DESCRIPTION

Title of Invention: POLYMER, PRODUCTION METHOD THEREFOR, AND COMPOSITION, AQUEOUS SOLUTION, MOLDED BODY, AND PACKAGING CONTAINING POLYMER

Technical Field

[0001]

The present invention relates to a polymer and a method for producing the same, and a composition, an aqueous solution, a molded article, and a packaged article containing the polymer.

Background Art

[0002]

Polyvinyl alcohol based polymers have excellent film characteristics (such as a mechanical strength, an oil resistance, a film forming capability, and an oxygen gas barrier capability) derived from the hydrophilicity and/or the high crystallinity thereof. Therefore, polyvinyl alcohol based polymers have been widely applied to raw materials of a viscosity modifier (thickener), an adhesive, a coating material for paper, a fiber processing agent, a binder, an emulsion stabilizer, a film, fibers, and the like, by utilizing the characteristics. Furthermore, for enhancing the capabilities of the vinyl alcohol based polymers corresponding to the applications, modified vinyl alcohol based polymers are being developed by introducing a functional group, controlling the crystallinity, and the like method.

[0003]

Polyvinyl alcohol is a crystalline polymer, and therefore has a decreased solubility in water with a too high saponification degree. With regard thereto, for securing the water solubility, there is a known method of decreasing the crystallinity by random copolymerization of a vinyl ester and another monomer.

PTL 1 describes, as a vinyl alcohol based block copolymer excellent in water solubility, aqueous solution stability, and strength, a block copolymer containing a vinyl alcohol based polymer block (B-b) and a copolymer block (B-c) containing a vinyl alcohol based monomer unit and an acrylic acid based monomer unit.

Citation List

Patent Literature

[0004]

PTL 1: WO 2020/262517

Summary of Invention

Technical Problem

[0005]

A vinyl alcohol based polymer has been known as a material having biodegradability, and according to the investigations by the present inventors, it has been found that the biodegradability is decreased in the case where an acrylic acid based monomer is copolymerized for enhancing the water solubility as in the technique of PTL 1. Therefore, it is difficult to provide a vinyl alcohol based polymer that achieves both water solubility and biodegradability simultaneously.

[0006]

The present invention intends to solve the aforementioned problem, and a problem to be solved thereby is to provide a polymer that is excellent in water solubility and biodegradability, and a composition, an aqueous solution, a molded article, and a packaged article containing the polymer.

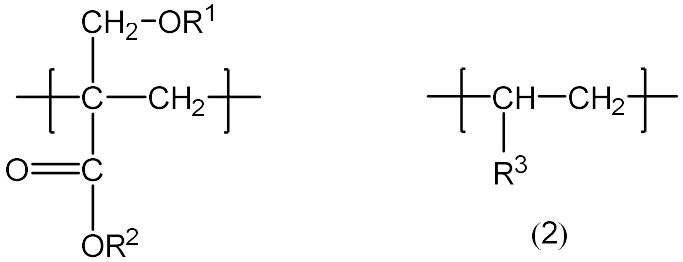
Solution to Problem

[0007]

As a result of the investigations by the present inventors for solving the problem, it has been found the problem can be solved by the present embodiment shown in the items [1] to [17] below.

[1] A polymer (X) containing a structural unit (A) represented by the following general formula (1) and a structural unit (B) represented by the following general formula (2):

[Chem 1]



(1)

(2)

in which in the formula (1), R^1 represents a hydrogen atom, an amino group, a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms, or a substituted or unsubstituted

heterocyclic group having 3 to 20 carbon atoms; and in the formula (1), R^2 represents a hydrogen atom, a metal atom, an ammonium group, a phosphonium group, or a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms; and in the formula (2), R^3 represents a hydroxy group or a group represented by -O-C(=O)-R^4, in which R^4 represents a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms.

[2] The polymer (X) according to the item [1], in which R^3 in the general formula (2) represents a hydroxy group or -O-C(=O)-CH_3.

[3] The polymer (X) according to the item [1] or [2], in which R^1 in the general formula (1) represents a hydrogen atom or an allyl group.

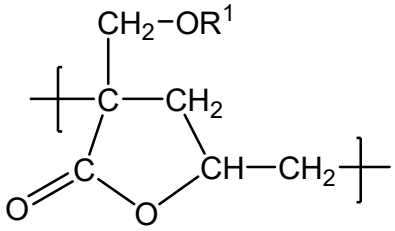
[4] The polymer (X) according to any one of the items [1] to [3], in which R^2 in the general formula (1) represents a hydrogen atom, an alkali metal atom, or a methyl group.

[5] The polymer (X) according to any one of the items [1] to [4], in which the polymer (X)

optionally contains a structural unit (C) represented by the following general formula (3), and

has a total content of the structural unit (A) and the structural unit (C) optionally contained of 0.01 to 20.0% by mol based on the total monomer units (100% by mol) of the polymer (X):

[Chem 2]



(3)

in which R^1 is the same as R^1 in the general formula (1).

[6] The polymer (X) according to any one of the items [1] to [5], in which the polymer (X) has a saponification degree of 70.00 to 99.99% by mol.

[7] The polymer (X) according to any one of the items [1] to [6], in which the polymer (X) has a number average degree of polymerization DPn of 100 to 5,000.

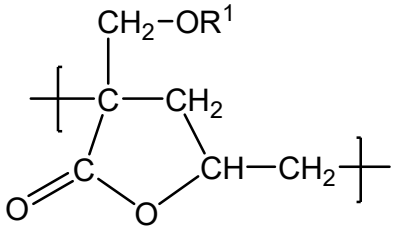
[8] The polymer (X) according to any one of the items [1] to [7], in which the polymer (X)

contains a structural unit (C) represented by the following general formula (3), and

has a ratio of a molar based content of the structural unit (A) with respect to a molar

based total content of the structural unit (A) and the structural unit (C) ((structural unit (A))/((structural unit (A)+structural unit (C))) of 0.01 to 0.99:

[Chem 3]



(3)

in which R^1 is the same as R^1 in the general formula (1).

[9] A composition containing the polymer (X) according to any one of the items [1] to [8].

[10] An aqueous solution containing the polymer (X) according to any one of the items [1] to [8].

[11] A molded article containing the polymer (X) according to any one of the items [1] to [8].

[12] The molded article according to the item [11], in which the molded article is a film.

[13] The molded article according to the item [11] or [12], in which the molded article is water-soluble.

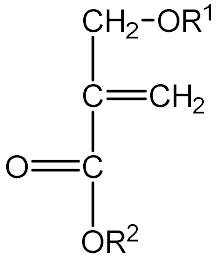
[14] A packaged article including a chemical packaged with the molded article according to the item [12] or [13].

[15] The packaged article according to the item [14], in which the chemical is an agricultural chemical or a detergent.

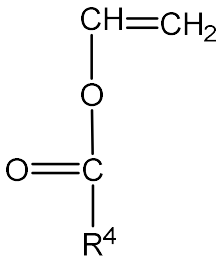
[16] A method for producing the polymer (X) according to any one of the items [1] to [8],

the method for producing the polymer (X), including a step of copolymerizing a monomer (a) represented by the following general formula (I) and a monomer (b) represented by the following general formula (II) to provide a copolymer; and a step of saponifying the copolymer:

[Chem 4]



(I)

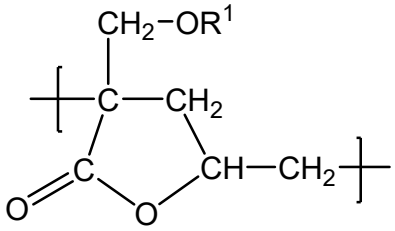


(II)

in which in the formula (I), R^1 and R^2 are the same as R^1 and R^2 in the general formula (1), and in the formula (II), R^4 is the same as R^4 in the description for the general formula (2).

[17] A polymer (X') containing a structural unit (C) represented by the following general formula (3):

[Chem 5]



(3)

in which in the formula (3), R^1 represents a hydrogen atom, an amino group, a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms, or a substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms.

Advantageous Effects of Invention

[0008]

The present invention can provide a polymer that is excellent in water solubility and biodegradability, a method for producing the same, and a composition, an aqueous solution, a molded article, and a packaged article containing the polymer.

Description of Embodiments

[0009]

One example of an embodiment to which the present invention is applied is described below. Other embodiments are encompassed by the present invention as long as conforming to the substance of the present invention.

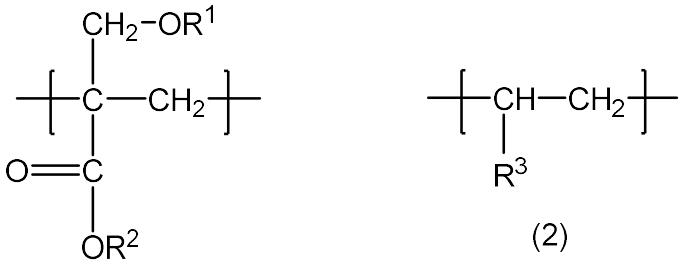
[0010]

[Polymer (X)]

The polymer (X) of the present invention contains a structural unit (A) represented by the following general formula (1) and a structural unit (B) represented by the following general formula (2):

[0011]

[Chem 6]



(1) (2)

in which in the formula (1), R^1 represents a hydrogen atom, an amino group, a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms, or a substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms; in the formula (1), R^2 represents a hydrogen atom, a metal atom, an ammonium group, a phosphonium group, or a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms; and in the formula (2), R^3 represents a hydroxy group or a group represented by -O-C(=O)-R^4, in which R^4 represents a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms.

[0012]

<Structural Unit (A)>

The structural unit (A) contained in the polymer (X) of the present invention is represented by the general formula (1).

One kind of the structural unit (A) may be contained in the polymer (X), or two or more kinds thereof may be contained therein.

It is considered that the polymer (X) of the present invention achieves the water solubility and the biodegradability simultaneously due to the structural unit (A) contained therein. It is considered that the mechanism therefor is that the -C(=O)-OR^2 group of the structural unit (A) contributes to the enhancement of the water solubility, and furthermore the structural unit (A) contains the quaternary carbon constituting the main chain of the polymer (X) and has the -OR^1 group capable of forming a hydrogen bond, thereby reducing molecular mobility and making the polymer more susceptible to attack by degrading enzymes.

[0013]

(R^1 in General Formula (1))

R^1 in the general formula (1) represents a hydrogen atom, an amino group, a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms, or a substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms.

In the general formula (1), the oxygen atom (-O-) that is bonded to both the $-CH_2-$ group and the R^1 group in the $-CH_2-OR^1$ group may be referred to as an "oxygen atom (1)".

In the following description, the ring-forming atom means an atom that constitutes the ring itself, which is a structure including atoms that are bonded in the form of ring, and the ring-forming atom does not encompass a hydrogen atom and atoms of a substituent and the like bonded to the atom constituting the ring.

[0014]

In the present invention, in the case where the group represented by R^1 has a heterocyclic ring, and the atom bonded to the oxygen atom (1) is the ring-forming atom of the heterocyclic ring, the group represented by R^1 is classified into a heterocyclic group. In the case where the heterocyclic ring constitutes a condensed ring, and the atom bonded to the oxygen atom (1) is the ring-forming atom of the condensed ring, the group represented by R^1 is classified into a heterocyclic group regardless of which ring-forming atom the atom bonded thereto is.

In the case where the group represented by R^1 has a hydrocarbon group other than the heterocyclic group, and the atom bonded to the oxygen atom (1) is a carbon atom of the hydrocarbon group, the group represented by R^1 is classified into a hydrocarbon group.

[0015]

Examples of the substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms represented by R^1 in the general formula (1) include a substituted or unsubstituted aliphatic hydrocarbon group having 1 to 20 carbon atoms and a substituted or unsubstituted aromatic hydrocarbon group having 6 to 20 carbon atoms.

In the present invention, in the case where the group represented by R^1 has a condensed ring other than a heterocyclic ring, and the condensed ring is constituted by an aromatic ring and a non-aromatic ring, the group represented by R^1 is classified into an aromatic hydrocarbon group in the case where the atom bonded to the oxygen atom (1) is the ring-forming atom of the aromatic ring constituting the condensed ring, and the group represented by R^1 is classified into an alicyclic hydrocarbon group in the case where the atom bonded to the oxygen atom (1) is the ring-forming atom of the non-aromatic ring constituting the condensed ring.

[0016]

Examples of the substituent that the substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms can have include a hydroxy group, a halogen atom, a cyano group,

a nitro group, a carboxy group, an amino group, a quaternary ammonium salt group, an alkoxy group, an aryloxy group, and an acyloxy group.

[0017]

The number of carbon atoms of the substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms except for the substituent is preferably 1 to 15, more preferably 1 to 10, and further preferably 1 to 5.

The number of carbon atoms of the substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms including the substituent is preferably 1 to 15, more preferably 1 to 10, and further preferably 1 to 5.

In the case where the numbers of carbon atoms are in the ranges, the polymer (X) is suppressed from being thickened to improve the coatability in forming a film, thereby further improving the productivity, the thickness accuracy, and the like of the film.

[0018]

The substituted or unsubstituted aliphatic hydrocarbon group having 1 to 20 carbon atoms may be linear, branched, or cyclic. The aliphatic hydrocarbon group may be a saturated aliphatic hydrocarbon group or may be an unsaturated aliphatic hydrocarbon group.

Examples of the substituent that the substituted or unsubstituted aliphatic hydrocarbon group having 1 to 20 carbon atoms can have include those exemplified above, and also include an aromatic hydrocarbon and a heterocyclic group.

[0019]

Examples of the substituted or unsubstituted aliphatic hydrocarbon group having 1 to 20 carbon atoms include a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted unsaturated aliphatic hydrocarbon group having 2 to 20 carbon atoms, a substituted or unsubstituted branched unsaturated aliphatic hydrocarbon group having 3 to 20 carbon atoms, and a substituted or unsubstituted alicyclic hydrocarbon group having 3 to 20 carbon atoms.

[0020]

Examples of the linear alkyl group having 1 to 20 carbon atoms include a methyl group, an ethyl group, an n-propyl group, an n-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an n-octyl group, an n-nonyl group, an n-decyl group, an n-undecyl group, an n-dodecyl group, an n-tridecyl group, an n-tetradecyl group, an n-pentadecyl group, an n-hexadecyl group, an n-heptadecyl group, an n-octadecyl group, an n-nonadecyl group, and an n-icosyl group.

[0021]

Examples of the branched alkyl group having 3 to 20 carbon atoms include an

isopropyl group (1-methylethyl group), a 1-methylpropyl group, a 2-methylpropyl group, a tert-butyl group, a 1,1-dimethylpropyl group, a 2,2-dimethylpropyl group, a 1,2-dimethylpropyl group, a 1-ethylpropyl group, a 2-ethylpropyl group, a 1,1-diethylpropyl group, a 1-methylbutyl group, a 2-methylbutyl group, a 3-methylbutyl group, a 1,1-dimethylbutyl group, a 2,2-dimethylbutyl group, a 3,3-dimethylbutyl group, a 1,3,3-trimethylbutyl group, a 1-ethylbutyl group, a 2-ethylbutyl group, a 1-propylbutyl group, a 1-methylpentyl group, a 2-methylpentyl group, a 3-methylpentyl group, a 4-methylpentyl group, a 4,4-dimethylpentyl group, a 1-methylhexyl group, a 2-methylhexyl group, a 3-methylhexyl group, a 4-methylhexyl group, a 5-methylhexyl group, a 5,5-dimethylhexyl group, a 1-methylheptyl group, a 2-methylheptyl group, a 3-methylheptyl group, a 4-methylheptyl group, a 5-methylheptyl group, a 6-methylheptyl group, a 6,6-dimethylheptyl group, a 1-methyloctyl group, a 2-methyloctyl group, a 3-methyloctyl group, a 4-methyloctyl group, a 5-methyloctyl group, a 6-methyloctyl group, a 7-methyloctyl group, a 7,7-dimethyloctyl group, a 1-methylnonyl group, a 2-methylnonyl group, a 3-methylnonyl group, a 4-methylnonyl group, a 5-methylnonyl group, a 6-methylnonyl group, a 7-methylnonyl group, a 8-methylnonyl group, a 3,5,5-trimethylhexyl group, and a 3,7,11,15-tetramethylhexadecyl group.

[0022]

Examples of the linear unsaturated aliphatic hydrocarbon group having 2 to 20 carbon atoms include a linear alkenyl group, such as an ethenyl group (vinyl group), a propenyl group (allyl group), a butenyl group, a pentenyl group, a hexenyl group, a heptenyl group, an octenyl group, a nonenyl group, undecenyl, a dodecenyl group, a tridecenyl group, a tetradecenyl group, a pentadecenyl group, a hexadecenyl group, a heptadecenyl group, an octadecenyl group, a nonadecenyl group, and an eicosenyl group; a linear alkynyl group, such as a propynyl group, a butynyl group, a pentynyl group, a hexynyl group, an octynyl group, and an undecynyl group; and a linear unsaturated aliphatic hydrocarbon group containing two or more unsaturated bonds, such as a heptadienyl group, a hexadienyl group, an octadienyl group, a nonadienyl group, a decadienyl group, an undecadienyl group, and a decatrienyl group. In the linear unsaturated aliphatic hydrocarbon groups, the position of the double bond or triple bond is optional.

[0023]

Examples of the branched unsaturated aliphatic hydrocarbon group having 3 to 20 carbon atoms include an isopropenyl group, a 1-methylpropenyl group, a 2-methylpropenyl group, a tert-butenyl group, a 1,1-dimethylpropenyl group, a 2,2-dimethylpropenyl group, a 1,2-dimethylpropenyl group, a 1-ethylpropenyl group, a 2-ethylpropenyl group, a 1,1-diethylpropenyl group, a 1-methylbutenyl group, a 2-methylbutenyl group, a 3-methyl-2-butenyl group, a 3-methyl-3-butenyl group, a 1,1-dimethylbutenyl group, a 2,2-

dimethylbutenyl group, a 3,3-dimethylbutenyl group, a 1,3,3-trimethylbutenyl group, a 1-ethylbutenyl group, a 2-ethylbutenyl group, a 3,3-dimethylbutenyl group, a 1-propylbutenyl group, a 1-methylpentenyl group, a 2-methylpentenyl group, a 3-methylpentenyl group, a 4-methylpentenyl group, a 4,4-dimethylpentenyl group, a 1-methylhexenyl group, a 2-methylhexenyl group, a 3-methylhexenyl group, a 4-methylhexenyl group, a 5-methylhexenyl group, a 5,5-dimethylhexenyl group, a 1-methylheptenyl group, a 2-methylheptenyl group, a 3-methylheptenyl group, a 4-methylheptenyl group, a 5-methylheptenyl group, a 6-methylheptenyl group, a 6,6-dimethylheptenyl group, a 1-methyloctenyl group, a 2-methyloctenyl group, a 3-methyloctenyl group, a 4-methyloctenyl group, a 5-methyloctenyl group, a 6-methyloctenyl group, a 7-methyloctenyl group, a 7,7-dimethyloctenyl group, a 1-methylnonenyl group, a 2-methylnonenyl group, a 3-methylnonenyl group, a 4-methylnonenyl group, a 5-methylnonenyl group, a 6-methylnonenyl group, a 7-methylnonenyl group, an 8-methylnonenyl group, a 1-ethenylnonyl group, and a 3,5,5-trimethylhexenyl group. In the branched unsaturated aliphatic hydrocarbon groups, the position of the double bond or triple bond is optional.

[0024]

Examples of the substituted or unsubstituted alicyclic hydrocarbon group having 3 to 20 carbon atoms include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclohexen-1-yl group, a bicyclo[2.2.1]heptan-1-yl group, a 1,2,3,4-tetrahydro-1-naphthalenyl group, a 1,4-dioxaspiro[4.5]deca-8-yl group, and a tricyclo[3.3.1.1^{3,7}]deca-1-yl group.

[0025]

Examples of the substituted or unsubstituted aromatic hydrocarbon group having 6 to 20 carbon atoms include a phenyl group, a 1-naphthalenyl group, a 2-naphthalenyl group, a 5,6,7,8-tetrahydro-1-naphthalenyl group, a 2,3-dihydro-1H-inden-5-yl group, an anthracenyl group, a fluorenyl group, a phenanthrenyl group, a pyrenyl group, and a tetracenyl group.

Examples of the substituent that the substituted or unsubstituted aromatic hydrocarbon group having 6 to 20 carbon atoms can have include those exemplified above, and also include an aliphatic hydrocarbon and a heterocyclic group.

[0026]

Examples of the substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms represented by R^1 in the general formula (1) include an oxetanyl group, a tetrahydro-3-furanyl group, a tetrahydro-2-furanyl group, a tetrahydro-2H-pyran-2-yl group, a tetrahydro-2H-pyran-4-yl group, a 1,3-benzodioxole-5-yl group, a tetrahydrothiophenium group, a silacyclohexan-1-yl group, a 3-isothiazolyl group, a 3-pyridinyl group, a 1H-indol-4-yl group,

a 3-quinolinyl group, a 5-quinolinyl group, a 7-quinolinyl group, and a 8-quinolinyl group.

Examples of the substituent that the substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms can have include those exemplified above, and also include an aliphatic hydrocarbon and an aromatic hydrocarbon group.

[0027]

Among the aforementioned options, R^1 preferably represents a hydrogen atom or a substituted or unsubstituted aliphatic hydrocarbon group having 1 to 20 carbon atoms, more preferably represents a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or a substituted or unsubstituted unsaturated hydrocarbon group having 2 to 20 carbon atoms, and further preferably represents a hydrogen atom and an allyl group, from the standpoint of the water solubility and the biodegradability.

[0028]

(R^2 in General Formula (1))

R^2 in the general formula (1) represents a hydrogen atom, a metal atom, an ammonium group, a phosphonium group, or a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms.

Examples of the metal atom represented by R^2 in the general formula (1) include an alkali metal atom, such as lithium, sodium, and potassium; and an alkaline earth metal atom, such as magnesium and calcium.

In the case where R^2 represents a metal atom, an ammonium group, or a phosphonium group, $-OR^2$ represents a salt of an oxygen atom with a metal atom, an ammonium group, or a phosphonium group.

The substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms represented by R^2 in the general formula (1) is described similarly as the substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms represented by R^1 in the general formula (1), and the example structures thereof are also the same.

[0029]

Among the aforementioned options, R^2 preferably represents a hydrogen atom, an alkali metal atom, or a substituted or unsubstituted aliphatic hydrocarbon group having 1 to 20 carbon atoms, more preferably represents a hydrogen atom, an alkali metal atom, or a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, further preferably represents a hydrogen atom, an alkali metal atom, or a methyl group, still further preferably represents an alkali metal atom, and particularly preferably represents sodium, from the standpoint of the water solubility and the biodegradability.

The content of the structural unit (A) in which R^2 represents an alkali metal atom is

preferably 20 to 100% by mol, more preferably 50 to 100% by mol, further preferably 70 to 100% by mol, still further preferably 90 to 100% by mol, and still more further preferably 95 to 100% by mol, based on the total amount (100% by mol) of the structural unit (A) contained in the polymer (X), from the standpoint of the water solubility.

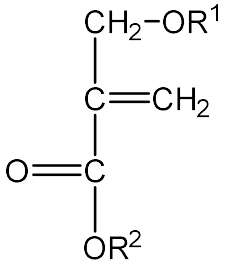
[0030]

(Monomer (a) providing Structural Unit (A))

The structural unit (A) is formed by polymerizing a monomer (a) represented by the following general formula (I):

[0031]

[Chem 7]



(I)

in which R^1 and R^2 are the same as R^1 and R^2 in the general formula (1).

[0032]

Examples of the monomer (a) include methyl 2-(hydroxymethyl)acrylate, methyl 2-(allyloxymethyl)acrylate, methyl 2-(methoxymethyl)acrylate, methyl 2-(ethoxymethyl)acrylate, methyl 2-(propoxymethyl)acrylate, methyl 2-[(1-methylethoxy)methyl]acrylate, methyl 2-(n-butoxymethyl)acrylate, methyl 2-[[(3,7,11,15-tetramethylhexadecyl)oxy]methyl]acrylate, methyl 2-[(n-dodecyloxy)methyl]acrylate, methyl 2-[(n-hexadecyloxy)methyl]acrylate, methyl 2-[(3-buten-1-yloxy)methyl]acrylate, methyl 2-[[(2-methyl-2-propen-1-yl)oxy]methyl]acrylate, methyl 2-[(2-buten-1-yloxy)methyl]acrylate, methyl 2-[(1-ethenylnonyloxy)methyl]acrylate, methyl 2-[[(1,1-dimethyl-3-buten-1-yl)oxy]methyl]acrylate, methyl 2-[(3,5-hexadienyloxy)methyl]acrylate, methyl 2-[(2-propyn-1-yloxy)methyl]acrylate, methyl 2-[(2-pentyn-1-yloxy)methyl]acrylate, methyl 2-(hydroperoxymethyl)acrylate, methyl 2-[(1,4-dioxaspiro[4.5]deca-8-yloxy)methyl]acrylate, methyl 2-[(3-isothiazolyloxy)methyl]acrylate, methyl 2-[(5-quinolinyloxy)methyl]acrylate, methyl 2-[(tricyclo[3.3.1.$1^{3,7}$]deca-1-yloxy)methyl]acrylate, methyl 2-(phenoxymethyl)acrylate, methyl 2-[(cyclohexyloxy)methyl]acrylate, methyl 2-[(5,6,7,8-tetrahydro-1-naphthalenyloxy)methyl]acrylate, butyl 2-(n-butoxymethyl)acrylate, ethyl 2-[(n-pentyloxy)methyl]acrylate, ethyl 2-[(n-hexyloxy)methyl]acrylate, ethyl 2-[(n-

heptyloxy)methyl]acrylate, ethyl 2-[(n-hexadecyloxy)methyl]acrylate, ethyl 2-[(n-octadecyloxy)methyl]acrylate, ethyl 2-[(10-undecyn-1-yloxy)methyl]acrylate, ethyl 2-[(2-heptyn-1-yloxy)methyl]acrylate, ethyl 2-[(1-methylethoxy)methyl]acrylate, ethyl 2-[(1-methylpropoxy)methyl]acrylate, ethyl 2-[(3-methylbutoxy)methyl]acrylate, ethyl 2-[(1-methylbutoxy)methyl]acrylate, ethyl 2-[(1-ethylpropoxy)methyl]acrylate, ethyl 2-[(aminooxy)methyl]acrylate, ethyl 2-[(2-propen-1-yloxy)methyl]acrylate, ethyl 2-[(3-buten-1-yloxy)methyl]acrylate, ethyl 2-[(4-penten-1-yloxy)methyl]acrylate, ethyl 2-[(cyclopropyloxy)methyl]acrylate, ethyl 2-[(cyclobutyloxy)methyl]acrylate, ethyl 2-[(cyclopentyloxy)methyl]acrylate, ethyl 2-[(cycloheptyloxy)acrylate, ethyl 2-[(1-cyclohexen-1-yloxy)methyl]acrylate, ethyl 2-[[(2,3-dihydro-1H-inden-5-yl)oxy]methyl]acrylate, ethyl 2-[[(5,6,7,8-tetrahydro-2-naphthalenyl)oxy]methyl]acrylate, ethyl 2-[(2-naphthalenyloxy)methyl]acrylate, ethyl 2-[(1-naphthalenyloxy)methyl]acrylate, ethyl 2-[[(1,2,3,4-tetrahydro-1-naphthalenyl)oxy]methyl]acrylate, ethyl 2-[(3-oxetanyloxy)methyl]acrylate, ethyl 2-[[(tetrahydro-3-furanyl)oxy]methyl]acrylate, tetrahydro-2-furanyl 2-[(2-propen-yloxy)methyl]acrylate, ethyl 2-[[(tetrahydro-2H-pyran-2-yl)oxy]methyl]acrylate, ethyl 2-[[(tetrahydro-2H-pyran-4-yl)oxy]methyl]acrylate, ethyl 2-[(1,3-benzodioxole-5-yloxy)methyl]acrylate, 1-[[2-(ethoxycarbonyl)-2-propen-1-yl]oxy]tetrahydrothiophenium, methyl 2-[(3-isothiazolyloxy)methyl]acrylate, 1-methylethyl 2-[(silacyclohexan-1-yloxy)methyl]acrylate, 1-[[2-(ethoxycarbonyl)-2-propen-1-yl]oxy]pyridinium, ethyl 2-[(3-pyridinyloxy)methyl]acrylate, ethyl 2-[(1H-indol-4-yloxy)methyl]acrylate, ethyl 2-[(7-quinolinyloxy)methyl]acrylate, ethyl 2-[(3-quinolinyloxy)methyl]acrylate, ethyl 2-[(8-quinolinyloxy)methyl]acrylate, ethyl 2-[(5-quinolinyloxy)methyl]acrylate, 1-[[2-(ethoxycarbonyl)-2-propen-1-yl]oxy)]quinolinium, tris[2-[(2-propen-1-yloxy-κO)methyl]-2-propenoato-κO]europium, bis[2-[(2-propen-1-yloxy-κO)methyl]-2-propenoato-κO]manganese, [2-[(2-propen-1-yloxy-κO)methyl]-2-propenoato-κO]silver, bis[2-[(2-propen-1-yloxy-κO)methyl]-2-propenoato-κO]zinc, tris[2-[(2-propen-1-yloxy-κO)methyl]-2-propenoato-κO]lanthanum, tris[2-[[(2-methyl-2-propen-1-yl)oxy-κO]methyl]-2-propenoato-κO]zinc, bis[2-[[(2-methyl-2-propen-1-yl)oxy-κO]methyl]-2-propenoato-κO]zinc, and bis[2-[(2-propen-1-yloxy-κO)methyl]-2-propenoato-κO]cobalt.

Among these, methyl 2-(hydroxymethyl)acrylate and methyl 2-(allyloxymethyl)acrylate are preferred from the standpoint of the water solubility and the biodegradability.

One kind of the monomer (a) may be used alone, or two or more kinds thereof may be used in combination.

[0033]

<Structural Unit (B)>

The structural unit (B) contained in the polymer (X) of the present invention is represented by the general formula (2). One kind of the structural unit (B) may be contained in the polymer (X), or two or more kinds thereof may be contained therein.

[0034]

(R^3 in General Formula (2))

R^3 in the general formula (2) represents a hydroxy group or a group represented by -O-C(=O)-R^4.

The substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms represented by R^4 in the group represented by -O-C(=O)-R^4 is described similarly as the substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms represented by R^1 in the general formula (1), and the example structures thereof are also the same. Among these, R^4 preferably represents a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or a substituted or unsubstituted unsaturated aliphatic hydrocarbon group having 2 to 20 carbon atoms, more preferably represents a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, further preferably represents an ethyl group or a methyl group, and particularly preferably represents a methyl group.

[0035]

Among the aforementioned options, R^3 preferably represents a hydroxy group or a group represented by -O-C(=O)-CH_3, and more preferably represents a hydroxy group, from the industrial standpoint and the standpoint of the water solubility.

The content of the structural unit (B) in which R^3 represents a hydroxy group is preferably 70.00 to 99.99% by mol, more preferably 75.00 to 99.00% by mol, further preferably 80.00 to 98.00% by mol, still further preferably 85.00 to 97.00% by mol, and still more further preferably 88.00 to 96.00% by mol, based on the total amount (100% by mol) of the structural unit (B) contained in the polymer (X), from the standpoint of the water solubility.

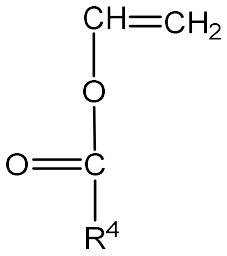
[0036]

(Monomer (b) providing Structural Unit (B))

The structural unit (B) is formed by polymerizing a monomer (b) represented by the following general formula (II):

[0037]

[Chem 8]



(II)

in which R^4 is the same as R^4 in the description for the general formula (2).

[0038]

Examples of the monomer (b) include vinyl acetate, vinyl formate, vinyl propionate, vinyl caprylate, and vinyl versatate. Among these, vinyl acetate is preferred from the industrial standpoint.

One kind of the monomer (b) may be used alone, or two or more kinds thereof may be used in combination.

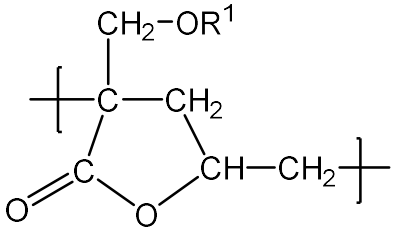
[0039]

<Structural Unit (C)>

The polymer (X) of the present invention may further contain a structural unit (C) represented by the following general formula (3). One kind of the structural unit (C) may be contained in the polymer (X), or two or more kinds thereof may be contained therein.

[0040]

[Chem 9]



(3)

in which R^1 is the same as R^1 in the general formula (1).

[0041]

The structural unit (C) corresponds to a structure formed in such a manner that after copolymerizing the monomer (a) and the monomer (b), and saponifying the resulting copolymer, the structural unit (A) derived from the monomer (a) and the structural unit (B) derived from the monomer (b) adjacent to the structural unit (A) form a lactone ring. The structural unit (C) contained in the polymer (X) prevents the surface of the polymer (X) from being melted

and adhered to form a lump, and as a result prevents the polymer (X) from being difficult to dissolve in water.

While the polymer (X) of the present invention contains the structural unit (A) and the structural unit (B) as described above, the present invention also provides a polymer (X') containing the structural unit (C), which corresponds to a precursor of the polymer (X).

[0042]

<Additional Structural Unit>

The polymer (X) of the present invention may contain or may not contain an additional structural unit other than the aforementioned structural units (which may be hereinafter referred simply to as an "additional structural unit").

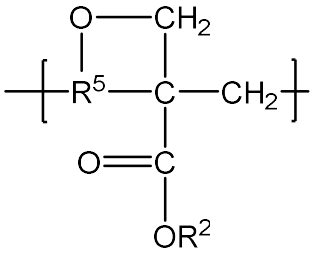
Examples of the additional structural unit include a structural unit derived from an ethylenically unsaturated monomer other than the monomer (a) and the monomer (b), and examples of the ethylenically unsaturated monomer include an α-olefin, such as ethylene, propylene, n-butene, and isobutylene; acrylic acid and a salt thereof; an acrylate ester compound, such as methyl acrylate, ethyl acrylate, n-propyl acrylate, isopropyl acrylate, n-butyl acrylate, isobutyl acrylate, tert-butyl acrylate, 2-ethylhexyl acrylate, dodecyl acrylate, and octadecyl acrylate; methacrylic acid and a salt thereof; a methacrylate ester compound, such as methyl methacrylate, ethyl methacrylate, n-propyl methacrylate, isopropyl methacrylate, n-butyl methacrylate, isobutyl methacrylate, tert-butyl methacrylate, 2-ethylhexyl methacrylate, dodecyl methacrylate, and octadecyl methacrylate; an acrylamide derivative, such as acrylamide, N-methylacrylamide, N-ethylacrylamide, N,N-dimethylacrylamide, diacetone acrylamide, acrylamide propanesulfonic acid and a salt thereof, acrylamide propyldimethylamine and a salt thereof or a quaternary salt thereof, and N-methylolacrylamide and a derivative thereof; a methacrylamide derivative, such as methacrylamide, N-methylmethacrylamide, N-ethylmethacrylamide, methacrylamide propanesulfonic acid and a salt thereof, methacrylamide propyldimethylamine and a salt thereof or a quaternary salt thereof, and N-methylolmethacrylamide and a derivative thereof; a vinyl ether compound, such as methyl vinyl ether, ethyl vinyl ether, n-propyl vinyl ether, isopropyl vinyl ether, n-butyl vinyl ether, isobutyl vinyl ether, tert-butyl vinyl ether, dodecyl vinyl ether, and stearyl vinyl ether; a nitrile compound, such as acrylonitrile and methacrylonitrile; a vinyl halide compound, such as vinyl chloride and vinyl fluoride; a vinylidene halide compound, such as vinylidene chloride and vinylidene fluoride; an allyl compound, such as allyl acetate and allyl chloride; an unsaturated dicarboxylic acid and a salt or an ester thereof, such as maleic acid, itaconic acid, and fumaric acid; a vinyl silyl compound, such as vinyltrimethoxysilane; and isopropenyl acetate.

[0043]

The polymer (X) of the present embodiment may further contain a structural unit represented by the following general formula (4):

[0044]

[Chem 10]



(4)

in which R^2 is the same as R^2 in the general formula (1), and R^5 represents a substituted or unsubstituted trivalent hydrocarbon group having 1 to 20 carbon atoms.

[0045]

The number of carbon atoms of the substituted or unsubstituted trivalent hydrocarbon group having 1 to 20 carbon atoms except for the substituent is preferably 1 to 15, more preferably 1 to 10, and further preferably 1 to 5.

The number of carbon atoms of the substituted or unsubstituted trivalent hydrocarbon group having 1 to 20 carbon atoms including the substituent is preferably 1 to 15, more preferably 1 to 10, and further preferably 1 to 5.

The substituted or unsubstituted trivalent hydrocarbon group having 1 to 20 carbon atoms is preferably a substituted or unsubstituted trivalent saturated aliphatic hydrocarbon group having 1 to 20 carbon atoms, and more preferably a substituted or unsubstituted trivalent saturated aliphatic hydrocarbon group having 1 to 20 carbon atoms.

[0046]

Examples of the substituent that the substituted or unsubstituted trivalent hydrocarbon group having 1 to 20 carbon atoms represented by R^5 in the general formula (4) can have include a hydroxy group, a halogen atom, a cyano group, a nitro group, a carboxy group, an amino group, a quaternary ammonium salt group, an alkoxy group, an aryloxy group, and an acyloxy group.

[0047]

Examples of the substituted or unsubstituted trivalent hydrocarbon group having 1 to 20 carbon atoms include an alkanetriyl group, such as a methanetriyl group, an ethanetriyl group, a 1,2,3-propanetriyl group, a 1,2,4-butanetriyl group, a 1,2,5-pentanetriyl group, a 1,3,5-

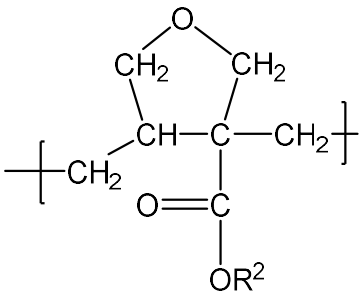
pentanetriyl group, a 1,2,6-hexanetriyl group, and a 1,3,6-hexanetriyl group; and an arylenetriyl group, such as a 1,2,3-benzenetriyl group, a 1,2,4-benzenetriyl group, and a 1,3,5-benzenetriyl group.

[0048]

The structural unit represented by the general formula (4) is preferably a structural unit represented by the following formula (4') from the standpoint of the productivity:

[0049]

[Chem 11]



(4')

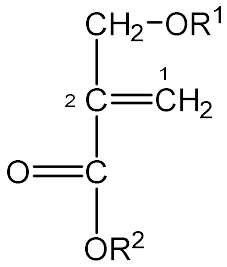
in which R^2 is the same as R^2 in the general formula (1).

[0050]

The structural unit represented by the general formula (4) is a structural unit that can be formed through polymerization of the monomer (a) involving intramolecular cyclization reaction. Specifically, for example, in the case where R^1 in the general formula (I) represents a group containing an ethylenic unsaturated bond, the structural unit represented by the general formula (4) can be formed through polymerization performed with addition reaction of the group containing an ethylenic unsaturated bond represented by R^1 and the carbon atom at the 2-position specified in the following formula:

[0051]

[Chem 12]



(I)

in which R^1 and R^2 are as described above.

[0052]

The group containing an ethylenic unsaturated bond represented by R^1 is preferably a linear alkenyl group having 1 to 20 carbon atoms, and more preferably an allyl group, among the options for R^1 described above.

[0053]

<Contents of Structural Units>

The content of the structural unit (A) in the polymer (X) of the present invention is preferably 0.01 to 20.0% by mol, more preferably 0.01 to 15.0% by mol, further preferably 0.01 to 10.0% by mol, still further preferably 0.01 to 8.0% by mol, still more further preferably 0.01 to 7.0% by mol, even further preferably 0.01 to 5.0% by mol, and even still further preferably 0.01 to 4.0% by mol, based on the total monomer units (100% by mol) of the polymer (X).

In the case where the content of the structural unit (A) is in the range, the polymer (X) tends to achieve the water solubility and the biodegradability at a higher level.

In the present invention, the content of each of the structural units based on the total monomer units (100% by mol) of the polymer (X) can be measured according to the method described in the examples.

The "total monomer units of the polymer (X)" herein is the total number of all the monomer units contained in the polymer (X) assuming that the structural unit based on one molecule of the monomer formed through polymerization of one molecule of the monomer is designated as the "monomer unit".

[0054]

The content of the structural unit (B) in the polymer (X) of the present invention is preferably 50.0 to 99.9% by mol, more preferably 60.0 to 99.8% by mol, further preferably 70.0 to 99.6% by mol, still further preferably 80.0 to 99.4% by mol, still more further preferably 85.0 to 99.2% by mol, even further preferably 87.0 to 99.0% by mol, even still further preferably 88.0 to 98.0% by mol, and even still more further preferably 90.0 to 97.0% by mol, based on the total monomer units (100% by mol) of the polymer (X).

In the case where the total content of the structural unit (B) is in the range, the polymer (X) tends to achieve the water solubility and the biodegradability at a higher level.

[0055]

The total content of the structural unit (A) and the structural unit (C) optionally contained (structural unit (A)+structural unit (C)) in the polymer (X) of the present invention is preferably 0.01 to 20.0% by mol, more preferably 0.01 to 15.0% by mol, further preferably 0.01 to 10.0% by mol, still further preferably 0.1 to 9.0% by mol, still more further preferably 1.0 to 8.0% by mol, even further preferably 3.0 to 6.0% by mol, and even still further preferably 4.0

to 5.0% by mol, based on the total monomer units (100% by mol) of the polymer (X).

In the case where the total content of the structural unit (A) and the structural unit (C) optionally contained is in the range, the polymer (X) tends to achieve the water solubility and the biodegradability at a higher level.

The "total content of the structural unit (A) and the structural unit (C) optionally contained" means the "content of the structural unit (A)" in the case where the polymer (X) does not contain the structural unit (C).

[0056]

The total content of the structural unit (B) and the structural unit (C) optionally contained (structural unit (B)+structural unit (C)) in the polymer (X) of the present invention is preferably 50.0 to 99.9% by mol, more preferably 60.0 to 99.8% by mol, further preferably 70.0 to 99.6% by mol, still further preferably 80.0 to 99.4% by mol, still more further preferably 90.0 to 99.2% by mol, even further preferably 92.0 to 99.0% by mol, even still further preferably 94.0 to 98.5% by mol, and even still more further preferably 95.0 to 98.0% by mol, based on the total monomer units (100% by mol) of the polymer (X).

In the case where the total content of the structural unit (B) and the structural unit (C) optionally contained is in the range, the polymer (X) tends to achieve the water solubility and the biodegradability at a higher level.

The "total content of the structural unit (B) and the structural unit (C) optionally contained" means the "content of the structural unit (B)" in the case where the polymer (X) does not contain the structural unit (C).

[0057]

In the case where the polymer (X) of the present invention contains the structural unit (C), the ratio of the molar based content of the structural unit (A) with respect to the molar based total content of the structural unit (A) and the structural unit (C) ((structural unit (A))/((structural unit (A)+structural unit (C))) is preferably 0.01 to 0.99, more preferably 0.05 to 0.99, further preferably 0.05 to 0.90, still further preferably 0.10 to 0.90, still more further preferably 0.10 to 0.80, even further preferably 0.10 to 0.70, even still further preferably 0.15 to 0.70, and even still more further preferably 0.20 to 0.60.

In the case where the ratio ((structural unit (A))/((structural unit (A)+structural unit (C))) is in the range, the polymer (X) tends to achieve the water solubility and the biodegradability at a higher level.

[0058]

The summation of the total content (structural unit (A)+structural unit (C)) and the total content (structural unit (B)+structural unit (C)) in the polymer (X) of the present invention

is preferably 70.0 to 100.0% by mol, more preferably 80.0 to 100.0% by mol, further preferably 90.0 to 100.0% by mol, still further preferably 95.0 to 100.0% by mol, and particularly preferably 99.0 to 100.0% by mol, from the standpoint of the water solubility and the biodegradability.

[0059]

(Saponification Degree)

The saponification degree of the polymer (X) of the present invention is preferably 70.00 to 99.99% by mol, more preferably 80.00 to 99.00% by mol, further preferably 85.00 to 98.00% by mol, still further preferably 86.00 to 97.00% by mol, and still more further preferably 88.00 to 96.00% by mol.

In the case where the saponification degree is the lower limit value or more, the mechanical strength tends to be enhanced, and in the case where the saponification degree is the upper limit value or less, the water solubility tends to be enhanced.

In the present invention, the saponification degree means the proportion (% by mol) of the saponified structural unit based on the total structural units derived from the vinyl ester based monomer in the polymer (X).

The "vinyl ester based monomer" herein means a carboxylic acid vinyl ester (CH_2=CH-O-C(=O)-R, in which R represents a hydrocarbon group), and is typically the monomer (b), and a monomer other than the monomer (b) may also be contained.

The "total structural units derived from the vinyl ester based monomer" used for calculating the saponification degree are structural units derived from the vinyl ester based monomer including the structural unit having an acyloxy group (-O-C(=O)-R) remaining not being saponified (which may be hereinafter referred to as a "vinyl ester unit", in which the structural unit having (-O-C(=O)-CH_3 remaining may be referred to as a "vinyl acetate unit"), the structural unit having a hydroxy group (-OH) converted from the acyloxy group through saponification (which may be hereinafter referred to as a "vinyl alcohol unit"), the structural unit having a lactone ring formed through saponification (which may be hereinafter referred to as a "lactone ring unit"), and the like.

The "saponified structural unit" used for calculating the saponification degree includes, among the structural units derived from the vinyl ester based monomer, the structural unit having a hydroxy group converted from the acyloxy group through saponification (which may be hereinafter referred to as a "vinyl alcohol unit"), the structural unit having a lactone ring formed through saponification, and the like.

The saponification degree of the polymer (X) can be measured by the method described in the examples.

[0060]

<Number Average Degree of Polymerization DPn>

The number average degree of polymerization DPn of the polymer (X) of the present invention is preferably 100 to 5,000, more preferably 200 to 4,000, further preferably 500 to 3,000, still further preferably 800 to 2,000, and particularly preferably 1,200 to 1,700.

In the case where the number average degree of polymerization DPn of the polymer (X) is the lower limit value or more, the mechanical strength tends to be improved, and in the case where the number average degree of polymerization DPn thereof is the upper limit value or less, the industrial manufacturability tends to be improved.

The number average degree of polymerization DPn of the polymer (X) can be measured by the method described in the examples.

[0061]

<Biodegradation Rate>

The biodegradation rate of the polymer (X) of the present invention is preferably 38% or more, more preferably 40% or more, further preferably 45% or more, and still further preferably 50% or more, from the standpoint of the biodegradability. The upper limit value of the biodegradation rate is not particularly limited, and may be 100% or less, or may be 95% or less.

The biodegradation rate can be measured by the method described in the examples.

[0062]

[Method for producing Polymer (X)]

The method for producing the polymer (X) of the present invention is not particularly limited.

The method for producing the polymer (X) of the present invention is preferably, for example, a production method including a step of copolymerizing the monomer (a) represented by the general formula (I) and the monomer (b) represented by the general formula (II) to provide a copolymer (which may be hereinafter referred to as a "polymerizing step"); and a step of saponifying the copolymer (which may be hereinafter referred to as a "saponifying step"), due to the simplicity thereof.

[0063]

(Polymerizing Step)

The descriptions for the monomer (a) and the monomer (b) used in the polymerizing step have been made in the descriptions for the structural unit (A) and the structural unit (B).

The polymerization method for copolymerizing the monomer (a) and the monomer (b) may be any method of batch polymerization, semi-batch polymerization, continuous

polymerization, semi-continuous polymerization, and the like, and the polymerizing method applied may be a known method, such as a bulk polymerization method, a solution polymerization method, a suspension polymerization method, an emulsion polymerization method, and a dispersion polymerization method. A solution polymerization method, an emulsion polymerization method, and a dispersion polymerization method are preferred from the industrial standpoint. The organic solvent used in the polymerizing step is not particularly limited, and examples thereof include an ester, such as methyl acetate and ethyl acetate; an aromatic hydrocarbon, such as toluene; and a lower alcohol, such as methanol and ethanol. Among these, a lower alcohol is preferred, and methanol is more preferred, from the standpoint of the cost. The amount of the solvent used in the polymerization system may be selected in consideration of the chain transfer of the solvent corresponding to the average degree of polymerization of the target polymer, and for example, in the case where methanol is used as the solvent, the mass ratio ((solvent)/(entire monomers)) of the solvent and the entire monomers contained in the polymerization system is preferably in a range of 0.01 to 10, and more preferably in a range of 0.05 to 3.

[0064]

The polymerization initiator used in copolymerization of the monomer (a) and the monomer (b) is not particularly limited, and can be selected from known polymerization initiators, such as an azo based initiator, a peroxide based initiator, and a redox based initiator, corresponding to the polymerization method.

Examples of the azo based initiator include 2,2'-azobisisobutyronitrile, 2,2'-azobis(2,4-dimethylvaleronitrile), and 2,2'-azobis(4-methoxy-2,4-dimethylvaleronitrile) ("V-70", a trade name, available from Fujifilm Wako Pure Chemical Corporation).

Examples of the peroxide based initiator include a percarbonate compound, such as diisopropyl peroxydicarbonate, di-2-ethylhexyl peroxydicarbonate, and diethoxyethyl peroxydicarbonate; a perester compound, such as tert-butyl peroxyneodecanoate, α-cumyl peroxyneodecanoate, and tert-butyl peroxyneodecanoate; acetylcyclohexylsulfonyl peroxide; diisobutyryl peroxide; and 2,4,4-trimethylpentyl-2-peroxyphenoxyacetate. These compounds may be further combined with potassium persulfate, ammonium persulfate, hydrogen peroxide, or the like, and used as the peroxide based initiator.

Examples of the redox based initiator include combinations of the peroxide based initiator described above with a reducing agent, such as sodium bisulfite, sodium bicarbonate, tartaric acid, L-ascorbic acid, and Rongalit.

Among these, an azo based initiator is preferred, and from the standpoint that the polymerization can be performed at a relatively low temperature, and the side reaction can be

suppressed, 2,2'-azobisisobutyronitrile is more preferred.

The amount of the polymerization initiator used cannot be determined conditionally since the amount thereof varies depending on the polymerization catalyst, and is preferably selected corresponding to the polymerization rate.

The amount of the polymerization initiator added is preferably 0.001 to 1.0 part by mass, more preferably 0.003 to 0.1 part by mass, and further preferably 0.005 to 0.05 part by mass, per the total amount (100 parts by mass) of the raw material monomers of the polymer (X).

[0065]

The polymerization of the monomer (a) and the monomer (b) in the polymerizing step may be performed in the presence of a chain transfer agent as long as achieving the effects of the present disclosure. Preferred examples of the chain transfer agent include an aldehyde compound, such as formaldehyde, acetaldehyde, and propionaldehyde; a ketone compound, such as acetone and methyl ethyl ketone; a mercaptan compound, such as 2-hydroxyethanethiol; and a phosphinate salt compound, such as sodium phosphinite monohydrate. Among these, an aldehyde compound and a ketone compound are preferably used. The amount of the chain transfer agent added to the polymerization system may be determined corresponding to the chain transfer coefficient of the chain transfer agent added and the degree of polymerization of the target copolymer, and for example, may be 1 to 1,000,000 ppm by mass, may be 5 to 80,000 ppm by mass, or may be 10 to 60,000 ppm by mass, based on the total amount of the raw material monomers of the polymer (X).

[0066]

The polymerization temperature is not particularly limited, may be 0 to 150°C, and is preferably 0 to 80°C, more preferably 10 to 80°C, further preferably 20 to 80°C, still further preferably 40 to 75°C, and still more further preferably 50 to 70°C. In the case where the polymerization temperature is 0°C or more, the polymerization rate becomes sufficient to enhance the productivity. In the case where the polymerization temperature is 150°C or less, the polymer (X) that has a narrow molecular weight distribution can be obtained.

[0067]

The monomer (a) and the monomer (b) may be added at one time or may be added sequentially, and it is preferred that a part of the monomer (a) and the entire amount of the monomer (b) are mixed, and then the polymerization reaction is started, followed by sequentially adding the remaining monomer (a). According to the procedure, the monomer composition in the polymerization solution can be retained constant, which facilitates the production of the polymer (X) having the target composition.

[0068]

At the time when the target polymerization conversion is achieved, the polymerization reaction is terminated by quenching, addition of a polymerization terminator, or both of them.

In the case where the polymerization system is quenched, while a method of allowing cooling water to flow in the jacket of the reaction vessel can be used, it is preferred to use a method of adding a liquid medium that has been cooled in advance to the reaction vessel.

A copolymer before saponification can be obtained in the aforementioned manner.

[0069]

(Saponifying Step)

The saponification is preferably performed in a state where the copolymer before saponification is dissolved in an alcohol or an aqueous alcohol.

Examples of the alcohol used in the saponification reaction include a lower alcohol, such as methanol and ethanol, in which methanol is preferred.

The alcohol used in the saponification reaction may contain or may not contain an additional solvent, such as acetone, an ester such as methyl acetate, and ethyl acetate, and toluene, and the content of the additional solvent is preferably 40% by mass or less, and more preferably 10% by mass or less, based on the total amount of the alcohol and the additional solvent.

The concentration of the alcohol solution of the copolymer before saponification is preferably 1 to 50% by mass, more preferably 5 to 45% by mass, and further preferably 8 to 40% by mass.

Examples of the catalyst used in the saponification reaction include a hydroxide of an alkali metal, such as sodium hydroxide and potassium hydroxide; an alkali catalyst, such as sodium methylate; and an acid catalyst, such as a mineral acid and an organic acid. Among these, sodium hydroxide is preferred from the standpoint of the easy handleability thereof.

[0070]

The temperature at which the saponification reaction is performed is not limited, and for example, is preferably 20 to 70°C. In the case where the temperature is 20°C or more, the saponification reaction can be rapidly performed. In the case where a gel-like product is deposited through the progress of the saponification, the product is crushed, and then washed and dried to form a copolymer after saponification. The saponification method is not limited to the method described above, and a known method may be applied thereto.

[0071]

In the case where the lactone ring described above is formed in the copolymer after saponification, the copolymer may be treated, depending on necessity, with a hydroxide of an

alkali metal, such as sodium hydroxide or potassium hydroxide, and thereby the saponification and the ring-opening of the lactone ring are performed, so as to control the saponification degree and the content ratio of the structural unit (C).

[0072]

[Aqueous Solution and Composition]

The aqueous solution of the present invention is an aqueous solution containing the polymer (X) of the present invention.

The content of the polymer (X) in the aqueous solution of the present invention is preferably 0.1 to 50.0% by mass, more preferably 1.0 to 40.0% by mass, further preferably 5.0 to 35.0% by mass, and still further preferably 10.0 to 30.0% by mass.

The aqueous solution of the present invention may contain a component other than the polymer (X) and water in such a range that does not impair the substance of the present invention. Examples of the component other than the polymer (X) and water include the additional components that the molded article of the present invention described later can contain.

[0073]

The composition of the present invention is a composition containing the polymer (X) of the present invention.

The composition of the present invention is not particularly limited as long as containing the polymer (X) of the present invention and a component other than the polymer (X) and a solvent.

Examples of the component other than the polymer (X) and the solvent include the additional components that the molded article of the present invention described later can contain.

[0074]

The aqueous solution and the composition of the present invention are used in various applications. Examples thereof are shown below, but the applications are not limited thereto.

(1) Dispersant uses: a dispersion stabilizer for organic and inorganic pigments in paints, adhesives, and the like; a dispersion stabilizer and a dispersion aid for suspension polymerization of various vinyl compounds, such as vinyl chloride, vinylidene chloride, styrene, (meth)acrylate, and vinyl acetate

(2) Coating agent uses: a coating agent for paper, a sizing agent, a textile processing agent, a leather finishing agent, a paint, an anti-fogging agent, a metal corrosion inhibitor, a brightener for zinc plating, an antistatic agent

(3) Adhesive uses: an adhesive, a pressure-sensitive adhesive, a rewettable adhesive,

various binders, an additive for cement and mortar

(4) Emulsifier uses: an emulsifier for emulsion polymerization, a post-emulsifier for bitumen and the like

(5) Flocculant uses: a flocculant for suspended matter and dissolved matter in water, a metal flocculant

(6) Paper processing uses: a paper strength enhancer, an oil resistance and solvent resistance imparting agent, a smoothness improving agent, a surface gloss improvement aid, a pore-filling agent, a barrier agent, a lightfastness imparting agent, a water resistance imparting agent, a dispersant for dyes and color developers, an adhesion force improving agent, a binder

(7) Agricultural uses: a binder for agricultural chemicals, a spreading agent for agricultural chemicals, an agricultural coating agent, a soil conditioner, an erosion preventive agent, a dispersant for agricultural chemicals

(8) Medical and cosmetic uses: a granulation binder, a coating agent, an emulsifier, a adhesive patch, a binder, a base material for film preparations, a film forming agent

(9) Viscosity modifier uses: a thickener, a rheology modifier

(10) Film uses: a water-soluble film, a polarizing film, a barrier film, a film for packaging textile products, a seed-curing sheet, a vegetation sheet, a seed tape, a hygroscopic film

(11) Molded article uses: fibers, a pipe, a tube, a leak-preventing membrane, water-soluble fibers for chemical lace, sponges

(12) Gel uses: a pharmaceutical gel, an industrial gel

(13) Post-reaction uses: uses for post-reaction with a low molecular weight organic compound, a high molecular weight organic compound, and an inorganic compound

[0075]

[Molded Article]

The molded article of the present invention is a molded article containing the polymer (X) of the present invention.

The form of the molded article of the present invention is not particularly limited, and examples thereof include optional forms such as fibers, a film, a sheet, a tube, and a bottle.

The method of molding the molded article of the present invention is not particularly limited, and examples thereof include a method of molding the polymer (X) of the present invention from a solution state dissolved in water, dimethylsulfoxide, or the like (for example, a cast molding method), and a method of plasticizing the polymer (X) by heating and then molding (for example, an extrusion molding method, an injection molding method, an inflation molding method, a press molding method, and a blow molding method).

[0076]

The content of the polymer (X) in the molded article of the present invention can be optionally determined corresponding to the physical property required for the molded article. For example, from the standpoint of the strength of the molded article, the content of the polymer (X) is preferably 10% by mass or more, more preferably 30% by mass or more, further preferably 50% by mass or more, still further preferably 70% by mass or more, still more further preferably 80% by mass or more, and even further preferably 90% by mass or more, and may be substantially 100% by mass, based on the mass (100% by mass) of the molded article.

[0077]

The molded article of the present invention may further contain, depending on necessity, a component other than the polymer (X) (which may be hereinafter referred to as an "additional component"). Examples of the additional component include a polymer other than the polymer (X), and additives, such as a plasticizer, a surfactant, a saccharide, an inorganic filler, an antioxidant, a lubricant, a release agent, a defoaming agent, a repellent, a filler, a crosslinking agent, an ultraviolet absorbent, a processing stabilizer, an antistatic agent, a flame retardant, a light stabilizer, a stripping agent, a preservative, a fragrance, a deodorant, an extender, a rust inhibitor, a weather resistance stabilizer, a colorant, a reinforcing agent, an anti-mold agent, a crystallization rate retarder, a compatibilizer, a slip agent, and a bleaching agent (such as sodium bisulfite and sodium pyrosulfite). One kind of these components may be used alone, or two or more kinds thereof may be used.

[0078]

The plasticizer is not particularly limited as long as being a material that is generally used as a plasticizer, and examples thereof include a polyhydric alcohol compound, such as glycerin, diglycerin, diethylene glycol, triethylene glycol, propylene glycol, dipropylene glycol, trimethylolpropane, pentaerythritol, and 1,3-butanediol; a polyether compound, such as polyethylene glycol and polypropylene glycol; a polyvinylamide compound, such as polyvinylpyrrolidone; an amide compound, such as N-methylpyrrolidone and dimethylacetamide; a compound obtained by adding ethylene oxide to a polyhydric alcohol, such as glycerin, pentaerythritol, and sorbitol; and water. One kind or two or more kinds of these materials may be used. Among these plasticizers, glycerin, diglycerin, diethylene glycol, triethylene glycol, propylene glycol, dipropylene glycol, trimethylolpropane, polyethylene glycol, and polyvinylpyrrolidone are preferred for the purpose of enhancing the water solubility, and in particular, glycerin, diglycerin, trimethylolpropane, polyethylene glycol, and polyvinylpyrrolidone are preferred from the point of the effect of suppressing the decrease of the water solubility of the film due to the bleed out of the plasticizer.

[0079]

The molecular weight of polyethylene glycol as the plasticizer is not particularly limited, and is preferably 100 to 1,000 in terms of number average molecular weight from the point of the compatibility with the polymer (X) and the effect of suppressing the decrease of the water solubility due to the bleed out. The molecular weight of polyvinylpyrrolidone as the plasticizer is also not particularly limited, and is preferably 1,000 to 20,000 in terms of mass average molecular weight from the point of the compatibility with the polymer (X).

[0080]

The amount of the plasticizer blended is preferably 1 to 50 parts by mass per 100 parts by mass of the polymer (X). In the case where the amount of the plasticizer blended is 1 part by mass or more, the effect obtained by blending the plasticizer is sufficiently exhibited. In the case where the amount of the plasticizer blended is 50 parts by mass or less, the plasticizer can be suppressed from being bled out.

The amount of the plasticizer blended is more preferably 20 parts by mass or more per 100 parts by mass of the polymer (X), from the point of the dissolving rate of the resulting molded article in water. The amount of the plasticizer blended is more preferably 40 parts by mass or less per 100 parts by mass of the polymer (X), from the point of the stiffness (i.e., the process passability in a bag making machine or the like) of the resulting molded article.

[0081]

The type of the surfactant is not particularly limited, and an anionic or nonionic surfactant is preferred. Preferred examples of the anionic surfactant include anionic surfactants of a carboxylic acid type, such as potassium laurate; a sulfate ester type, such as octyl sulfate; and a sulfonic acid type, such as dodecylbenzene sulfonate. Preferred examples of the nonionic surfactant include nonionic surfactants of an alkyl ether type, such as polyoxyethylene lauryl ether and polyoxyethylene oleyl ether; an alkyl phenyl ether type, such as polyoxyethylene octyl phenyl ether; an alkyl ester type, such as polyoxyethylene laurate; an alkylamine type, such as polyoxyethylene lauryl amino ether; an alkylamide type, such as polyoxyethylene lauric acid amide; a polypropylene glycol ether type, such as polyoxyethylene polyoxypropylene ether; an alkanolamide type, such as oleic acid diethanolamide; and an allyl phenyl ether type, such as polyoxyalkylene allyl phenyl ether. One kind or a combination of two or more kinds of the surfactants may be used.

[0082]

The amount of the surfactant blended is preferably 0.01 to 2 parts by mass, more preferably 0.1 to 1 part by mass, and further preferably 0.2 to 0.5 part by mass, per 100 parts by mass of the polymer (X). In the case where the amount of the surfactant blended is 0.01

part by mass or more, the releasability between a metal surface, such as a drum of a film making machine, and the film formed therewith is enhanced to enhance the productivity. In the case where the amount of the surfactant blended is 2 parts or less, the surfactant can be suppressed from bleeding to the surface of the film.

[0083]

Examples of the saccharide include a monosaccharide, an oligosaccharide, a polysaccharide, and a chain sugar alcohol. Examples of the monosaccharide include glucose. Examples of the oligosaccharide include galactooligosaccharide, isomaltooligosaccharide, xylooligosaccharide, soybean oligosaccharide, nigerooligosaccharide, lactosucrose, and fructooligosaccharide. Examples of the polysaccharide include starch, cellulose, chitin, chitosan, hemicellulose, pectin, pullulan, agar, alginic acid, carrageenan, dextrin,and trehalose. Examples of the chain sugar alcohol include a tetritol having 4 carbon atoms, such as threitol and erythritol; a pentitol having 5 carbon atoms, such as arabitol and xylitol; and a hexitol having 6 carbon atoms, such as glycitol, mannitol, and sorbitol. One kind or two or more kinds thereof may be used. The addition of a saccharide can further enhance the water solubility and the biodegradability of the molded article, can enhance the borate ion resistance thereof, and can suppress the decrease of the cold water solubility thereof after packaging a chemical, particularly a chemical that deteriorates the polymer (such as a chlorine based substance). Among the saccharides, starch is preferred from the point of the good cold water solubility of the film having the saccharide added thereto. Examples of the starch used include raw starch, such as corn and potato, and processed starch obtained by subjecting the raw starch to a physical or chemical treatment (such as dextrin, oxidized starch, etherified starch, and cationized starch).

[0084]

The molded article of the present invention may further contain an inorganic filler depending on necessity. Examples of the inorganic filler that can be used in the molded article of the present invention include silica, heavy, light, or surface-treated calcium carbonate, aluminum hydroxide, aluminum oxide, titanium oxide, diatomaceous earth, barium sulfate, calcium sulfate, zeolite, zinc oxide, silicic acid, silicate salt, mica, magnesium carbonate, clay, such as kaolin, halloysite, pyrophyllite, and sericite, and talc. One kind or two or more kinds thereof may be used. Among these, talc is preferred from the point of the dispersibility in the polymer (X). The average particle diameter of the inorganic filler is preferably 1 μm or more from the point of the blocking resistance of the film, and is preferably 10 μm or less from the point of the dispersibility in the polymer (X). It is more preferred to use an inorganic filler having an average particle diameter of approximately 1 to 7 μm from the standpoint of

satisfying the demanded characteristics of both the blocking resistance of the film exhibited by the inorganic filler blended, and the dispersibility of the inorganic filler in the polymer (X).

[0085]

The amount of the inorganic filler blended is preferably 0.5 to 20 parts by mass, more preferably 0.7 to 15 parts by mass, and further preferably 1 to 10 parts by mass, per 100 parts by mass of the polymer (X), from the point of the blocking resistance of the molded article and the dispersibility of the inorganic filler in the polymer (X). In the case where the amount of the inorganic filler blended is 20 parts by mass or less, there is a tendency that the dispersibility thereof in the polymer (X) is improved, and the water solubility of the resulting molded article is enhanced.

[0086]

In the production of the molded article of the present invention, the production raw material therefor can be prepared in such a manner that the polymer (X) is blended with a plasticizer, a saccharide, an inorganic filler, and the like depending on necessity, which are then mixed by a known method, such as a method of dissolving or dispersing the materials in a solvent in an agitation tank, and a method of melting and mixing the materials in an extruder.

[0087]

(Film)

Among the forms of the molded article of the present invention, particularly a film is one of the preferred embodiments thereof.

The molded article that is a film is preferably water-soluble.

The film containing the polymer (X) of the present invention may be formed only of the polymer (X) or may contain the additional components described above.

The film containing the polymer (X) of the present invention may be a single layer film, or may be a multilayer film including other films.

The thickness of the film containing the polymer (X) of the present invention in the form of a single layer film is preferably 10 to 200 μm, more preferably 20 to 150 μm, and further preferably 30 to 120 μm. In the case where the thickness of the film is the lower limit value or more, the excellent handleability is obtained, in the case where the thickness thereof is the upper limit value or less, the excellent water solubility is obtained.

[0088]

The production method of the film containing the polymer (X) of the present invention is not particularly limited, and the film can be produced by a known method, such as a casting method or a melt extrusion method. For example, the polymer (X) and the additional components described above depending on necessity are dissolved in an aqueous solvent, and

the resulting solution is allowed to stand on a smooth casting surface, and after evaporating the aqueous solvent, released from the casting surface, resulting in the water-soluble film of the present invention. The aqueous solvent is preferably water. The casting surface may be any material that is a smooth and hard material, such as steel, aluminum, glass, and a polymer (such as polyolefin, polyethylene, polyamide, polyvinyl chloride, polycarbonate, and polyhalocarbon). The evaporation rate of the aqueous solvent can be further increased by heating the casting surface, or exposing the deposited solution, for example, to heated air or infrared ray. The casting surface may be flat, or may be a standard (drum type) industrial film making casting machine.

[0089]

For enhancing the blocking resistance of the film, depending on necessity, the surface of the film may be roll-matted, anti-blocking powder, such as silica or starch, may be applied to the film, or the film may be subjected to an embossing treatment. The roll-matting of the surface of the film can be performed by forming minute unevenness on the surface of the roll that is brought into contact with the film before drying in producing the film. The embossing treatment can be generally performed by nipping the formed film with an embossed roll and a rubber roll under application of heat or pressure. The application of the powder has a large anti-blocking effect, but cannot be used depending on the purpose of the film. Therefore, the roll-matting or the embossing treatment is preferably performed, and from the point of the extent of the anti-blocking effect, the roll-matting is particularly preferred.

[0090]

The film containing the polymer (X) of the present invention has excellent water solubility and biodegradability, and therefore is useful in a wide range of fields, such as a sanitary material, a film for packaging a chemical, a base film for hydrographic transfer, a base material film for embroidery, a release film for molding artificial marble, a film for packaging seeds, and a film for a waste containment bag. In the use as a film for packaging a chemical, the kind of the chemical is as described for the chemical used in the packaged article of the present invention described later.

[0091]

[Packaged Article]

The packaged article of the present invention is a packaged article including a chemical packaged with a molded article that is the film of the present invention. The preferred embodiments of the film containing the polymer (X) of the present invention as one embodiment of the molded article of the present invention are as described above.

Examples of the chemical that is packaged in the packaged article of the present

invention include an agricultural chemical, a detergent (including a bleach), and an antiseptic. Among these, the chemical is preferably an agricultural chemical or a detergent. The property of the chemical is not particularly limited, and may be acidic, neutral, or alkaline. The chemical may contain a boron-containing compound. The form of the chemical may be either powder, bulk, gel, or liquid.

Examples

[0092]

The present invention is described in more detail with reference to examples below, but the present invention is not limited to the examples.

[0093]

[Production of Polymer and Production of Film of Polymer]

Polymers and films of polymers were produced in the following procedure.

In the following description, the polymers produced in Comparative Examples, which are the comparison targets of the polymers (X) produced in Examples, each are referred to as a "polymer (Y)".

[0094]

Examples 1 to 3

<Production of Polymer (X) and Production of Film of Polymer (X)>

(Polymerizing Step)

In a reaction vessel equipped with a reflux condenser, an agitator, a thermometer, a nitrogen introducing tube, a charging port for a post-addition liquid, and a pump, the monomer (1) and the monomer (2) shown in Table 1, and methanol were charged in the composition shown in Table 1 to form a mixed liquid. The interior of the system was purged with nitrogen while agitating the mixed liquid. Separately, as a sequential addition solution, a methanol solution of the monomer (1) (concentration: 40% by mass) was prepared, and bubbled with nitrogen for 30 minutes. Heating of the reaction vessel was started, and at the time when the temperature reached 60°C, the polymerization initiator (2,2'-azobisisobutyronitrile (AIBN)) in the amount shown in Table 1 was added to initiate polymerization. During the polymerization proceeding, the methanol solution of the monomer (1) prepared above was added to the system in a dropwise manner, so that the monomer composition in the polymerization solution (i.e., the molar ratio of the monomer (1) and the monomer (2)) was kept constant. The polymerization was terminated at the time when the polymerization conversion of the monomer (2) reached 30%.

[0095]

(Saponifying Step)

Subsequently, the unreacted monomers were removed under reduced pressure while occasionally adding methanol thereto, so as to prepare a methanol solution of a copolymer before saponification. Methanol was further added to the methanol solution of the copolymer before saponification, so as to regulate the concentration of the methanol solution of the copolymer before saponification to the concentration shown in the column "Methanol solution concentration of polymer" in Table 1. Subsequently, saponification was performed by adding a methanol solution of sodium hydroxide thereto to make the molar ratio of sodium hydroxide with respect to the structural unit derived from the monomer (2) in the copolymer before saponification to be the value shown in the column "Molar ratio (NaOH/monomer (2))" in Table 1, while retaining the temperature to 40°C. After adding the methanol solution of sodium hydroxide, a gelled product of the polymer thus formed was pulverized with a pulverizer, and the saponification reaction was performed by allowing the solution to stand at 40°C for 1 hour in the air. To the product in the form of white solid obtained through filtration, 1,000 parts by mass of methanol was added, and the solution was washed by allowing to stand at room temperature (23°C) for 3 hours. After repeating the washing operation twice, the product obtained through centrifugal separation was dried in a dryer at 40°C under a reduced pressure of 1.3 Pa for 20 hours, so as to provide a copolymer after saponification.

[0096]

(Post-processing Step)

Subsequently, in a reaction vessel equipped with a reflux condenser, an agitator, and a thermometer, 100 parts by mass of the copolymer after saponification obtained above and 2,400 parts by mass of water were charged, heating of the reaction vessel was started, and the mixture was agitated at 95°C for 1 hour to provide an aqueous solution of the copolymer after saponification.

Subsequently, a sodium hydroxide aqueous solution was added thereto to make the molar ratio of sodium hydroxide with respect to the structural unit (C) in the copolymer after saponification to be 1, and the mixture was agitated for 1 hour while retaining the temperature to 40°C, so as to provide an aqueous solution of the polymer (X).

[0097]

(Film-forming Step)

The aqueous solution of the polymer (X) obtained in the post-processing step was cast on a PET film, and dried in air at 25°C and 65%RH for 5 days to provide a film of the polymer (X) (thickness: 50 μm).

[0098]

Example 4

The polymerizing step and the saponifying step were performed in the same manner as in Example 1 except that the synthesis condition and the saponification condition were changed to the conditions shown in Table 1. The post-processing step in Example 1 was not performed, and the polymer obtained in the saponifying step was designated as the polymer (X). A film of the polymer (X) (thickness: 50 μm) was obtained by using the resulting polymer (X) in the same manner as in the film-forming step in Example 1.

[0099]

Example 5

The polymer (X) was obtained in the same manner as in Example 4 except that the post-processing step was performed under the same condition as in Example 1 after the saponifying step in Example 4. A film of the polymer (X) (thickness: 50 μm) was obtained by using the resulting polymer (X) in the same manner as in the film-forming step in Example 1.

[0100]

Example 6

The polymerizing step and the saponifying step were performed in the same manner as in Example 1 except that the synthesis condition and the saponification condition were changed to the conditions shown in Table 1. The post-processing step in Example 1 was not performed, and the polymer obtained in the saponifying step was designated as the polymer (X). A film of the polymer (X) (thickness: 50 μm) was obtained by using the resulting polymer (X).

[0101]

<Production of Polymer (Y) and Production of Film of Polymer (Y)>

Comparative Example 1

(Polymerizing Step)

In a reaction vessel equipped with a reflux condenser, an agitator, a thermometer, a nitrogen introducing tube, and a pump, the monomer (2) and methanol were charged in the composition shown in Table 1 to form a mixed liquid. The interior of the system was purged with nitrogen while agitating the mixed liquid. Heating of the reaction vessel was started, and at the time when the temperature reached 60°C, the polymerization initiator (2,2'-azobisisobutyronitrile (AIBN)) in the amount shown in Table 1 was added to initiate polymerization. The polymerization was terminated at the time when the polymerization conversion of the monomer (2) reached 30%.

[0102]

(Saponifying Step)

Subsequently, the unreacted monomer (2) was removed under reduced pressure to prepare a methanol solution of a polymer before saponification. Thereafter, the saponifying step was performed in the same manner as in Example 1. The post-processing step in Example 1 was not performed, and the polymer obtained in the saponifying step was designated as the polymer (Y).

[0103]

(Film-forming Step)

In reaction vessel equipped with a reflux condenser, an agitator, and a thermometer, 100 parts by mass of the polymer (Y) obtained in the saponifying step and 2,400 parts by mass of water were charged, heating of the reaction vessel was started, and the mixture was agitated at 95°C for 1 hour to provide an aqueous solution of the polymer (Y). The resulting aqueous solution of the polymer (Y) cast on a PET film, and dried in air at 25°C and 65%RH for 5 days to provide a film of the polymer (Y) (thickness: 50 μm).

[0104]

Comparative Example 2

The polymerizing step, the saponifying step, and the post-processing step were performed in the same manner as in Example 1 except that the synthesis condition and the saponification condition were changed to the conditions shown in Table 1, so as to provide an aqueous solution of the polymer (Y). A film of the polymer (Y) (thickness: 50 μm) was obtained by using the resulting aqueous solution of the polymer (Y) in the same manner as in the film-forming step in Example 1.

[0105]

Comparative Examples 3 and 4

The polymerizing step and the saponifying step were performed in the same manner as in Example 1 except that the synthesis condition and the saponification condition were changed to the conditions shown in Table 1. The post-processing step in Example 1 was not performed, and the polymer obtained in the saponifying step was designated as the polymer (Y). A film of the polymer (Y) (thickness: 50 μm) was obtained by using the resulting polymer (Y) in the same manner as in the film-forming step in Comparative Example 1.

[0106]

<Contents and Molar Ratios of Structural Units>

The contents of the structural units in the polymer (X) obtained in Examples and the polymer (Y) obtained in Comparative Examples were measured through analysis by ^{1}H-NMR (500 MHz).

Specifically, for the polymer (X) obtained in Examples 1 to 3, the contents (% by mol)

of the structural units were obtained from the ^{1}H-NMR measurement result of the acid-treated polymer (X) and the ^{1}H-NMR measurement result of the non-acid-treated polymer (X) described below.

[0107]

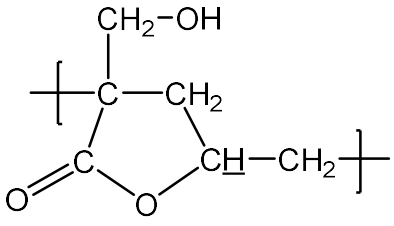
(^{1}H-NMR Measurement of Acid-treated Polymer (X))

The acid treatment of the polymer (X) was performed in the following manner. The polymer (X) was agitated in a hydrochloric acid aqueous solution of pH 2 at 100°C for 1 hour and then dried at 120°C, and thereby all the groups -C(=O)-OCH_3 or -C(=O)-ONa in the structural unit derived from the monomer (1) in the polymer (X) were converted to a carboxylic acid structure (-COOH) or a lactone ring structure.

The structural unit having a carboxylic acid structure (-COOH) on the side chain derived from methyl 2-(hydroxymethyl)acrylate is referred to as a "2-(hydroxymethyl)acrylic acid unit" in the following analysis.

The structural unit having a lactone ring structure derived from methyl 2-(hydroxymethyl)acrylate is a structural unit represented by the following formula (3') (hereinafter the structural unit is referred to as a "lactone ring unit") that is formed through reaction of the structural unit derived from methyl 2-(hydroxymethyl)acrylate and, adjacent to the structural unit, the structural unit derived from the monomer (2). In the following formula (3'), the underlined one hydrogen atom corresponds to the "main chain methine proton in the lactone ring unit" described later, and the four hydrogen atoms constituting the two methylene groups (-CH_2-) adjacent to the left and right of the carbon atom having the methine proton each correspond to the "main chain methylene proton in the lactone ring unit".

[Chem 13]



(3')

The polymer (X) after the acid treatment was washed with methanol to remove salts, and then dried under reduced pressure at 90°C for 2 days, which was used as the measurement target of ^{1}H-NMR. The measurement apparatus used was a nuclear magnetic resonator "LAMBDA 500", available from JEOL, Ltd., and the ^{1}H-NMR measurement was performed at 80°C with DMSO-d6 as a solvent. The content (Z_a) (% by mol) of the structural unit derived from the monomer (a) and the content (Z_b) (% by mol) of the structural unit derived from the

monomer (b) based on the total monomer units of the polymer (X) were calculated according to the following expressions.

(Z_a) (% by mol) = ((X+Y)/((W-T×3)/2))×100

(Z_b) (% by mol) = 100 - (Z_a)

The meanings of the symbols in the expressions are as follows. In the chemical formula in the parentheses in the following description, the proton from which the peak for which the integral value is calculated is derived is underlined.

Y: the integral value of the peak derived from the side chain proton in the 2-(hydroxymethyl)acrylic acid unit (-$CH_2C(CH_2OH)(COO\underline{H})$-) (broad peak detected in a range of 11.0 ppm to 13.0 ppm)

X: the integral value of the main chain methine proton in the lactone ring unit (peak at 4.5 ppm to 4.8 ppm)

W: the total integral value of the peaks derived from the main chain methylene protons in the vinyl alcohol unit, the vinyl acetate unit, and the 2-(hydroxymethyl)acrylic acid unit, the main chain methylene proton in the lactone ring unit, and the side chain proton in the vinyl acetate unit (-$CH_2CH(OCOC\underline{H}_3)$-) (peak at 1.2 ppm to 2.4 ppm)

T: the integral value of the peak derived from the main chain methine proton in the vinyl acetate unit (-$CH_2C\underline{H}(OCOCH_3)$-) (peak at 4.8 ppm to 5.2 ppm)

[0108]

(^{1}H-NMR Measurement of Non-acid-treated Polymer (X))

The ^{1}H-NMR measurement of the non-acid-treated polymer (X) was performed at 50°C with the same nuclear magnetic resonator as above with deuterated water as a solvent. The content (Z_A) (% by mol) of the structural unit (A), the content (Z_B) (% by mol) of the structural unit (B), the content (Z_C) (% by mol) of the structural unit (C), and the content (Z_{BH}) (% by mol) of the structural unit (B) in which R^3 in the general formula (2) represents a hydroxy group, based on the total monomer units of the polymer (X) were calculated according to the following expressions.

(Z_C) (% by mol) = (Q/((P-3×R)/2))×100

(Z_A) (% by mol) = (Z_a)-(Z_C)

(Z_B) (% by mol) = (Z_b)-(Z_C)

(Z_{BH}) (% by mol) = (Z_B)-((R/((P-3×R)/2))×100)

The meanings of the symbols in the expressions are as follows.

P: the total integral value of the peaks derived from the main chain methylene protons in the vinyl alcohol unit, the vinyl acetate unit, and the 2-(hydroxymethyl)acrylic acid unit, the main chain methylene proton in the lactone ring unit, and the side chain proton in the vinyl

acetate unit (-$CH_2CH(OCOC\underline{H}_3)$-) (peak at 1.5 ppm to 3.1 ppm)

Q: the integral value of the main chain methine proton in the lactone ring unit (peak at 5.0 ppm to 5.1 ppm)

R: the integral value of the peak derived from main chain methine proton in the vinyl acetate unit (-$CH_2C\underline{H}(OCOCH_3)$-) (peak at 5.1 ppm to 5.7 ppm)

[0109]

The contents (% by mol) of the structural units in the polymer (X) obtained in Examples 4 and 5 were measured by the method according to Examples 1 to 3.

[0110]

The ^{1}H-NMR measurement of the polymer (X) obtained in Example 6 was performed at 80°C with the same nuclear magnetic resonator as above with DMSO-d6 as a solvent. The content (Z_A) (% by mol) of the structural unit (A), the content (Z_B) (% by mol) of the structural unit (B), the content (Z_C) (% by mol) of the structural unit (C), and the content (Z_{BH}) (% by mol) of the structural unit (B) in which R^3 in the general formula (2) represents a hydroxy group, based on the total monomer units of the polymer (X), and the content (Z_a) (% by mol) of the structural unit derived from the monomer (a) and the content (Z_b) (% by mol) of the structural unit derived from the monomer (b) based on the total monomer units of the polymer (X) were calculated according to the following expressions.

(Z_A) (% by mol) = (N')/(((P'-D')-5×(S'-G')-2×N'-3×(R'-N'))/2+(S'-G')+N')×100

(Z_a) (% by mol) = (Z_A)+(S'-G')/(((P'-D')-5×(S'-G')-2×N'-3×(R'-N'))/2+(S'-G')+N')×100

(Z_C) (% by mol) = (Q')/(((P'-D')-5×(S'-G')-2×N'-3×(R'-N'))/2+(S'-G')+N')×100

(Z_B) (% by mol) = 100-(Z_a)-(Z_C)

(Z_{BH}) (% by mol) = (Z_B)-((R'-N')/(((P'-D')-5×(S'-G')-2×N'-3×(R'-N'))/2+(S'-G')+N'))×100

(Z_b) (% by mol) = 100-(Z_a)

The meanings of the symbols in the expressions are as follows.

P': the total integral value of the peaks derived from the main chain methylene protons in the vinyl alcohol unit, the vinyl acetate unit, and the unit derived from methyl 2-(allyloxymethyl)acrylate, the main chain methine proton formed through intramolecular cyclization of methyl 2-(allyloxymethyl)acrylate, the main chain methylene proton in the lactone ring unit, and the side chain proton in the vinyl acetate unit (-$CH_2CH(OCOC\underline{H}_3)$-) (peak at 0.7 ppm to 2.8 ppm)

D': the integral value of the solvent peak of DMSO (peak at 2.45 ppm to 2.55 ppm)

Q': the integral value of the main chain methine proton in the lactone ring unit (peak

at 4.5 ppm to 4.7 ppm)

R': the total integral value of the peaks derived from the main chain methine proton in the vinyl acetate unit (-$CH_2C\underline{H}(OCOCH_3)$-) and one of the protons separated into two of the methylene proton of the side chain allyl group in the unit derived from methyl 2-(allyloxymethyl)acrylate (-CH_2-O-CH_2-CH=C$\underline{H}_2$) (peak at 4.7 ppm to 5.2 ppm)

N': the integral value of the peak derived from one of the protons separated into two of the methylene proton of the side chain allyl group in the unit derived from methyl 2-(allyloxymethyl)acrylate (-CH_2-O-CH_2-CH=C$\underline{H}_2$) (peak at 5.2 ppm to 5.3 ppm)

G': the integral value of the peak derived from one of the protons separated into two of the main chain methylene proton derived from the 1,2-glycol bond formed by the vinyl alcohol unit (peak at 3.2 ppm to 3.3 ppm)

S': the total integral value of the peaks derived from one of the protons separated into two of the main chain methine proton derived from the 1,2-glycol bond formed by the vinyl alcohol unit and one of the protons separated into two of the methylene proton of the 5-membered ring formed through intramolecular cyclization of methyl 2-(allyloxymethyl)acrylate (-CH_2-O-C$\underline{H}_2$-CH-CH_2-) (peak at 3.2 ppm to 3.3 ppm)

[0111]

The ^{1}H-NMR measurement of the polymer (Y) obtained in Comparative Example 2 was performed at 80°C with the same nuclear magnetic resonator as above with deuterated water as a solvent. The content ($Z_{A'}$) (% by mol) of the structural unit (A'), the content (Z_B) (% by mol) of the structural unit (B), the content ($Z_{C'}$) (% by mol) of the structural unit (C'), and the content (Z_{BH}) (% by mol) of the structural unit (B) in which R^3 in the general formula (2) represents a hydroxy group, based on the total monomer units of the polymer (Y) were calculated according to the following expressions.

$(Z_{C'})$ (% by mol) = $(T/((S-3\times U)/2))\times 100$

$(Z_{A'})$ (% by mol) = $(V/((S-3\times U)/2))\times 100$

(Z_B) (% by mol) = $100-(Z_{A'})-(Z_{C'})\times 2$

(Z_{BH}) (% by mol) = $(Z_B)-((U/((S-3\times U)/2))\times 100)$

The meanings of the symbols in the expressions are as follows.

S: the total integral value of the peaks derived from the main chain methylene protons in the vinyl alcohol unit, the vinyl acetate unit, and the structural unit derived from methyl acrylate, the main chain methylene proton in the lactone ring unit, and the side chain proton in the vinyl acetate unit (-$CH_2CH(OCOC\underline{H}_3)$-) (peak at 1.3 ppm to 2.4 ppm and peak at 2.6 to 2.8 ppm)

T: the integral value of the peak derived from ((-CH_2CH)(R^a)$CH_2C\underline{H}(R^b)$-)) of the

main chain methine proton in the lactone ring unit (in which R^a-R^b form a bond, and -R^a-R^b- means the -CO-O- structure) (peak at 4.6 ppm to 5.0 ppm)

U: the integral value of the peak derived from the main chain methine proton in the vinyl acetate unit (-$CH_2C\underline{H}(OCOCH_3)$-) (peak at 5.0 ppm to 5.4 ppm)

V: the integral value of the peak derived from the main chain methine proton in the structural unit derived from methyl acrylate (peak at 2.4 ppm to 2.6 ppm)

[0112]

The contents (% by mol) of the structural units in the polymer (Y) obtained in the Comparative Examples 3 and 4 were measured by the method according to the method of Comparative Example 2.

The structural unit (A') and the structural unit (C') of the polymer (Y) shown in Table 3 are as described below.

[0113]

<Structural Unit (A')>

Structural unit (A') of Comparative Example 2: a structural unit derived from methyl acrylate in which R' in the side chain (-COOR') represents a methyl group, a hydrogen atom, or sodium

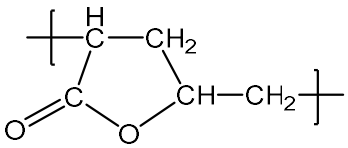
Structural unit (A') of Comparative Example 3: a structural unit derived from dimethyl itaconate in which R' in the side chain (-COOR') represents a methyl group, a hydrogen atom, or sodium

Structural unit (A') of Comparative Example 4: a structural unit derived from monomethyl maleate in which R' in the side chain (-COOR') represents a methyl group, a hydrogen atom, or sodium

[0114]

<Structural Unit (C')>

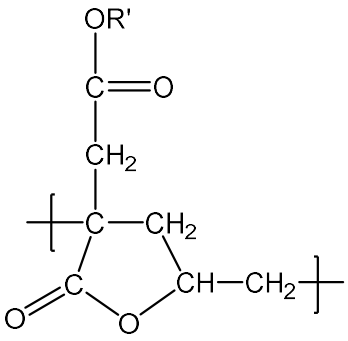
Structural unit (C') of Comparative Example 2: a structural unit represented by the following formula (3c-1):



(3c-1)

[0115]

Structural unit (C') of Comparative Example 3: a structural unit represented by the following formula (3c-2):

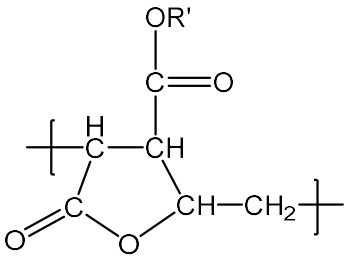


(3c-2)

in which R' represents a methyl group, a hydrogen atom, or sodium

[0116]

Structural unit (C') of Comparative Example 4: a structural unit represented by the following formula (3c-3):



(3c-3)

in which R' represents a methyl group, a hydrogen atom, or sodium

[0117]

The ratio of the molar based content of the structural unit (A) with respect to the molar based total content of the structural unit (A) and the structural unit (C) ((structural unit (A))/((structural unit (A)+structural unit (C))) and the ratio of the molar based content of the structural unit (A') with respect to the molar based total content of the structural unit (A') and the structural unit (C') ((structural unit (A'))/((structural unit (A')+structural unit (C'))) each were calculated from the contents of the structural units calculated from the ^{1}H-NMR measurements above.

[0118]

<Measurement Method of Number Average Degree of Polymerization DPn>

The number average degree of polymerization DPn was measured in the following manner.

The polymer (X) and the polymer (Y) each were measured for the number average molecular weight (Mn) with a size exclusion high-speed liquid chromatography instrument "HLC-8320GPC", available from Tosoh Corporation. The measurement condition was as

follows.

Columns: two columns of HFIP column "GMHHR-H(S)", available from Tosoh Corporation, connected in series

Standard sample: polymethyl methacrylate

Solvent and mobile phase: sodium trifluoroacetate HFIP solution (concentration: 20 mM)

Flow rate: 0.2 mL/min

Temperature: 40°C

Concentration of sample solution: 0.1% by mass (filtered with a filter having an aperture of 0.45 μm)

Injection amount: 10 μL

Detector: RI

The number average degree of polymerization DPn was obtained according to the following expression using the number average molecular weight (Mn) obtained above and the average molecular weight (MW) of all the structural units contained in the polymer (X) or the polymer (Y) calculated based on the composition calculated from the ^{1}H-NMR measurement.

DPn = Mn/MW

[0119]

<Measurement Method of Saponification Degree<

The saponification degree (% by mol) was obtained according to the following expression using the composition calculated from the ^{1}H-NMR measurement.

Saponification degree (% by mol) = $((Z_{BH})+(Z_C))\times 100/(Z_b)$

[0120]

<Evaluation Method of Water Solubility of Film>

The film of the polymer (X) and the polymer (Y) produced in Examples and Comparative Examples (which may be hereinafter referred simply to as a "film") was cut into a rectangular shape of 30 mm × 40 mm, and was held in a slide mount. Separately, a glass beaker with a capacity of 600 mL having 500 mL of distilled water therein was placed in a thermostat bath set to 5°C, and distilled water in the beaker was stirred with a stirring bar of 5 cm × 1 cm in diameter placed therein and a magnetic stirrer (HS-4SP, available from AS ONE Corporation) at a rotation number of 400 rpm. After distilled water in the beaker reached 5°C, while retaining the temperature of distilled water to 5°C, the slide mount was immersed in distilled water under stirring to start measurement of the water solubility. At this time, the dissolution state of the film was visually observed, and the period of time until the film was broken and dissolved (i.e., the measured rupture time) was measured. The measured rupture

time of the film was normalized to the value at a film thickness of 50 μm according to the following expression, and thus the complete dissolution time was calculated for each of the films.

Complete dissolution time (sec) = (50/film thickness (μm))^2 × measured rupture time (sec)

The complete dissolution time of the film thus calculated was evaluated according to the following standard. In the following four-level evaluation on a scale of 1 to 4, a score closer to 4 indicates a better result.

4: less than 70 seconds

3: 70 seconds or more and less than 75 seconds

2: 75 seconds or more and less than 145 seconds

1: 145 seconds or more

[0121]

<Evaluation Method of Biodegradability>

The polymer (X) and the polymer (Y) synthesized in Examples and Comparative Examples each were used as a sample, and evaluated for the biodegradability with reference to the biodegradability evaluation method described in OECD 301B. Specifically, to 200 mL of a mineral medium solution, activated sludge (obtained from a sewage treatment plant) in 30 ppm and the polymer as the sample in 15 mgDOC/L were added, which were then cultured at 22°C for 28 days with a pressure sensor type BOD measuring instrument "OxiTop" (available from WTW GmbH), and the oxygen amount consumed by biodegradation during the culture time was measured. The biodegradation rate (%) was calculated according to the following expression using the resulting oxygen amount.

Biodegradation rate (%) = ($R1O_2$-$R2O_2$)×100/ThOD

$R1O_2$: oxygen amount consumed in system having polymer added (mg/L)

$R2O_2$: oxygen amount consumed in blank system (mg/L)

ThDO: theoretical oxygen demand (mg/L)

[0122]

In the biodegradation test of the polymer, it was judged that the test was normally performed in the case where the degradation conversion of sodium benzoate as the control substance exceeded 60%. The biodegradation rate of the polymer in the test that was judged as being performed normally was evaluated according to the following standard. In the following three-level evaluation on a scale of 1 to 3, a score closer to 3 indicates a better result.

3: 50% or more

2: 38% or more and less than 50%

1: less than 38%

[0123]

The synthesis conditions and the like of the polymer (X) and the polymer (Y) are shown in Table 1, the evaluation results of the polymer (X) are shown in Table 2, and the evaluation results of the polymer (Y) are shown in Table 3.

[0124]

[Table 1]

Table 1

	Class of polymer	Synthesis condition			
		Monomer (1)			
		Monomer (a)		Monomer (a')	
		Kind	Charged amount (part by mass)	Kind	Charged amount (part by mass)
Example 1	Polymer (X)	methyl 2-(hydroxymethyl)acrylate	0.06	-	-
Example 2	Polymer (X)	methyl 2-(hydroxymethyl)acrylate	0.11	-	-
Example 3	Polymer (X)	methyl2-(hydroxymethyl)acrylate	0.08	-	-
Example 4	Polymer (X)	methyl 2-(hydroxymethyl)acrylate	0.05	-	-
Example 5	Polymer (X)	methyl 2-(hydroxymethyl)acrylate	0.05	-	-
Example 6	Polymer (X)	methyl 2-(allyloxymethyl)acrylate	0.14	-	-
Comparative Example 1	Polymer (Y)	-	-	-	-
Comparative Example 2	Polymer (Y)	-	-	methyl acrylate	0.06
Comparative Example 3	Polymer (Y)	-	-	dimethyl itaconate	0.09
Comparative Example 4	Polymer (Y)	-	-	monomethyl maleate	0.06

In Table, "-" means that the component is not used.

Table 1 (continued)

	Synthesis condition				Saponification condition	
	Monomer (2) / Monomer (b)		Methanol	Polymerization initiator	Concentration of methanol solution of polymer (% by mass)	Molar ratio (NaOH/ monomer (2))
	Kind	Charged amount (part by mass)	Charged amount (part by mass)	Charged amount (part by mass)		
Example 1	vinyl acetate	100	50.75	0.08	25	0.009
Example 2	vinyl acetate	100	49.69	0.09	25	0.009
Example 3	vinyl acetate	100	29.69	0.09	25	0.008
Example 4	vinyl acetate	100	52.40	0.05	25	0.005
Example 5	vinyl acetate	100	52.40	0.05	25	0.005
Example 6	vinyl acetate	100	41.03	0.05	25	0.006
Comparative Example 1	vinyl acetate	100	37.64	0.08	25	0.008
Comparative Example 2	vinyl acetate	100	25.39	0.08	25	0.100
Comparative Example 3	vinyl acetate	100	32.34	0.08	25	0.008
Comparative Example 4	vinyl acetate	100	53.91	0.08	25	0.075

In Table, "-" means that the component is not used.

[0125]

[Table 2]

Table 2

	Polymer (X)					
	Kind of monomer (1)	Content of structural unit (unit: % by mol)				
		Structural unit derived from monomer (1)	Structural unit derived from monomer (2)	Structural unit (A)	Structural unit (B)	Structural unit (C)
Example 1	methyl 2-(hydroxymethyl)acrylate	4.4	95.6	1.4	92.6	3.0
Example 2	methyl 2-(hydroxymethyl)acrylate	7.3	92.7	2.6	88.0	4.7
Example 3	methyl 2-(hydroxymethyl)acrylate	5.5	94.5	2.5	91.5	3.0
Example 4	methyl 2-(hydroxymethyl)acrylate	3.0	97.0	0.5	94.5	2.5
Example 5	methyl 2-(hydroxymethyl)acrylate	3.0	97.0	1.0	95.0	2.0
Example 6	methyl 2-(allyloxymethyl)acrylate	3.2	96.8	0.02	95.7	1.1

Table 2 (continued)

	Polymer (X)			
	Content of structural unit (unit: % by mol)			Molar ratio ((structural unit (A))/((structural unit (A)+structural unit (C)))
	Total of structural units (A) and (C)	Total of structural units (B) and (C)	Structural unit (B) in which R^1 represents hydroxy group	
Example 1	4.4	95.6	85.8	0.32
Example 2	7.3	92.7	84.4	0.36
Example 3	5.5	94.5	85.4	0.45
Example 4	3.0	97.0	77.2	0.17
Example 5	3.0	97.0	80.2	0.33
Example 6	1.1	96.8	83.1	0.01

Table 2 (continued)

	Polymer (X)		Properties	
	Saponification degree (% by mol)	Number average degree of polymerization DPn	Water solubility of film	Biodegradability
Example 1	92.89	1,250	3	3
Example 2	96.12	1,034	4	2
Example 3	93.54	1,799	4	2
Example 4	82.10	1,660	3	3
Example 5	84.76	1,660	4	3
Example 6	87.00	1,170	2	3

[0126]

[Table 3]

Table 3

	Polymer (Y)					
	Kind of monomer (1)	Content of structural unit (unit: % by mol)				
		Structural unit derived from monomer (1)	Structural unit derived from monomer (2)	Structural unit (A')	Structural unit (B)	Structural unit (C')
Comparative Example 1	not used	0	100.0	0	100.0	0
Comparative Example 2	methyl acrylate	5.0	95.0	3.5	93.5	1.5
Comparative Example 3	dimethyl itaconate	1.6	98.4	0.9	97.7	0.7
Comparative Example 4	monomethyl maleate	4.5	95.5	2.1	93.1	2.4

Table 3 (continued)

	Polymer (Y)			
	Content of structural unit (unit: % by mol)			Molar ratio ((structural unit (A'))/((structural unit (A')+structural unit (C')))
	Total of structural units (A') and (C')	Total of structural units (B) and (C')	Structural unit (B) in which R^1 represents hydroxy group	
Comparative Example 1	0	100.0	88.0	-
Comparative Example 2	5.0	95.0	93.5	0.70
Comparative Example 3	1.6	98.4	85.2	0.55
Comparative Example 4	4.5	95.5	82.9	0.46

Table 3 (continued)

	Polymer (Y)		Properties	
	Saponification degree (% by mol)	Number average degree of polymerization DPn	Water solubility of film	Biodegradability
Comparative Example 1	88.00	1,350	1	3
Comparative Example 2	99.95	1,320	1	1
Comparative Example 3	87.32	1,260	2	1
Comparative Example 4	89.35	1,210	4	1

[0127]

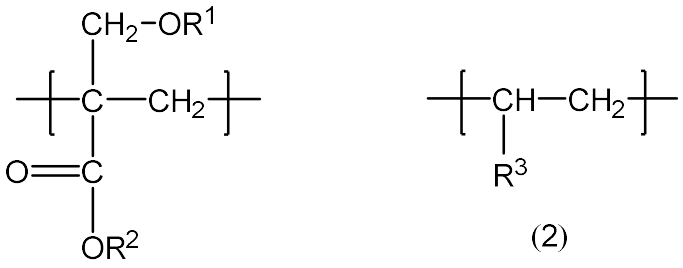
It is understood from the results shown in Tables 2 and 3 that the polymers of Examples 1 to 6, which are the polymer (X) of the present invention, are excellent in water solubility and biodegradability.

CLAIMS

[Claim 1]

A polymer (X) comprising a structural unit (A) represented by the following general formula (1) and a structural unit (B) represented by the following general formula (2):

[Chem 1]



(1)

(2)

wherein in the formula (1), R^1 represents a hydrogen atom, an amino group, a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms, or a substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms; in the formula (1), R^2 represents a hydrogen atom, a metal atom, an ammonium group, a phosphonium group, or a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms; and in the formula (2), R^3 represents a hydroxy group or a group represented by -O-C(=O)-R^4, wherein R^4 represents a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms.

[Claim 2]

The polymer (X) according to claim 1, wherein R^3 in the general formula (2) represents a hydroxy group or -O-C(=O)-CH_3.

[Claim 3]

The polymer (X) according to claim 1 or 2, wherein R^1 in the general formula (1) represents a hydrogen atom or an allyl group.

[Claim 4]

The polymer (X) according to claim 1 or 2, wherein R^2 in the general formula (1) represents a hydrogen atom, an alkali metal atom, or a methyl group.

[Claim 5]

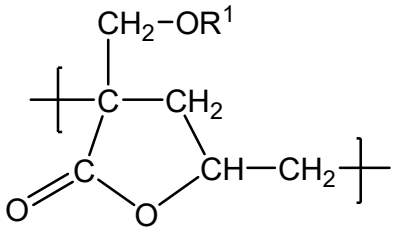
The polymer (X) according to claim 1 or 2, wherein the polymer (X)

optionally contains a structural unit (C) represented by the following general formula (3), and

has a total content of the structural unit (A) and the structural unit (C) optionally contained of 0.01 to 20.0% by mol based on the total monomer units (100% by mol) of the

polymer (X):

[Chem 2]



(3)

wherein R^1 is the same as R^1 in the general formula (1).

[Claim 6]

The polymer (X) according to claim 1 or 2, wherein the polymer (X) has a saponification degree of 70.00 to 99.99% by mol.

[Claim 7]

The polymer (X) according to claim 1 or 2, wherein the polymer (X) has a number average degree of polymerization DPn of 100 to 5,000.

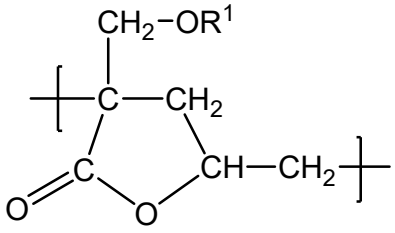
[Claim 8]

The polymer (X) according to claim 1 or 2, wherein the polymer (X)

contains a structural unit (C) represented by the following general formula (3), and

has a ratio of a molar based content of the structural unit (A) with respect to a molar based total content of the structural unit (A) and the structural unit (C) ((structural unit (A))/((structural unit (A)+structural unit (C))) of 0.01 to 0.99:

[Chem 3]



(3)

wherein R^1 is the same as R^1 in the general formula (1).

[Claim 9]

A composition comprising the polymer (X) according to claim 1 or 2.

[Claim 10]

An aqueous solution comprising the polymer (X) according to claim 1 or 2.

[Claim 11]

A molded article comprising the polymer (X) according to claim 1 or 2.

[Claim 12]

The molded article according to claim 11, wherein the molded article is a film.

[Claim 13]

The molded article according to claim 12, wherein the molded article is water-soluble.

[Claim 14]

A packaged article comprising a chemical packaged with the molded article according to claim 12.

[Claim 15]

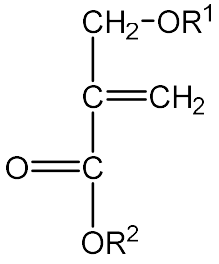
The packaged article according to claim 14, wherein the chemical is an agricultural chemical or a detergent.

[Claim 16]

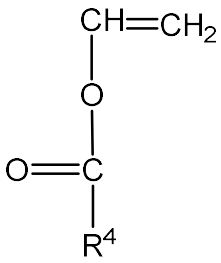
A method for producing the polymer (X) according to claim 1 or 2,

the method for producing the polymer (X), comprising a step of copolymerizing a monomer (a) represented by the following general formula (I) and a monomer (b) represented by the following general formula (II) to provide a copolymer; and a step of saponifying the copolymer:

[Chem 4]



(I)



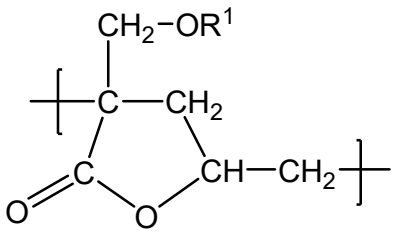
(II)

wherein in the formula (I), R^1 and R^2 are the same as R^1 and R^2 in the general formula (1), and in the formula (II), R^4 is the same as R^4 in the description for the general formula (2).

[Claim 17]

A polymer (X') comprising a structural unit (C) represented by the following general formula (3):

[Chem 5]



(3)

wherein in the formula (3), R^1 represents a hydrogen atom, an amino group, a substituted or unsubstituted hydrocarbon group having 1 to 20 carbon atoms, or a substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms.