaping data), thereby producing the shaped product. Methods other than the SLA method, the DLP method, and the ink jet method may be applied to the 3D printer.

[0114] In the washing step 86, the surplus photocurable composition is washed away and removed from the shaped product produced by the optical shaping using the photocurable composition in the shaping step 84. That is, the uncured photocurable composition attached to the shaped product is removed.

[0115] In the curing step 88 according to the embodiment, the photocurable composition is further photocured, whereby the artificial nail is finished. In the curing step 88, the shaped product is photocured based on preset photocuring conditions. The curing conditions include the designation of the photocuring device and the designation of the operating conditions of the photocuring device. In the curing step 88, the artificial nail is produced by photocuring the shaped product based on the operating conditions set in the curing conditions using the photocuring device specified in the curing conditions.

In the embodiment, light having any wavelength can be applied as light (for example, laser light) applied for the optical shaping and the photocuring, and preferably light having a wavelength at which relatively high light energy can be obtained, and more preferably a wavelength of from 320 nm to 420 nm, for example. As a result, the energy efficiency at the time of the optical shaping and the photocuring can be improved, and the optical shaping and the photocuring can be performed effectively.

[0116] In the shape acquiring step 80, shape information on the shape and dimension of the artificial nail to be formed is received. The shape information on the shape and dimension of the artificial nail to be formed preferably includes information which identifies a

three-dimensional shape including an external shape, a length, a width, a thickness, a bending amount (that is, curvature) in a longitudinal direction, and a bending amount in a width direction of the artificial nail to be formed. As the shape information of the artificial nail, at least three-dimensional data indicating a shape of a surface (hereinafter, referred to as a back surface of the artificial nail) in contact with a surface of a human nail (hereinafter, referred to as a bare nail) and information including a thickness at each position of the back surface of the artificial nail to be formed are applied. That is, the shape information of the artificial nail includes three-dimensional data (hereinafter referred to as shape data) which can identify the three-dimensional shape (that is, the outer shape) of the artificial nail to be formed or data which can generate shape data. Note that the back surface of the artificial nail includes a surface (for example, a surface or the like which protrudes from a tiptoe) removed from the bare nail.

[0117] In the shape acquiring step 80, the shape information on the shape and dimension of the artificial nail to be formed may not only be received, but also the shape information on the shape and dimension of the artificial nail to be formed may be read and acquired using a three-dimensional shape measuring device (that is, 3D scanner).

The shape information of the artificial nail acquired in the shape acquiring step 80 preferably includes information specifying a requester and a mounting target of the artificial nail to be formed. That is, the shape information of the artificial nail to be formed preferably includes information (for example, customer information) which identifies on which of someone's fingers the artificial nail is intended to be worn or a customer who requests the formation of the artificial nail. In addition, the shape information preferably includes at least information (that is, target information) indicating on which one of a first finger (that is, thumb, pollex), a second finger (that is, index finger, forefinger), a third finger (that is, middle finger), a fourth finger (that is, ring finger), and a fifth finger (that is, little finger) the artificial nail is mounted together with information indicating on which of the left and right hands and feet the artificial nail is mounted.

[0118] In the shape acquiring step 80, the input information is received as the shape information of the artificial nail by inputting the information specifying the requester and the mounting target of the artificial nail to be formed.

The shape information acquired in the shape acquiring step 80 includes the optical shaping material (for example, a photocurable composition or a component contained in the photocurable composition) used for the optical shaping of the artificial nail, the designation of the 3D printer used for the optical shaping, and the designation of the curing conditions. In this case, in the shape acquiring step 80, the optical shaping material, the designation of the

3D printer, and the designation of the curing condition are input, whereby the input designation is received as the shape information of the artificial nail.

[0119] In the design step 82, the three-dimensional shape data of the artificial nail formed from the shape information of the artificial nail is generated. In addition, in the design step 82, the shaping data to be used in the shaping step 84 is generated from the generated shape data.

The design step 82 sets the shaping conditions in the shaping step 84. The shaping conditions include the setting (or designation) of the 3D printer as the three-dimensional shaping device used to produce the shaped product in the shaping step 84, setting of a wavelength (for example, central wavelength or wavelength band) of light, light intensity, irradiation time, and the like at the time of operating the 3D printer. In addition, the shaping conditions also include the photocurable compositions used for the optical shaping.

[0120] In the case in which the designation of the 3D printer and the designation of the shaping conditions are included in the shape information of the artificial nail to be formed, in the design step 82, the designation of the 3D printer and the designation of the shaping condition are performed based on the shape information of the artificial nail to be formed. In addition, in the case in which the designation of the 3D printer and the designation of the shaping conditions are not included in the shape information of the artificial nail to be formed, in the design step 82, the 3D printer and the shaping conditions are input and designated or selected from combinations set in advance and designated.

[0121] In addition, in the design step 82, the curing conditions in the curing step 88 is designated. The curing conditions include the designation of the photocuring device as the curing device used for the photocuring of the shaped product in the curing step 88, and a wavelength of light (for example, laser light), light intensity, light irradiation time, and the like at the time of operating the photocuring device. The setting of the curing conditions is performed based on the shape information of the artificial nail to be formed in the case in which the designation of the photocuring device and the designation of the curing conditions are included in the shape information of the artificial nail to be formed. In addition, in the case in which the designation of the photocuring device and the designation of the curing conditions are not included in the shape information of the artificial nail to be formed, in the design step 82, the curing conditions are designated in the same manner as the shaping condition.

[0122] In the design step 82, in the case in which the shaping data are generated from the shape data, the dimension and shape of the artificial nail as the shaped product cured are predicted based on the shaping conditions, the curing conditions, and the predetermined

prediction information, and the shaping data are generated such that the predicted dimension and shape of the artificial nail match the dimension and shape of the artificial nail to be formed (however, including the state that can be regarded as substantially matching).

As a result, in the shaping step 84, the shaped product is produced by the optical shaping based on the shaping data and the shaping conditions generated in the design step 82, and in the curing step 88, the shaped product is photocured based on the curing conditions designated in the design step 82. The shaped product optically shaped is further photocured and the artificial nail is produced, whereby the artificial nail excellent in the flexural strength and the flexural modulus can be obtained.

[0123] On the other hand, the evaluating step 90 is provided in the process of producing the artificial nail according to the embodiment. In the evaluating step 90, it is evaluated whether the artificial nail having the same size (dimension) and shape as the artificial nail to be formed is produced. At this time, in the evaluating step 90, the post-curing data as the three-dimensional data of the shaped product cured (for example, after photocuring in the curing step 88) is acquired, and the shape data and the shaping data of the artificial nail formed from the design step 82 are acquired. In the evaluating step 90, the produced artificial nail is evaluated by checking (or comparing) the post-curing data with the shape data.

In the evaluating step 90, in the case in which the dimension and shape of the produced artificial nail are evaluated to be the same as the dimension and shape of the artificial nail to be formed, the produced artificial nail is delivered to the customer as a product.

[0124] In addition, Fig. 2 shows a perspective view of an outline of an artificial nail, in which an artificial nail 10 represented by shape data is shown by a two-dot chain line, and an artificial nail 12 (that is, shaped product cured) represented by post-shaping data is shown by a solid line. In Fig. 2, root sides (that is, an opposite side to a fingertip) of the artificial nails 10 and 12 are set as an origin side of a Z axis to show X, Y, and Z axes.

[0125] In general, in the case in which the shaped product is cured, a length, a width, a thickness, and a volume of the shaped product cured is considerably contracted as compared with the shaped product not cured. Even in the shaped products which are optically shaped using the photocurable composition, contraction occurs during optical shaping and after photocuring as compared with before photocuring. That is, the shaped product is contracted in the case in which the shaped product is optically shaped in the shaping step 84 with respect to the shaping data, and considerably contracted even in the case in which the shaped product is photocured in the curing step 88.

The contraction of the shaped product in the optical shaping and the photocuring is influenced by the photocurable composition, the shaping conditions, the curing conditions, and the like which are used for the optical shaping. In addition, the contraction of the shaped product in the optical shaping and the photocuring may be influenced by environmental conditions (for example, temperature and humidity) at the time of photocuring and curing the shaped product.

The artificial nail is formed thin, and has a warpage in at least one of the length direction and the width direction so that the surface (hereinafter, also referred to as the back surface of the artificial nail) in contact with the surface of the bare nail is concave. For this reason, slight contraction occurs in the artificial nail 12 cured, whereby the warpage changes and the fitting feeling changes in the case in which the artificial nail 10 is actually mounted on a nail.

[0126] From this, in the embodiment, the contraction state after the curing of the shaped product is predicted based on at least the photocurable composition (or the component of the photocurable composition), the shaping conditions, and the curing conditions used for the shaping as the prediction information. In addition, the prediction information may also include environmental information such as temperature and humidity in each of the shaping environment and the curing environment. The predicted contraction state includes the change in warpage due to the thickness and the like of the artificial nail, in addition to the dimensions such as a length, a width, a thickness, and a volume.

[0127] In the design step 82 according to the embodiment, in the case of generating the shaping data used for the optical shaping from the shape data of the artificial nail, the contraction state (for example, contraction amount or contraction rate, change in warpage) occurring in the shaped product cured is predicted, and the shape data are corrected based on the predicted contraction state, thereby generating the shaping data of the artificial nail. The shaping data are generated such that the cured artificial nail 12 has the same length, width, thickness, and volume as the artificial nail 10 to be formed, and the warpage of the artificial nail 12 is similar to the warpage of the artificial nail 10.

[0128] In addition, in the design step 82, the prediction information is updated using the post-cure data of the artificial nail 10 acquired in the evaluating step 90, the shaping conditions and the curing conditions at the time of producing the artificial nail 10. In addition, it is more preferable to include the environmental information in the update of the prediction information.

In the evaluating step 90, in the case in which it is evaluated that there is a difference in the dimension, the shape, and the like between the artificial nail shown by the shape data

and the artificial nail shown by the post-curing data after curing (for example, in the case in which the produced artificial nail 12 cannot be regarded as the artificial nail 10), the prediction information is updated, the shaping data is regenerated by correcting the shape data of the corresponding artificial nail based on the updated prediction information, and the reform (that is, reproducing) of the artificial nail 12 is performed based on the regenerated shaping data.

[0129] Fig. 3 is a block diagram showing a schematic configuration of a shaping design system 20 according to the embodiment. A computer aided design (CAD) system is used for the shaping design system 20 according to the embodiment, and the CAD system is responsible for the processing function in the design step 82. In addition, the shaping design system 20 may include a configuration which is responsible for at least the processing function of the evaluating step 90, and may include a configuration which is responsible for the processing function of the shape acquiring step 80. In addition, the shaping design system 20 may include a configuration which is responsible for the processing functions of the shaping step 84 and the curing step 88. The shaping design system 20 according to the embodiment includes, as an example, a configuration which is responsible for the processing functions in the shape acquiring step 80, the shaping step 84, the curing step 88, and the evaluating step 90, and the shaping design system 20 also functions as the system for producing the artificial nail 10.

[0130] The shaping design system 20 includes an arithmetic processing unit 22 provided with a CPU and the like, a main storage unit 24, an input unit 26, an output unit 28, an auxiliary storage unit 30, and an interface unit 32, and is configured by a computer in which the arithmetic processing unit 22, the main storage unit 24, the input unit 26, the output unit 28, the auxiliary storage unit 30, and the interface unit 32 are connected to one another via a bus 34.

[0131] An operation program (OS) and the like of the arithmetic processing unit 22 are stored in the main storage unit 24, and the arithmetic processing unit 22 reads an operation program from the main storage unit 24 and executes the operation program, whereby the shaping design system 20 is operated. In addition, the input unit 26 is provided with input devices such as a keyboard, a mouse, and a tablet, and the output unit 28 is provided with output devices such as a display and a printer.

[0132] The interface unit 32 of the shaping design system 20 is connected to a three-dimensional measurement device (that is, a 3D scanner) 36 used as a reading unit in the case in which the shaping design system 20 functions as the shape acquiring step 80 and the evaluating step 90, the three-dimensional measuring device (that is, a 3D printer) 38 used in

the shaping step 84, and a photocuring device 40 as a curing device used in the curing step 88.

As the 3D printer 38, for example, a desktop 3D printer Form 2 (manufactured by Formlabs) is used.

[0133] In the embodiment, an environment sensor 42 which detects environment information (for example, installation environment of the 3D printer 38) such as temperature and humidity at the time of performing the shaping in the shaping step 84 is provided, and an environment sensor 44 which detects environment information (for example, installation environment of the photocuring device 40) such as temperature and humidity at the time of performing the curing in the curing step 88 is provided. Each of the environment sensors 42 and 44 is connected to the shaping design system 20.

[0134] In the shaping design system 20, the interface unit 32 may be connected to a dedicated communication network such as a local area network (LAN) or a public communication network such as the Internet, which is preferable. In this case, each of the 3D scanner 36, the 3D printer 38, the photocuring device 40, and the environment sensors 42 and 44 can transmit and receive data (or information) to and from each other via the dedicated communication network or the public communication network, and can be connected to the shaping design system 20. As a result, even if each of the 3D scanner 36, the 3D printer 38, the photocuring device 40, and the shaping design system 20 is provided at a different place (for example, a remote place), the shaping design system 20 can control the 3D scanner 36, the 3D printer 38, and the photocuring device 40, and the shaping design systems 20 can be connected to one or more of the 3D scanners 36, the 3D printers 38, and the photocuring devices 40, respectively, whereby the system for producing an artificial nail can be configured.

[0135] The auxiliary storage unit 30 of the shaping design system 20 uses, for example, a nonvolatile storage medium such as a hard disk device capable of rewriting information. For example, the shaping design program 50 such as commercially available CAD software (for example, 3D CAD software) is installed in the auxiliary storage unit 30. A shape acquisition program 52, a shaping program 54, a photocuring program 56, an evaluation program 58, and the like are stored in the auxiliary storage unit 30. In addition, a database 60 of prediction information is formed in the auxiliary storage unit 30, and a prediction program 62 and a learning program 64 are stored therein.

[0136] The arithmetic processing unit 22 reads the shaping design program 50 and the shape acquisition program 52 from the auxiliary storage unit 30 and executes the shaping design program 50 and the shape acquisition program 52, whereby the shaping design system 20 receives a design unit which is responsible for the design step 82 and a receiving unit which is

responsible for the shape acquiring step 80. The shaping design system 20 receives the shape information of the artificial nail and generates the shape data from the received shape information by functioning as the receiving unit and the design unit. In addition, the shaping design system 20 generates the shaping data from the shape data, and sets the shaping conditions and the curing conditions.

[0137] The shaping design system 20 can output the shaping data, the shaping information, and the curing information by making the interface unit 32 function as the output unit.

The arithmetic processing unit 22 executes the shaping program 54, and the shaping design system 20 controls the operation of the 3D printer 38 by functioning as the output unit and functioning as the shaping unit responsible for the shaping step 84, thereby optically shaping the artificial nail.

The arithmetic processing unit 22 reads and executes the photocuring program 56 and the evaluation program 58, and the shaping design system 20 functions as a curing unit responsible for the curing step 88 and an evaluation unit responsible for the evaluating step 90. As a result, the shaping design system 20 photocures the artificial nail by controlling the operation of the photocuring device 40, thereby forming the artificial nail 12. In addition, the shaping design system 20 acquires post-curing data from the artificial nail 12 and evaluates the acquired post-curing data by controlling the operation of the 3D scanner 36.

[0138] The arithmetic processing unit 22 reads and executes the learning program 64, whereby the shaping design system 20 constructs (or updates) the database 60 by functioning as a learning unit. In addition, the arithmetic processing unit 22 reads and executes the prediction program 62, whereby the shaping design system 20 functions as a prediction unit which predicts the post-curing data for the shape data or the shaping data from the prediction information stored in the database 60. In addition, the shaping design system 20 functions as the prediction unit, whereby the shaping design system 20 generates the shaping data obtained by correcting the shape data based on the prediction result.

[0139] The shaping information and the curing information of the artificial nail are stored as the prediction information in the database 60 by being associated with the shape information of the artificial nail. The shape information of the artificial nail stored in the database 60 includes shape data indicating at least the dimension and shape of the artificial nail to be formed.

The shaping information associated with the shape information of the artificial nail includes at least the shaping data applied to the optical shaping, information identifying the 3D printer used for the optical shaping by the shaping data, and information identifying the photocurable composition used for the optical shaping. That is, the designation of the

shaping conditions can be used for the shaping information.

[0140] The curing information associated with the shape information of the artificial nail includes at least information identifying the photocuring device 40 used for the photocuring, the wavelength of light used for the photocuring, the light irradiation time, and the curing environment (for example, temperature and humidity). That is, the designation of the curing conditions can be used for the curing information. In addition, the curing information is not only associated with the shape information of the artificial nail, but also associated with the shaping information associated with the shape information of the artificial nail.

[0141] The database 60 includes the evaluation information of the produced artificial nail 12, and the evaluation information is associated with the shape information, the shaping information, and the curing information of the artificial nail. The evaluation information includes at least post-curing data, and also includes information indicating a contraction state as a difference between the shaping data of the shaping information associated with the shape data and the post-curing data. The information indicating the contraction state includes a contraction amount (or contraction rate) generated in the artificial nail 12 and the shape change (for example, change in warpage).

The shape information of the artificial nail may include information of a customer who requests the production the artificial nail 10, whereby the artificial nail can be produced based on the customer information stored in the database 60 by identifying a person wearing the artificial nail to be formed by the customer information.

[0142] The shaping information may include the environmental state (for example, temperature and humidity) at the time of shaping the artificial nail. In addition, in the case of curing the shaped artificial nail, it is considered that the curing rate, and the like change according to the environmental conditions (for example, temperature and humidity), whereby the curing information includes the environment state (for example, temperature and humidity) in the case in which the shaped artificial nail is cured.

[0143] The shaping design system 20 functions as the learning unit and acquires each of the shape information, the shaping information, the curing information, and the evaluation information of the artificial nail, and stores the shape information, the shaping information, the curing information, and the evaluation information of the artificial nail in the database 60 by associating the shape information, the shaping information, the curing information, and the evaluation information with each other, thereby constructing and updating the database 60.

[0144] As a result, in the case in which the shaping design system 20 functions as the prediction unit, the contraction state is predicted by setting the shaping information and the curing information, whereby the shaping data are generated such that the post-curing data

becomes similar to the shape data. In addition, as an initial value of the prediction information stored in advance in the database 60, an initial value (for example, a default value) arbitrarily set may be applied, and the evaluation result may be used for average shape information (for example, model data, average data, or reference data) on a fingernail in the case in which the shaping is performed using the shaping information and the curing information as a reference.

[0145] Next, the production of the artificial nail by the shaping design system 20 (that is, the shaping system) according to the embodiment will be described with reference to Fig. 4.

For the production of the artificial nail according to the embodiment, the photocurable composition is used as the optical shaping material. The photocurable composition according to the embodiment is not particularly limited as long as it is a photocurable composition used for optical shaping, and is preferably a photocurable composition containing: a (meth)acrylic monomer (hereinafter, referred to as a (meth)acrylic monomer (X)) which is at least one selected from di(meth)acrylic monomers which have no hydroxyl group and carboxy group and have two aromatic rings and two (meth)acryloyloxy groups in one molecule, and has a weight average molecular weight of 400 or more and 800 or less; a (meth)acrylic monomer (hereinafter, referred to as a (meth)acrylic monomer (D)) which is at least one selected from (meth)acrylic monomers which have at least one ring structure and one (meth)acryloyloxy group in one molecule, and has a weight average molecular weight of 130 or more and 350 or less; and a photopolymerization initiator.

[0146] The wavelength of light (for example, laser light) applied to the optical shaping in the 3D printer 38 and the wavelength of the light (for example, laser light) applied for the photocuring in the photocuring device 40 are preferably adjusted and applied according to the photopolymerization initiator.

[0147] As shown in Fig. 4, in the production of the artificial nail 10 (or an artificial nail 12 as the artificial nail 10), the shape information of the artificial nail 10 to be formed is acquired in a first step 100. For acquiring the shape information, for example, in the case in which there is a sample (for example, the sample may be a human hand having a real nail) of the artificial nail 10 to be formed, the sample is mounted on the 3D scanner 36, and a surface shape of a nail is read three-dimensionally (that is, stereoscopically). As a result, a three-dimensional image of the sample is obtained, and shape data 0 of the artificial nail 10 can be constructed from the three-dimensional image of the sample. Such a three-dimensional image may be input to the shaping design system 20 via a dedicated communication network or a public communication network.

[0148] The shape information of the artificial nail 10 preferably includes customer

information and information on a finger to which the artificial nail 10 is applied. In addition, assuming that artificial nails are put on each finger of left and right hands of a person, in the case in which ten artificial nails 10 are produced as one set, for each of the ten artificial nails 10, for example, information identifying a finger to be worn is acquired together. In the shaping design system 20, as an example, ten artificial nails 10 (that is, artificial nails are put on each nail of left and right fingers of a person) are described as being produced as one set.

[0149] In the case in which a photocurable composition used for the production of the artificial nail 10 is designated, in step 100, the designated photocurable composition (which may be, for example, a component of the photocurable composition, a proportion of the component, or a trade name of the photocurable composition) may be accepted. In addition, if the shaping conditions, the curing conditions or the like are designated in the case of producing the artificial nail 10, these designations are accepted in step 100.

[0150] In the next step 102, the shape data is generated based on the acquired shape information of the artificial nail 10. The commercially available 3D CAD software or the like is used to generate the shape data, and the shape data can be created from shape information (for example, a three-dimensional image of a sample and the like).

[0151] If the shape data are created, in step 104, the contraction state occurring in the artificial nail 12 in the case of producing the artificial nail 12 obtained by the optical shaping and the photocuring is predicted. In the case in which the photocurable composition, the shaping conditions, and the curing conditions are designated in the shape information, the contraction state is read (or predicted) from the prediction information (for example, database 60) based on the photocurable composition, the shaping conditions, and the curing conditions which are designated in the shape information. In addition, in the case in which at least one of the photocurable composition, the shaping conditions, and the curing conditions are not designated in the shape information, conditions not designated are set according to the 3D printer 38 and the photocuring device 40 connected to the shaping design system 20.

[0152] In addition, in the case of predicting the contraction state, it is preferable for the environment sensors 42 and 44 to detect the environment information (for example, temperature and humidity) on the installation environment of the 3D printer 38 used for the optical shaping by the environment sensors 42 and 44 and the environment information (for example, temperature and humidity) on the installation environment of the photocuring device 40 used for the photocuring and to predict the contraction state including the detected environment information.

Thereafter, in step 106, the shaping data are generated by correcting the shape data based on the predicted contraction state.

[0153] Here, an example of the generation of the shaping data according to the embodiment will be described with reference to Fig. 5. Fig. 5 is a perspective view showing an image of the shaped product optically shaped represented by the shaping data.

[0154] In the embodiment, in the case of producing one set of artificial nails 10, the shaping data are generated such that two units 70L and 70R are divided into by five for each of the left and right hands to perform the optical shaping. In the units 70L and 70R, artificial nails 72A, 72B, 72C, 72D, and 72E from the artificial nail 72A on the thumb side to the artificial nail 72E on the little finger side are arranged.

[0155] In the embodiment, the 3D printer 38 to which the SLA method is applied is used, and the 3D printer is set in such a manner that a base 74 having a substantially rectangular flat plate shape is provided on a platform side of the 3D printer 38, five mounts 76 are provided on the base 74, and the artificial nails 72A to 72E are formed on the mounts 76. In addition, the artificial nails 72A to 72E are arranged such that the side opposite to the fingertip side is in contact with the mount 76.

[0156] On the other hand, the base 74 is provided with an ID 78 as an identification code for identifying the artificial nails 72A to 72E. As the ID 78, any code that can identify the artificial nails 72A to 72E in each of the units 70L and 70R can be applied. In addition, the ID 78 is set to be different between the units 70L and 70R and to clearly identify that the units 70L and 70R are a set (that is, one set).

[0157] In the embodiment, as one example of the ID 78, an arrangement of an alphabet corresponding to a customer name is applied. In the unit 70L, as the ID 78, an ID 78L including a code indicating that it corresponds to a nail of a left hand is applied, and in the unit 70R, as the ID 78, an ID 78R including a code indicating that it corresponds to a nail of a right hand is applied.

[0158] Specifically, a code identifying a thumb (that is, a nail of the thumb) is "0" and a code identifying a little finger (that is, a nail of the little finger) is "4". In the unit 70L, the ID 78L which includes a code L0 indicating the artificial nail 72A of the thumb of the left hand, a code L4 indicating the artificial nail 72E of the little finger, and an arrow indicating an arrangement direction from the artificial nail 72A of the thumb to the artificial nail 72E of the little finger is formed. In the unit 70R, the ID 78R which includes a code R0 indicating the artificial nail 72A of the thumb of a left hand, a code R4 indicating the artificial nail 72E of the little finger, and an arrow indicating an arrangement direction from the artificial nail 72A of the thumb to the artificial nail 72E of the little finger is formed.

A three-dimensional data file (for example, STL file) of shaping data formed in this manner includes the shaping data obtained by correcting the shape data of each artificial nail

based on the prediction information. In the STL file, data is generated in the 3D printer 38 so as to be optically shaped from the base 74 side.

[0159] In the case in which a plural sets of artificial nails 10 are optically shaped in parallel, the STL file is generated as synthetic data in which data are arranged such that the units 70L and 70R of each set are optically shaped on one platform in parallel.

In the case in which the STL file is generated as described above, the process proceeds to step 108 to perform the optical shaping processing. In the optical shaping processing, in the 3D printer 38, the photocurable composition set in the optical shaping conditions is used. As a result, an optically shaped product in which the photocurable compositions are layered in a layered shape (for example, a layered shape having a thickness of 100 μm) is obtained. The optically shaped product is formed such that each set of artificial nails is formed on each mount 76 of the base 74, and one or more sets are optically shaped. The shaping design system 20 detects the environmental conditions (for example, environmental temperature and environmental humidity) of the installation environment of the 3D printer 38 at the time of the shaping by using the environment sensor 42, and the detected environmental conditions are included in the database 60 and included in the prediction information.

[0160] Here, the time required for the optical shaping in the 3D printer 38 is an irradiation time of light (for example, laser light) at a vertical movement time and each movement position of the platform. In the case in which the platform of the 3D printer 38 is large enough to be able to optically shape, for example, 16 sets of artificial nails, even if the time required for the optical shaping of 2 sets of artificial nails is 60 minutes, the time required for the optical shaping of 16 sets of artificial nails which is 8 times 2 sets of artificial nails are 120 minutes twice 60 minutes. In each set, an ID 78 is assigned to the units 70L and 70R. Therefore, even if a plurality of sets are optically shaped in parallel, each of the optically shaped artificial nails can be identified without mistake.

[0161] The process of producing the artificial nail to which the shaping design system 20 is applied includes the washing step 86. An uncured liquid (that is, a liquid photocurable composition) adheres to the surfaces of the units 70L and 70R immediately after the optical shaping is performed. For this reason, when the platform is removed from the 3D printer 38, the uncured liquid adhering to the optically shaped product on the platform is scraped off.

[0162] In the washing step 86, the uncured liquid remaining in each of the optically shaped products (that is, units 70L and 70R) without being scraped off at this time is removed. In the washing step 86, the artificial nail (that is, the unit of the artificial nail attached to the base 74 via the mount 76) removed from the platform is performed. In addition, in the washing

step 86, for example, an ultrasonic cleaning machine or the like using ethanol (EtOH), isopropyl alcohol (IPA), or the like as a cleaning solution is used.

[0163] As shown in Fig. 4, in step 110, the photocuring processing is performed using the photocuring device 40 on the units 70L and 70R of the artificial nails for which the washing process is completed. The photocuring processing is performed with light having a wavelength (for example, laser light), light intensity, and light irradiation time designated by the curing conditions. As a result, the artificial nail 12 obtained by optically shaping the artificial nail 10 is produced.

The shaping design system 20 stores the installation environment of the photocuring device 40 acquired by the environment sensor 44 in the database 60 as the prediction information associated with the shape information of the artificial nail 10.

[0164] Thereafter, in step 112, the post-curing data which are three-dimensional data of each of the artificial nails 12 formed in the units 70L and 70R are acquired by mounting each of the units 70L and 70R of the cured artificial nails 12 on the 3D scanner 36 and reading the units 70L and 70R.

In steps 114 and 116, the artificial nail 12 with respect to the artificial nail 10 is evaluated by comparing the post-curing data and the shape data for each of the artificial nails 12. At this time, the dimensions (for example, length, width, thickness, volume, and the like) and the external shape (for example, each warpage in a longitudinal direction and a width direction) of the artificial nail 12 shown by the post-curing data are compared with those of the artificial nail 10, and in the case in which each artificial nail 12 matches or is regarded as matched with the artificial nails 10 in terms of the dimension and shape (that is, in the case in which each artificial nail 12 is within an allowable error range), the artificial nail 12 is evaluated to be excellent and is determined to be affirmative in step 116.

[0165] If an affirmative determination is made in step 116, the process proceeds to step 118, and the post-curing data of the artificial nail 12 is stored in the database 60 by being associated with the shape information of the artificial nail 10. At this time, the post-curing data of the artificial nail 12 is stored in the database 60 together with the contraction information including the contraction state of the post-curing data for the shaping data of the artificial nail 10.

[0166] On the other hand, in any artificial nail 12, in the case in which at least one of the dimension and shape state of the artificial nail 12 indicated by the post-curing data is different from the artificial nail 10 indicated by the shape data (for example, in the case in which one of the dimension and the shape state of the artificial nail 12 with respect to the artificial nail 10 exceeds the preset error range), the artificial nail 12 is evaluated to be a defect and is

determined to be negative in step 116.

If the negative determination is made in step 116, the process proceeds to step 120. In this step 120, the difference (for example, the contraction amount, the contraction rate, or the degree of warpage) of the shaping data with respect to the post-curing data is obtained, and the obtained difference is stored in the database 60 by being associated with each of the shape data (or shape information), the shaping data (or shaping information), and the curing information. At the same time, in step 120, the prediction information on the artificial nail 10 is updated.

[0167] Thereafter, the process proceeds to step 104, and the shape data of the artificial nail 10 is corrected (or re-corrected) based on the updated prediction information to generate the shaping data, and the artificial nail 10 is reformed. At this time, although an artificial nail may be performed in units of sets, in the embodiment, since each of the units 70L and 70R is provided with the ID 78 that can identify each other, the artificial nail can be reproduced in each unit unit. As a result, if the produced artificial nail 12 is evaluated to be excellent, the produced artificial nail 12 is delivered (or commercialized) as the artificial nail 10.

[0168] In this way, in the case in which the shaping design system 20 generates the shaping data from the shape data of the artificial nail 10, the contraction state after the curing is predicted, and the shaping data are generated based on the prediction result. For this reason, it is possible to produce the artificial nail 12 as the artificial nail 10 with high accuracy. As a result, the artificial nail 10 having the high fitting feeling is obtained.

[0169] Since the prediction information used for prediction includes the photocurable composition based on the optical shaping, the shaping information according to the shaping conditions, and the curing information according to the curing conditions, the prediction can be made with high accuracy, including not only the contraction state for each optical shaping but also the contraction state after the photocuring. The prediction information preferably includes the environmental information at the time of the optical shaping and the environmental information at the time of the photocuring, whereby for example, a change in a contraction state caused by a slight change in a curing rate (for example, a difference in environmental information) can be predicted with high accuracy.

[0170] The prediction information preferably includes customer information and the like for identifying the artificial nail 10, whereby in the case in which the production of a similar artificial nail is demanded (or requested), the requested artificial nail 10 can be produced with ease and high accuracy.

[0171] Since the shaping design system 20 acquires the post-curing data and updates (or learns) the prediction information by associating the contraction information including the

acquired post-curing data with the shape information, it is possible to predict the contraction state after the photocuring with higher accuracy and produce the artificial nail 10 with higher accuracy as the number of artificial nails 10 to be formed increases.

Since the shaping design system 20 identifiably produces a set of artificial nails 10 and each of the artificial nails 10 in the set by setting artificial nails 10 corresponding to a person as one set, it is possible to easily produce a large number of artificial nails 12 and it possible to clarify which of the artificial nails 10 each of artificial nails 12 corresponds to.

[0172] In the embodiment, the shaping design system 20 combines the processing functions for the shape acquiring step 80, the shaping step 84, the curing step 88, and the evaluating step 90, but the invention is not limited thereto. The shape acquiring step 80, the shaping step 84, the curing step 88, and the evaluating step 90 may be provided with a computer for control separately from the shaping design system 20. In this case, the computer provided in each of the shape acquiring step 80, the shaping step 84, the curing step 88, and the evaluating step 90 can transmit and receive data via a dedicated communication network, a public communication network, or the like and is preferably connected to the shaping design system 20. As a result, it is possible to easily perform an operation from the reception of the artificial nail 10 to be formed to the production of the artificial nail 12 as the artificial nail 10. In addition, the artificial nail 12 as the artificial nail 10 can be produced efficiently and with high accuracy.

[Examples]

[0173] Hereinafter, the invention will be more specifically described with reference to Examples, but the invention is not limited to the Examples.

[0174] [Examples 1 to 30 and Comparative Examples 1 to 7]

<Preparation of Photocurable Composition>

Each component shown in Tables 1 to 4 below was mixed to obtain a photocurable composition.

<Measurement and Evaluation>

The following measurement and evaluation were performed using the obtained photocurable composition. The results are shown in Tables 1 to 4.

[0175] (Viscosity of Photocurable Composition)

The viscosity of the photocurable composition was measured under the condition of 25°C and 50 rpm by an E-type viscometer.

[0176] (Flexural Strength and Flexural Modulus of Optically Shaped Product)

The obtained photocurable composition was shaped to have a size of 80 mm × 10 mm × 4 mm thickness using a 3D printer (FORM 2 manufactured by FormLab) to obtain a

shaped product. The resulting shaped product was irradiated with ultraviolet light having a wavelength of 365 nm under the condition of 5 J/cm² to perform the photocuring, thereby obtaining the optically shaped product.

The flexural strength and the flexural modulus of the test piece were each measured in accordance with ISO178 (or JIS K7171). These measurements were performed using a tensile test device (manufactured by Intesco Co., Ltd.) under the conditions of a punch radius of 5 mm, a fulcrum radius of 5 mm, an inter-fulcrum distance of 64 mm, and a push-in speed of 2 mm/min.

[0177] In the case in which the photocurable composition is used for the production of the artificial nail and the like, the flexural strength is preferably 10 Mpa or more, and more preferably 40 Mpa or more.

In this case, the flexural modulus is preferably 400 MPa or more and more preferably 1500 MPa or more.

[0178] (Bending Resistance of Optically Shaped Product (Case of Thickness of 0.5 mm))

The obtained photocurable resin composition was shaped to have a size of an outer diameter of 8 mm, an inner diameter of 7.5 mm (however, a thickness of 0.5 mm), a circumference is 90°, and a length of 15 mm using a 3D printer (Form 2 manufactured by FormLab), and photocured by being irradiated with ultraviolet light having a wavelength of 365 nm under the condition of 5 J/cm², thereby obtaining the optically shaped product.

[0179] One piece of the obtained shaped product (hereinafter, referred to as “artificial nail 1”) was placed under a metal cube having a size of 50 mm length, 50 mm width, and 50 mm height, and the metal cube was applied with a load of 20 kg weight from above and then it was visually checked whether the metal cube breaks. A total of five pieces of artificial nails 1 were evaluated, and in the case in which five pieces maintained the shape without breaking, artificial nail 1 was evaluated as “A”, in the case in which two pieces to four pieces maintained the shape without breaking, artificial nail 1 was evaluated as “B”, and in the case in which 0 piece to one piece maintained the shape without breaking, artificial nail 1 was evaluated as “C”.

[0180] (Bending Resistance of Optically Shaped Product (Case of 1.0 mm Thick))

The obtained photocurable resin composition was shaped to have a size of an outer diameter of 8 mm, an inner diameter of 7 mm (however, a thickness of 1.0 mm), a circumference is 90°, and a length of 15 mm using a 3D printer (FORM 2 manufactured by FormLab), and photocured by being irradiated with ultraviolet light having a wavelength of 365 nm under the condition of 5 J/cm², thereby obtaining the optically shaped product.

[0181] One piece of the obtained shaped product (hereinafter, referred to as “artificial nail

2”) was placed under a metal cube having a size of 50 mm length, 50 mm width, and 50 mm height, and the metal cube was applied with a load of 20 kg weight from above and then it was visually checked whether the metal cube breaks. The total five pieces of artificial nails 2 were evaluated, and in the case in which five pieces maintained the shape without breaking, artificial nail 1 was evaluated as “A”, in the case in which two pieces to four pieces maintained the shape without breaking, artificial nail 1 was evaluated as “B”, and in the case in which 0 piece to one piece maintained the shape without breaking, artificial nail 1 was evaluated as “C”.

[0182] (Tensile Strength and Elongation Rate of Optically Shaped Product)

The resulting photocurable resin composition was used for a 3D printer (FORM 2 manufactured by FormLab), shaped to have a size of 30 mm × 10 mm × 0.5 mm thickness, and photocured by being irradiated with ultraviolet light having a wavelength of 365 nm under the condition of 5 J/cm², thereby obtaining the optically shaped product.

[0183] Based on the method described in ISO527-1 (or JIS K7161), the obtained shaped product (hereinafter, referred to as a “tensile test piece”) was measured under the conditions of an inter-chuck distance of 20 mm and a tensile rate of 5 mm/min, and the tensile strength (unit: MPa) and the elongation rate (unit: %) were determined in the case in which the tensile test piece is fractured.

[0184] (Glass Transition Temperature (T_g) of Optically Shaped Product)

The tensile test piece was measured by a differential scanning calorimeter (DMS) (DMS 6100 dynamic viscoelasticity measuring device manufactured by Hitachi High-Tech Science Corporation) at a heating rate of 5 °C/min to determine T_g (that is, glass transition temperature).

[0185]

[Table 1]

		Mw	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10
Composition	(Meth)acrylic monomer (X)	ABE-300	468.6	800	600			850	550	500		600
		A-BPE-4	512.6									
		A-BPE-10	776.9		800							
		BP-4PA	568.7							750	700	
		BP-2EM	479.0			500						
	(Meth)acrylic monomer (D)	PO-A	192.2	200	400	200	500					
		POB-A	254.3					150	100	200	200	400
		A-LEN-10	268.3									
		PO	206.2									
		THEA	156.2									
Evaluation	Photopolymerization initiator	FA511AS	204.3									
		CHDMMA	198.3									
		M-600A	222.2						350	300	250	100
		Irg819		10	10	10	10	10	10	10	10	10
		Irg184										
	(1) Viscosity (mPa·s)	TPO										
				310	100	310	50	660	380	260	1100	670
				90	68	66	70	100	50	43	50	50
				3000	2700	2500	2450	2900	2100	1900	2000	2100
				A	A	A	A	A	A	A	A	A
	(2) Flexural strength (MPa)			A	A	A	A	A	A	A	A	A
	(3) Flexural modulus (MPa)											
	(4) Bending resistance (thickness of 0.5 mm)											
	(5) Bending resistance (thickness of 1.0 mm)											
	(6) Tensile strength (MPa)			60	55	55	45	65	40	38	40	60
	(7) Elongation rate (%)			10	15	15	10	10	20	20	25	10
	(8) Tg (°C)			75	60	70	60	80	55	50	55	70

[0186]

[Table 2]

		Mw	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16	Example 17	Example 18	Example 19	Example 20
Composition	(Meth)acrylic monomer (X)				400	200				800		
		ABE-300					400		600		850	600
		A-BPE-4						600				
		A-BPE-10		600								
		BP-4PA										
		BP-2EM	400									
	(Meth)acrylic monomer (D)	PO-A										
		POB-A	600	400								
		A-LEN-10			600	800	600	400				
		PO							400			
		THFA								200	150	
		FA511AS										400
Photopolymerization initiator	CHDMMA	198.3										
	M-600A	222.2										
	Irg819		10	10	10	10	10	10	10	10	10	10
	Irg 184											
	TPO											
Evaluation	(1) Viscosity (mPa·s)		70	200	360	270	330	300	80	190	280	120
	(2) Flexural strength (MPa)		55	10	90	40	80	15	70	78	67	74
	(3) Flexural modulus (MPa)		2300	400	3300	1500	3000	600	2300	2800	2300	2100
	(4) Bending resistance (thickness of 0.5 mm)		A	A	A	A	A	A	A	A	A	A
	(5) Bending resistance (thickness of 1.0 mm)		A	A	A	A	A	A	A	A	A	A
	(6) Tensile strength (MPa)		40	15	65	30	60	15	40	55	45	50
	(7) Elongation rate (%)		10	65	15	35	15	70	10	10	15	10
	(8) Tg (°C)		50	20	60	30	50	25	55	70	55	60

[0187]

[Table 3]

		Mw	Example 21	Example 22	Example 23	Example 24	Example 25	Example 26	Example 27	Example 28	Example 29	Example 30
Composition	(Meth)acrylic monomer (X)	ABE-300	800			600		600	400	600	500	
		A-BPE-4		700	700		750					
		A-BPE-10										600
		BP-4PA										
		BP-2EM										
	(Meth)acrylic monomer (D)	PO-A										
		POB-A		200				400			200	
		A-LEN-10			200				600			400
		PO										
		THFA										
		FA511AS										
		CHDMMA	200	100	100							
Evaluation	Photopolymerization initiator	M-600A				400	250			400	300	
		Irg819	10	10	10	10	10					
		Irg184						10	10	10	10	10
	(1) Viscosity (mPa·s) (2) Flexural strength (MPa) (3) Flexural modulus (MPa) (4) Bending resistance (thickness of 0.5 mm) (5) Bending resistance (thickness of 1.0 mm) (6) Tensile strength (MPa) (7) Elongation rate (%) (8) Tg (°C)	TPO						10	10	10	10	10
			570	310	510	560	670	190	370	570	270	310
			83	60	74	80	80	80	85	78	40	15
			2500	2300	2600	2800	2700	2900	3100	2700	1800	600
			A	A	A	A	A	A	A	A	A	A
			A	A	A	A	A	A	A	A	A	A
			55	40	50	60	60	55	60	60	35	15
			10	10	15	25	25	10	15	25	20	70
			60	50	60	60	60	65	60	60	50	25

[0188]

[Table 4]

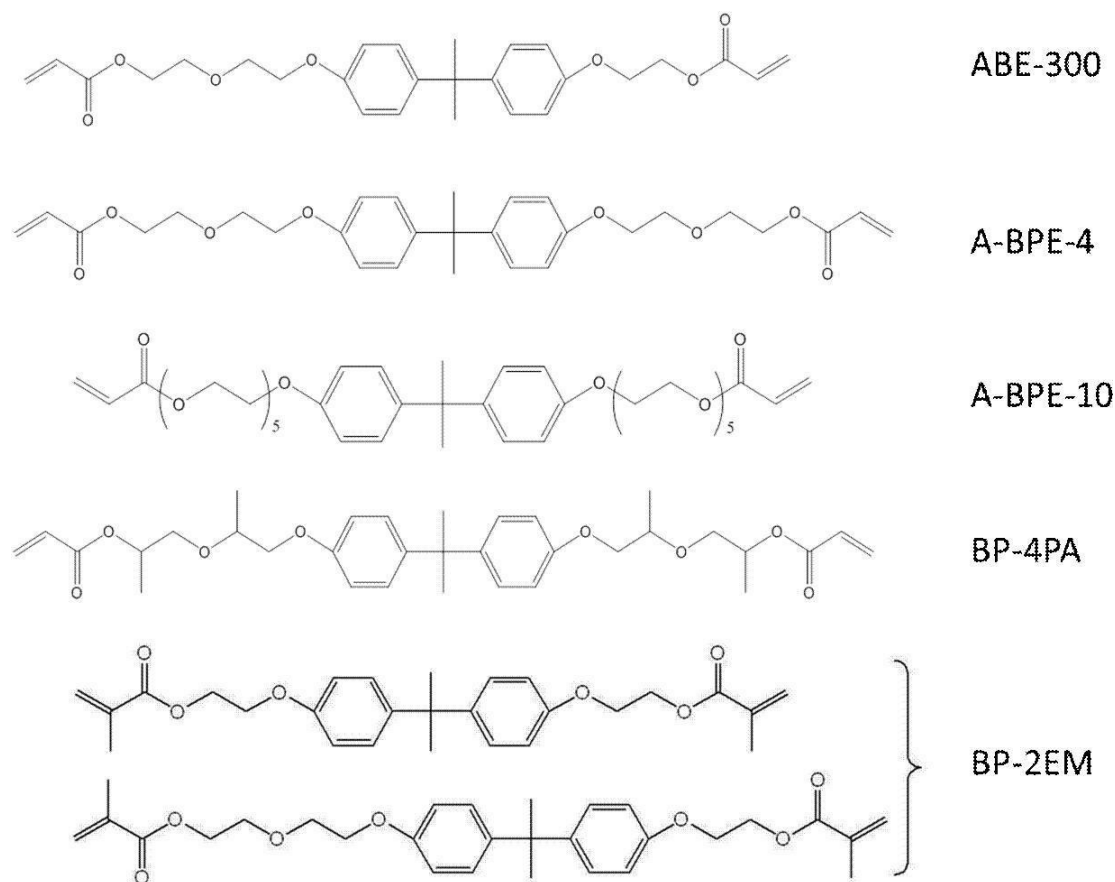
			Mw	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7
Composition	(Meth)acrylic monomer (X)	ABE-300	468.6							850
		A-BPE-4	512.6	1000						
		A-BPE-10	776.9						1000	
		BP-4PA	568.7							
	(Meth)acrylic monomer (D)	BP-2EM	479.0							
		PO-A	192.2							
		POB-A	254.3							
		A-LEN-10	268.3					1000		
		PO	206.2							
		THFA	156.2							
		EA511AS	204.3							
		CHDMMMA	198.3							
		M-600A	222.2		1000					
		4EG-A	302.3			1000				
		APG-200	300.4				1000			
		AIB	128.2							150
Evaluation	Photopolymerization initiator	Irg819		10	10	10	10	10	10	10
		Irg184								
		TPO								
				1100	185	12	10	140	600	180
	(1) Viscosity (mPa·s)									
	(2) Flexural strength (MPa)			68	6	23	38	12	8	80
	(3) Flexural modulus (MPa)			2350	70	850	1500	120	90	2600
	(4) Bending resistance (thickness of 0.5 mm)			B	A	C	C	C	B	C
	(5) Bending resistance (thickness of 1.0 mm)			C	A	C	C	C	C	C
	(6) Tensile strength (MPa)			50	1	20	24	10	2	60
	(7) Elongation rate (%)			5	250	5	2	30	5	5
	(8) Tg (°C)			80	17	50	90	30	2	65

[0189] In Tables 1 to 4, numerals of the “composition of photocurable composition” columns in each Example and each Comparative Example are expressed by parts by mass.

[0190] In Tables 1 to 4, the structures of each of the (meth)acrylic monomers (X) are as follows.

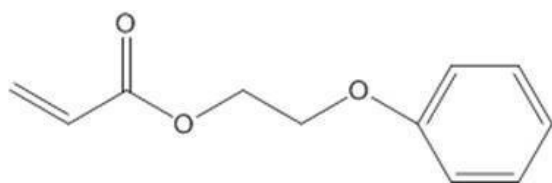
Here, ABE-300, A-BPE-4, and A-BPE-10 are acrylic monomers manufactured by Shin-Nakamura Chemical Co., Ltd., and BP-4PA is an acrylic monomer manufactured by Kyoeisha Chemical Co., Ltd., and BP-2EM is a methacrylic monomer manufactured by Kyoeisha Chemical Co., Ltd.

[0191]

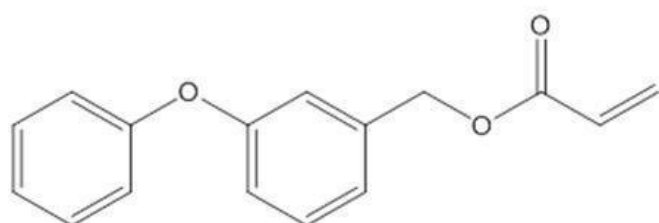


[0192] In Tables 1 to 4, the structures of each of the (meth)acrylic monomers (D) are as follows.

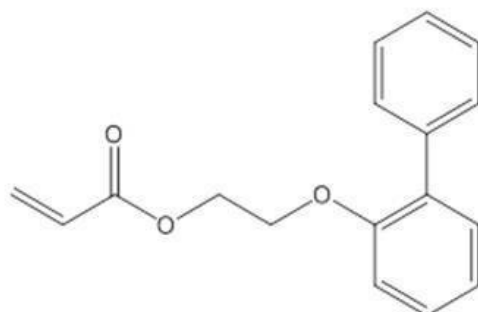
Here, PO-A, POB-A, M-600A, and 4EG-A are acrylic monomers manufactured by Kyoeisha Chemical Co., Ltd., PO is a methacrylic monomer manufactured by Kyoeisha Chemical Co., Ltd., A-LEN-10 and APG-200 are manufactured by Shin-Nakamura Chemical Co., Ltd., THFA and AIB are manufactured by Osaka Organic Chemical Industry Ltd., FA511AS is manufactured by Hitachi Chemical Co., Ltd., and CHDMMA is an acrylic monomer manufactured by Nippon Kasei Co., Ltd.



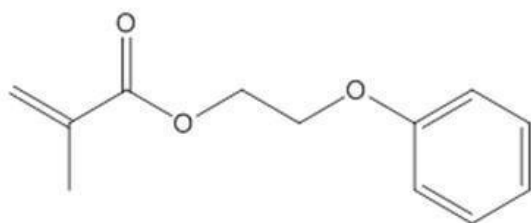
PO-A



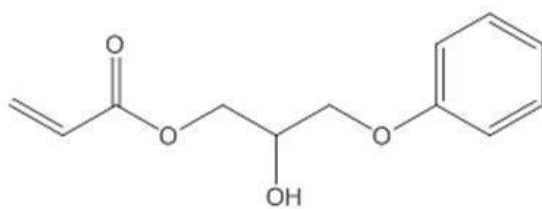
POB-A



A-LEN-10

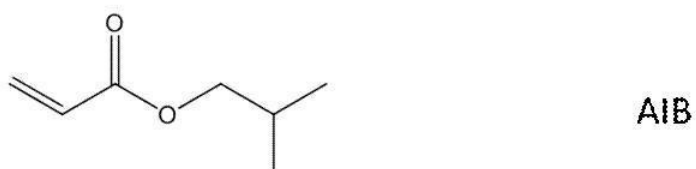
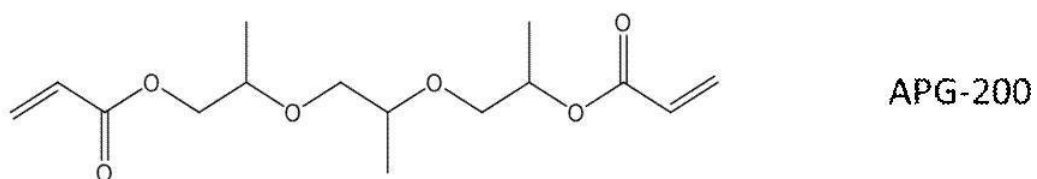
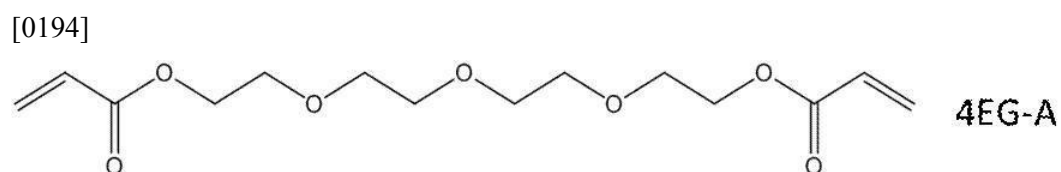
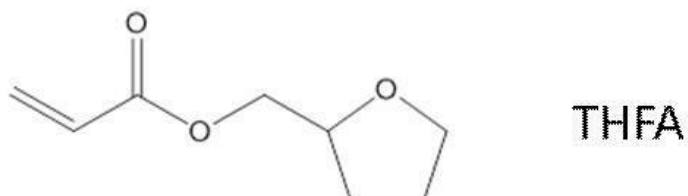
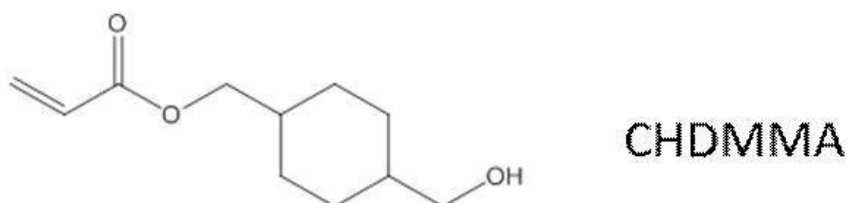
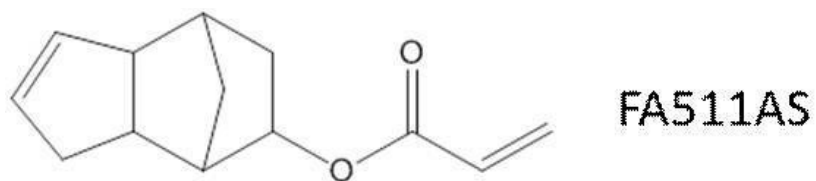


PO



M-600A

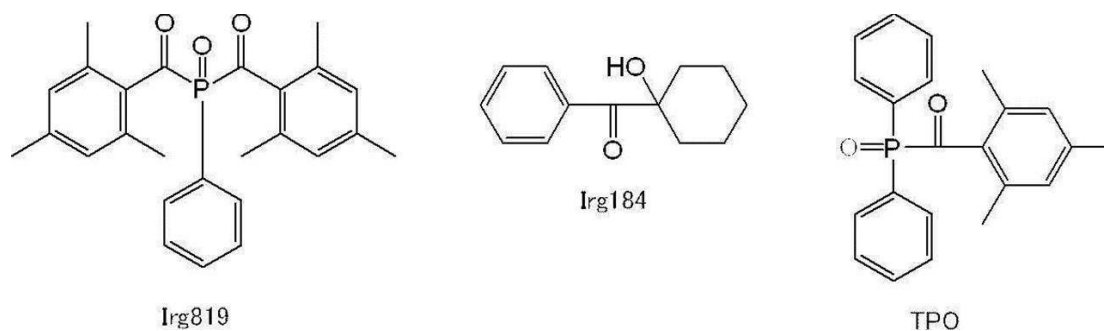
[0193]



[0195] In Tables 1 to 4, the structures of each of the photopolymerization initiators are as follows.

Here, Irg 819 is “Irgacure 819” (acyl phosphine oxide compound) manufactured by BASF, Irg 184 is “Irgacure 184” (alkyl phenone-based compound) manufactured by BASF, and TPO is “IrgacureTPO” (acyl phosphine oxide type compound) manufactured by BASF.

[0196]



[0197] As shown in Tables 1 to 4, in Examples 1 to 30 containing the (meth)acrylic monomer (X) and the (meth)acrylic monomer (D), in particular, the optically shaped product having excellent bending resistance could be obtained. In addition, the flexible strength, the flexible modulus, the bending resistance, the tensile strength, and the elongation rate were well balanced.

The viscosity and the glass transition temperature (that is, T_g) of the photocurable compositions of Examples 1 to 30 were in the range suitable for the optical shaping.

From the above, it has been confirmed that the photocurable compositions of Examples 1 to 30 are particularly suitable for the optical shaping of the artificial nail.

[0198] The disclosures of Japanese Patent Applications 2017-066067 and 2017-084814 are incorporated herein by reference in their entirety. All documents, patent applications, and technical standards described herein are incorporated herein by reference to the extent similar to the case in which individual documents, patent applications, and technical specifications incorporated by reference are specifically and individually recorded. The foregoing description of the exemplary embodiments of the invention has been provided for the purposes of illustration and description, and is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to those skilled in the art. The embodiments will best explain the principles and practical applications of the invention, and selected and described to enable those skilled in the art to understand the invention together with various embodiments and various modifications as suitable for particular application envisaged. It is intended that the scope of the invention be defined by the following claims and their equivalents.

CLAIMS

1. A photocurable composition used for optical shaping, comprising:

a (meth)acrylic monomer (X) which is at least one selected from di(meth)acrylic monomers that have no hydroxyl group and no carboxy group and that have two aromatic rings and two (meth)acryloyloxy groups in one molecule, and which has a weight average molecular weight of 400 or more and 800 or less;

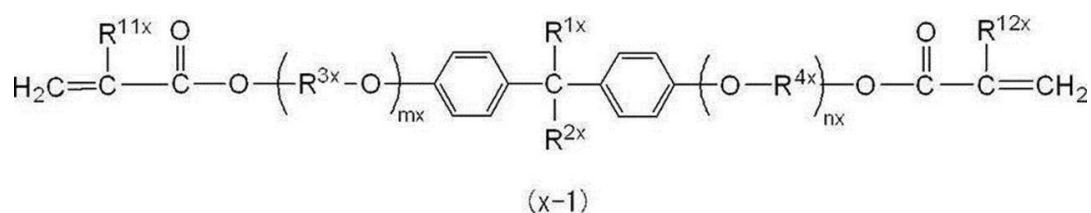
a (meth)acrylic monomer (D) which is at least one selected from (meth)acrylic monomers that have at least one ring structure and one (meth)acryloyloxy group in one molecule, and which has a weight average molecular weight of 130 or more and 350 or less; and

a photopolymerization initiator.

2. The photocurable composition according to claim 1, wherein at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) has an ether bond in one molecule.

3. The photocurable composition according to claim 1 or 2, wherein at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) has 1 or more and 10 or less ether bonds in one molecule.

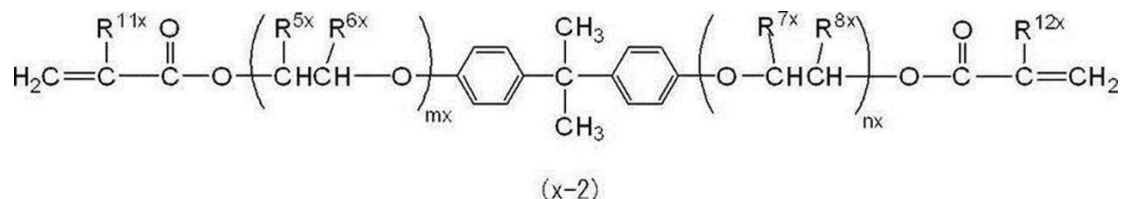
4. The photocurable composition according to any one of claims 1 to 3, wherein at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) is a compound represented by the following Formula (x-1):



wherein, in Formula (x-1), each of R^{1x} , R^{2x} , R^{11x} , and R^{12x} independently represents a hydrogen atom or a methyl group, each of R^{3x} and R^{4x} independently represents a linear or branched alkylene group having from 2 to 4 carbon atoms, each of mx and nx independently represents from 0 to 10, and satisfies a relationship of $1 \leq (mx + nx) \leq 10$.

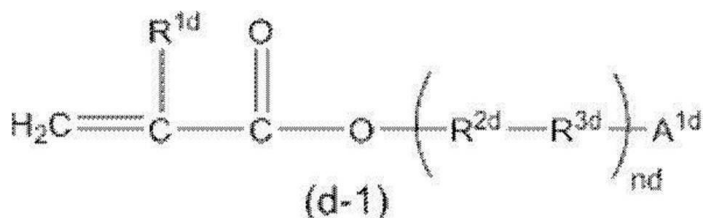
5. The photocurable composition according to any one of claims 1 to 4, wherein at least one of the di(meth)acrylic monomers constituting the (meth)acrylic monomer (X) is a

compound represented by the following Formula (x-2):



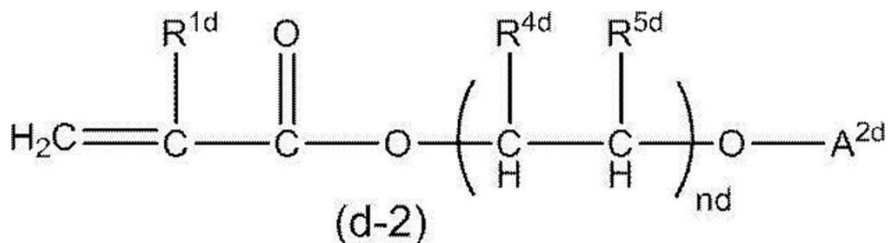
wherein, in Formula (x-2), each of R^{5x} , R^{6x} , R^{7x} , R^{8x} , R^{11x} , and R^{12x} independently represents a hydrogen atom or a methyl group, each of mx and nx independently represents from 0 to 10, and satisfies a relationship of $1 \leq (mx + nx) \leq 10$.

6. The photocurable composition according to any one of claims 1 to 5, wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a compound represented by the following Formula (d-1):



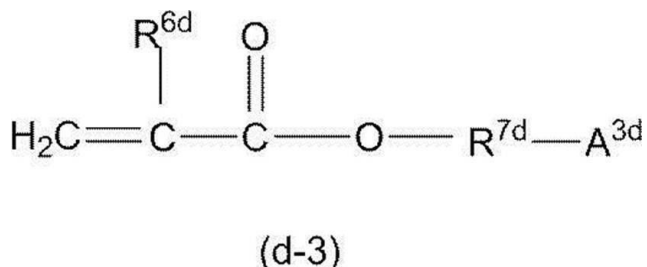
wherein, in Formula (d-1), R^{1d} represents a hydrogen atom or a methyl group, R^{2d} represents a single bond or a linear or branched alkylene group having from 1 to 5 carbon atoms, R^{3d} represents a single bond, an ether bond ($-\text{O}-$), an ester bond ($-\text{O}-\text{C}(=\text{O})-$), or $-\text{C}_6\text{H}_4-\text{O}-$, A^{1d} represents an aromatic ring which may have a substituent, and nd represents 1 or 2.

7. The photocurable composition according to claim 6, wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a compound represented by the following Formula (d-2):



wherein, in Formula (d-2), each of R^{1d} , R^{4d} , and R^{5d} independently represents a hydrogen atom or a methyl group, A^{2d} represents an aromatic ring which may have a substituent, and nd represents 1 or 2.

8. The photocurable composition according to any one of claims 1 to 5, wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a compound represented by the following Formula (d-3):



wherein, in Formula (d-3), R^{6d} represents a hydrogen atom or a methyl group, R^{7d} represents a single bond or a methylene group, and A^{3d} represents a ring structure other than an aromatic ring.

9. The photocurable composition according to claim 8, wherein the ring structure other than an aromatic ring is a ring structure having a dicyclopentenyl skeleton, a ring structure having a dicyclopentanyl skeleton, a ring structure having a cyclohexane skeleton, a ring structure having a tetrahydrofuran skeleton, a ring structure having a morpholine skeleton, a ring structure having an isobornyl skeleton, a ring structure having a norbornyl skeleton, a ring structure having a dioxolane skeleton, or a ring structure having a dioxane skeleton.

10. The photocurable composition according to any one of claims 1 to 5, wherein at least one of the (meth)acrylic monomers constituting the (meth)acrylic monomer (D) is a (meth)acrylic monomer which has at least one ring structure, one hydroxyl group, and one (meth)acryloyloxy group in one molecule.

11. The photocurable composition according to any one of claims 1 to 6, wherein the (meth)acrylic monomer (D) is o-phenylphenol EO-modified acrylate.

12. The photocurable composition according to any one of claims 1 to 6, wherein the (meth)acrylic monomer (D) is 3-phenoxybenzyl acrylate.

13. The photocurable composition according to any one of claims 1 to 12, wherein a content of the acrylic monomer (X) is 200 parts by mass or more with respect to 1000 parts by mass of a total content of (meth)acrylic monomers.

14. The photocurable composition according to any one of claims 1 to 13, wherein a content of the acrylic monomer (D) is from 30 parts by mass to 800 parts by mass with respect to 1000 parts by mass of a total content of (meth)acrylic monomers.

15. The photocurable composition according to any one of claims 1 to 14, wherein the photopolymerization initiator is at least one selected from an alkylphenone-based compound or an acylphosphine oxide-based compound.

16. The photocurable composition according to any one of claims 1 to 15, wherein a content of the photopolymerization initiator is from 1 part by mass to 50 parts by mass with respect to 1000 parts by mass of a total content of (meth)acrylic monomers.

17. The photocurable composition according to any one of claims 1 to 16, wherein a viscosity at 25°C and 50 rpm, which is measured using an E-type viscometer, is from 20 mPa·s to 3000 mPa·s.

18. The photocurable composition according to any one of claims 1 to 17, wherein the photocurable composition is used for producing an artificial nail by optical shaping.

19. An artificial nail comprising a cured product of the photocurable composition according to claim 18.

20. A method of generating shaping data, comprising:

a receiving step of receiving shape information specifying a three-dimensional external shape of an artificial nail to be formed;

a predicting step of predicting, based on predetermined prediction information, a contraction state of a shaped product which is optically shaped by a three-dimensional shaping device based on three-dimensional shaping data and predetermined shaping information and then is photocured by a curing device under a predetermined curing condition;

a generating step of generating the three-dimensional shaping data to optically shape the shaped product of the artificial nail to be formed by the three-dimensional shaping device by correcting three-dimensional shape data, of the artificial nail to be formed, obtained from the shape information based on a prediction result obtained in the predicting step; and

an outputting step of outputting the shaping data generated in the generating step.

21. The method of generating shaping data according to claim 20, wherein the prediction information comprises shaping information indicating a shaping condition including the three-dimensional shaping device and an optical shaping material used for optical shaping in the three-dimensional shaping device and curing information indicating the curing condition.

22. The method of generating shaping data according to claim 20 or 21, wherein the prediction information comprises shape data of the artificial nail produced in advance, shaping data generated from the shape data, and three-dimensional post-curing data representing an external shape after the curing of the shaped product which is optically shaped and photocured based on the shaping data.

23. The method of generating shaping data according to any one of claims 20 to 22, comprising:

an acquiring step of acquiring three-dimensional post-curing data representing the external shape of the shaped and cured product which is optically shaped and photocured based on the shaping data; and

an updating step of updating the prediction information based on the post-curing data acquired in the acquiring step, the shape data of the formed artificial nail for the post-curing data, the prediction result predicted for the shape data in the predicting step, and the shaping data which are generated based on the prediction result.

24. The method of generating shaping data according to any one of claims 20 to 23, comprising: a combining step of combining the shaping data of a plurality of artificial nails to be formed, such that the plurality of artificial nails to be formed are arranged on a base plate and integrally formed by the three-dimensional shaping device.

25. The method of generating shaping data according to claim 24, wherein the combining step comprises providing data, in which identification information, specifying each of the plurality of artificial nails to be formed, is formed on the base plate.

26. The method of generating shaping data according to claim 24 or 25, wherein in the combining step, the shaping data is combined such that each of a plurality of base plates, on which the plurality of artificial nails to be formed are arranged, is optically shaped in

parallel by the three-dimensional shaping device.

27. A method of producing an artificial nail, comprising:

a receiving step of receiving shape information specifying a three-dimensional external shape of an artificial nail to be formed;

a predicting step of predicting, based on predetermined prediction information, a contraction state of a shaped product which is optically shaped by a three-dimensional shaping device based on three-dimensional shaping data and predetermined shaping information and then is photocured by a curing device under a predetermined curing condition;

a generating step of generating the three-dimensional shaping data to optically shape the shaped product of the artificial nail to be formed by the three-dimensional shaping device by correcting three-dimensional shape data, of the artificial nail to be formed, obtained from the shape information based on a prediction result obtained in the predicting step;

a shaping step of generating the shaped product by the three-dimensional shaping device based on the shaping data generated in the generating step; and

a curing step of further photocuring the shaped product shaped in the shaping step.

28. The method of producing an artificial nail according to claim 27, comprising:

an acquiring step of acquiring three-dimensional post-curing data, representing the external shape of the shaped product, from the post-curing shaped product photocured in the curing step; and

an evaluating step of evaluating the post-curing shaped product by comparing the post-curing data with the shape data of the artificial nail to be formed.

29. The method of producing an artificial nail according to claim 28, comprising:

an updating step of updating the prediction information based on an evaluation result obtained in the evaluating step.

30. The method of producing an artificial nail according to any one of claims 27 to 29, comprising: a washing step of removing excess optical shaping material, used for optically shaping the shaped product, from the shaped product optically shaped in the shaping step, prior to the curing step.

31. A system for producing an artificial nail, comprising:

a three-dimensional shaping device which optically shapes a three-dimensional shaped product based on three-dimensional shaping data to be input;

a curing device which photocures the shaped product optically shaped by the three-dimensional shaping device; and

a shaping design device which comprises a receiving unit receiving shape information specifying a three-dimensional external shape of an artificial nail to be formed, a prediction unit predicting, based on predetermined stored prediction information, a contraction state of a shaped product which is optically shaped by the three-dimensional shaping device based on the three-dimensional shaping data and predetermined shaping information and then is photocured by the curing device under a predetermined curing condition, a generation unit generating three-dimensional shaping data to optically shape the shaped product of the artificial nail to be formed by the three-dimensional shaping device by correcting three-dimensional shape data of the formed artificial nail obtained from the shape information based on a prediction result obtained from the prediction unit, and an output unit outputting the shaping data to the three-dimensional shaping device.

32. The system for producing an artificial nail according to claim 31, wherein the prediction information comprises shaping information indicating a shaping condition including the three-dimensional shaping device and an optical shaping material used for shaping in the three-dimensional shaping device and curing information indicating the curing condition.

33. The system for producing an artificial nail according to claim 31 or 32, wherein the prediction information stored in the shaping design device comprises shape data of the artificial nail produced in advance, shaping data generated from the shape data, and three-dimensional post-curing data representing an external shape after the curing of the shaped product which is optically shaped and photocured based on the shaping data.

34. The system for producing an artificial nail according to any one of claims 31 to 33, wherein the shaping design device comprises:

an acquisition unit which acquires three-dimensional post-curing data representing the post-curing external shape of the shaped product which is optically shaped and photocured based on the shaping data; and

an updating unit which updates the post-curing data acquired in the acquiring unit, the shape data of the formed artificial nail for the post-curing data, the prediction result

predicted for the shape data in the prediction unit, and the prediction information based on the shaping data which is generated based on the prediction result.

35. The system for producing an artificial nail according to any one of claims 31 to 34, wherein the shaping design device comprises a combination unit that combines the shaping data of a plurality of artificial nails to be formed such that the plurality of artificial nails to be formed are arranged on a base plate and integrally formed by the three-dimensional shaping device.

36. The system for producing an artificial nail according to claim 35, wherein the combination unit of the shaping design device provides data including identification information specifying each of the plurality of artificial nails formed on the base plate.

37. The system for producing an artificial nail according to claim 35 or 36, wherein the combination unit of the shaping design device combines the shaping data such that each of a plurality of base plates, on which the plurality of artificial nails to be formed are arranged, is shaped in parallel by the three-dimensional shaping device.

38. The system for producing an artificial nail according to any one of claims 31 to 37, comprising:

an acquisition unit which acquires three-dimensional post-curing data representing the external shape of the shaped product, from the post-curing shaped product photocured by the curing device; and

an evaluation device that comprises an evaluation unit which evaluates the post-curing shaped product by comparing the post-curing data with the shape data of the formed artificial nail.

39. The system for producing an artificial nail according to claim 38, wherein the shaping design device comprises an updating unit that updates the prediction information based on an evaluation result of the evaluation unit of the evaluation device.