excellent in durability against an aqueous solvent (water, a phosphate buffered physiological saline (PBS), an alcohol, etc.). Also, it gives a coating film excellent in a function of inhibiting adhesion of a biological substance, since ion balance of the copolymer is controlled by previously adjusting a pH of the composition for forming a coating film with a pH adjusting agent, etc., or by washing the coating film after drying with water and/or an aqueous solution containing an electrolyte.

Further, when the copolymer contained in the composition for forming a coating film of the present invention is to be synthesized, a phosphoric acid ester group which is a side chain of the copolymer has been known, for example, as disclosed in Patent Document 3, to have strong association property so that it sometimes gelled depending on the polymerization conditions, but in the present invention, a method for manufacturing a transparent varnish containing a copolymer can be provided by controlling the total concentration of the compound for synthesizing the copolymer in the reaction solvent to 4% by mass or less, or controlling an order of addition of a reactant and a reagent, or an addition temperature without gelation. According to this method, even if a polymer containing, for example, around 50mol% of a recurring unit having a phosphoric acid ester group in the copolymer according to the present invention is used, a transparent varnish containing a copolymer can be manufactured without gelation. The varnish containing a copolymer can be used as a composition for forming a coating film of the present invention, or a raw material for preparing the same.

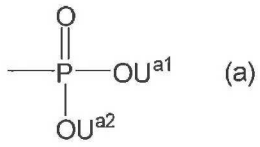
EMBODIMENTS TO CARRY OUT THE INVENTION

[0038] The coating film of the present invention is a coating film obtained by a method comprising a process of applying a composition for forming a coating film containing a copolymer which contains a recurring unit containing an organic group of the following formula (a) and a recurring unit containing an organic group of the following formula (b):

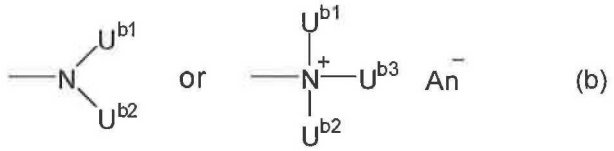
[0039]

CLAIMS

1. A coating film which has a function of inhibiting adhesion of a biological substance, obtained by a method comprising a process of applying a composition for forming a coating film which comprises a copolymer comprising a recurring unit containing an organic group of the following formula (a) and a recurring unit containing an organic group of the following formula (b):



(a)



(b)

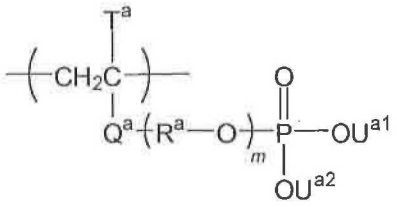
wherein U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion,
and a solvent onto a substrate; and
a process of drying at a temperature of -200°C to 200°C.

2. The coating film according to Claim 1, wherein the solvent comprises water or an alcohol.

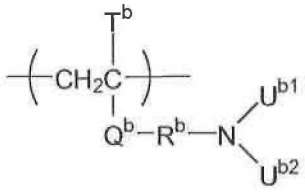
3. The coating film according to Claim 1 or 2, wherein a concentration of the copolymer in the composition for forming a coating film is 0.01% by mass to 4% by mass.

4. The coating film according to any one of Claims 1 to 3, wherein the substrate is selected from the group consisting of glass, a metal containing compound, a semi-metal containing compound and a resin.

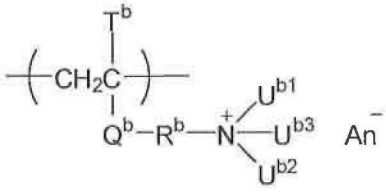
5. The coating film according to any one of Claims 1 to 4, wherein the copolymer comprises recurring units of the following formula (a1) and the formula (b1):



(a1)



or



(b1)

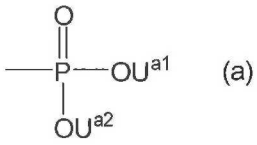
wherein T^a, T^b, U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, Q^a and Q^b each independently represents a single bond, an ester bond or an amide bond, R^a and R^b each independently represents a linear or branched alkylene group having 1 to 10 carbon atoms which may be substituted by a halogen atom, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion, and m is an integer of 0 to 6.

6. The coating film according to any one of Claims 1 to 5, wherein m is 1, and R^a and R^b each independently represents an ethylene group or a propylene group.

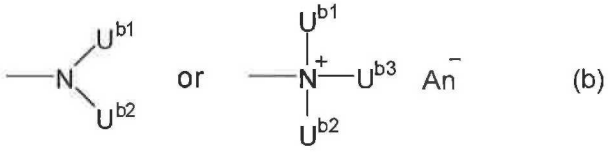
7. The coating film according to any one of Claims 1 to 6, wherein the method further comprises a process of previously adjusting a pH of the composition for forming a coating film.

8. The coating film according to any one of Claims 1 to 7, wherein the method further comprises a process of washing a film obtained after the process of drying with at least one solvent selected from the group consisting of water and an aqueous solution containing an electrolyte.

9. A method for manufacturing a coating film which has a function of inhibiting adhesion of a biological substance, comprising a process of applying a composition for forming a coating film which comprises a copolymer comprising a recurring unit containing an organic group of the following formula (a) and a recurring unit containing an organic group of the following formula (b):



(a)



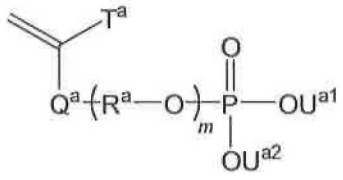
(b)

wherein U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion,

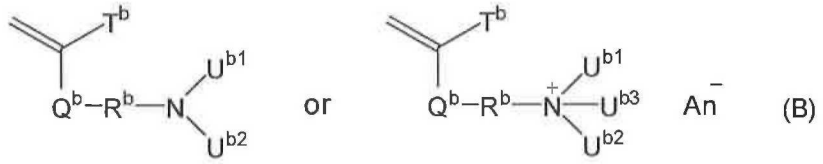
and a solvent onto a substrate; and

a process of drying at a temperature of -200°C to 200°C.

10. A copolymer obtained by copolymerizing a monomer mixture comprising at least compounds of the following formula (A) and the formula (B):



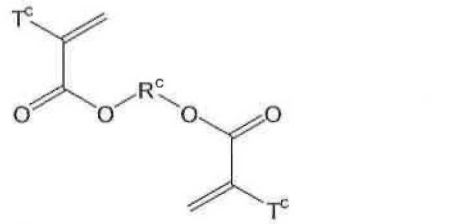
(A)



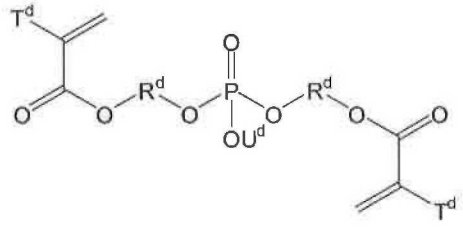
(B)

wherein T^a, T^b, U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, Q^a and Q^b each independently represents a single bond, an ester bond or an amide bond, R^a and R^b each independently represents a linear or branched alkylene group having 1 to 10 carbon atoms which may be substituted by a halogen atom, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion, and m is an integer of 0 to 6,

and a compound of the following formula (C) or (D):



(C)

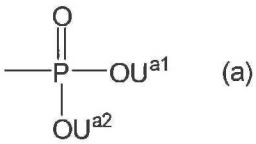


(D)

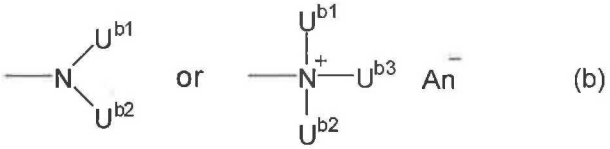
wherein T^c, T^d and U^d each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, R^c and R^d each independently represents a linear or branched alkylene group having 1 to 10 carbon atoms which may be substituted by a halogen atom

wherein a ratio of the compound of the formula (A) based on the whole monomers forming the copolymer is 20 to 80 mol%.

11. A composition for forming a coating film which comprises (i) a copolymer comprising a recurring unit containing an organic group of the following formula (a) and a recurring unit containing an organic group of the following formula (b):



(a)



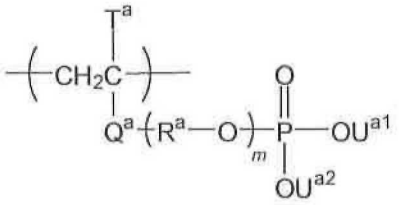
(b)

wherein U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion;

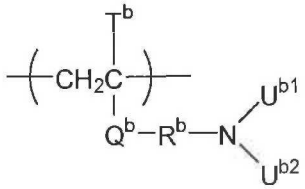
(ii) a solvent; and

(iii) a pH adjusting agent selected from the group consisting of ammonia, diethanolamine, pyridine, N-methyl-D-glucamine, tris(hydroxymethyl)aminomethane, potassium hydroxide, sodium hydroxide, potassium chloride, sodium chloride, sulfuric acid, phosphoric acid, hydrochloric acid, carbonic acid and choline.

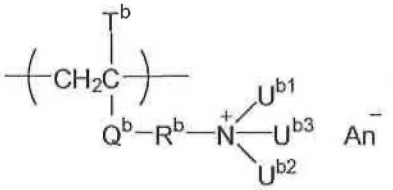
12. The composition according to Claim 11, wherein the copolymer comprises recurring units of the following formula (a1) and the formula (b1):



(a1)



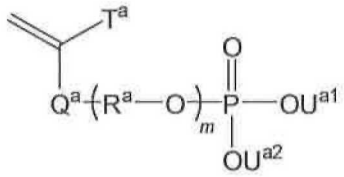
or



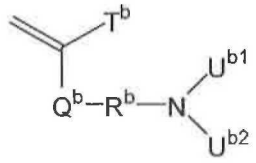
(b1)

wherein T^a, T^b, U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, Q^a and Q^b each independently represents a single bond, an ester bond or an amide bond, R^a and R^b each independently represents a linear or branched alkylene group having 1 to 10 carbon atoms which may be substituted by a halogen atom, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion, and m is an integer of 0 to 6.

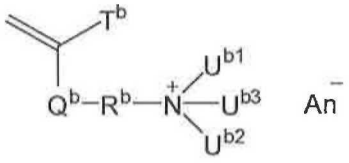
13. A method for manufacturing a varnish containing a copolymer which comprises a process of reacting compounds of the following formula (A) and the formula (B):



(A)



or



(B)

wherein T^a, T^b, U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, Q^a and Q^b each independently represents a single bond, an ester bond or an amide bond, R^a and R^b each independently represents a linear or branched alkylene group having 1 to 10 carbon atoms which may be substituted by a halogen atom, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion, and m is an integer of 0 to 6,

in a solvent with a total concentration of the both compounds of 0.01% by mass to 4% by mass.

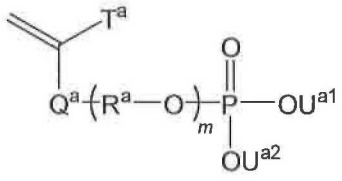
14. The manufacturing method of a varnish containing a copolymer according to Claim 13, wherein m is 1, and R^a and R^b each independently represents an ethylene group or a propylene group.

15. The manufacturing method of a varnish containing a copolymer according to Claim 13 or 14, wherein the solvent comprises water or an alcohol.

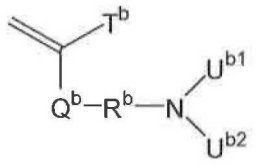
16. The manufacturing method of a varnish containing a copolymer according to any one of Claims 13 to 15, wherein the solvent comprises 10% by mass to 100% by mass of water.

17. The manufacturing method of a varnish containing a copolymer according to any one of Claims 13 to 15, wherein the solvent comprises 10% by mass to 100% by mass of an alcohol.

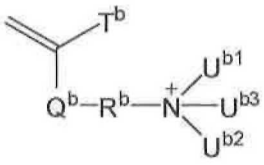
18. A method for manufacturing a varnish containing a copolymer which comprises a process of reacting a mixture containing compounds of the following formula (A) and the formula (B):



(A)



or

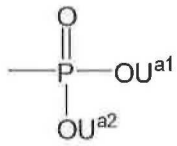


(B)

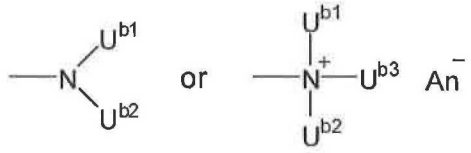
wherein T^a, T^b, U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, Q^a and Q^b each independently represents a single bond, an ester bond or an amide bond, R^a and R^b each independently represents a linear or branched alkylene group having 1 to 10 carbon atoms which may be substituted by a halogen atom, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion, and m is an integer of 0 to 6,
a solvent and a polymerization initiator, by adding the mixture dropwise into a solvent maintained at a temperature higher than 10-hr half-life temperature of the polymerization initiator.

19. A sol which comprises a copolymer comprising a recurring unit containing an

organic group of the following formula (a) and a recurring unit containing an organic group of the following formula (b):



(a)



(b)

wherein U^{a1}, U^{a2}, U^{b1}, U^{b2} and U^{b3} each independently represents a hydrogen atom or a linear or branched alkyl group having 1 to 5 carbon atoms, An^- represents an anion selected from the group consisting of a halide ion, an inorganic acid ion, a hydroxide ion and an isothiocyanate ion.

20. The sol according to Claim 19, wherein an average particle diameter in particle diameter distribution measured by a dynamic light scattering method is 2 nm or more and 500 nm or less.