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(54) **Contact lens cleaning solutions**

(57) A copolymer of a zwitterionic monomer and a hydrophobic monomer having a fluoroalkyl or silyl group has useful surface binding and biocompatibilising properties when used in aqueous solution, especially for cleaning, storing or soaking contact lenses. A preferred polymer is made by copolymerising 2-(methacryloyloxyethyl)-2'-(trimethylammonium)ethyl phosphate inner salt and a fluoroalkyl methacrylate in mole ratios 1:4-20:1.

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Description

[0001] The present invention relates to aqueous solutions for cleaning, soaking or storing contact lenses which contain a solution of a biocompatible polymer having pendant zwitterionic groups formed from monomers including zwitterionic groups and comonomers having hydrophobic groups which are fluoroalkyl or silyl groups.

[0002] In our earlier publication WO93/01221 we described copolymers of monomers having zwitterionic groups with comonomers comprising groups providing stable surface binding. The surface binding groups were selected according to the surface to which binding was desired. Ionic groups were provided for electrostatic bonding to counterionically charged surfaces. Reactive groups were provided for bonding to coreactive groups at a surface. Hydrophobic groups were provided for binding to hydrophobic surfaces.

[0003] In a copolymer having hydrophobic pendant groups, these were provided from a comonomer of the general formula Y^1Q , in which Y^1 was an ethylenically unsaturated polymerisable group and Q was a straight or branched alkyl, alkoxy alkyl or (oligo-alkoxy) alkyl chain containing 6 to 12 carbon atoms, a fluoroalkyl group or a siloxane group. A fluoroalkyl group could contain 2 to 23 carbon atoms whilst the siloxane group contained at least one dialkyl substituted silicon atom.

[0004] The polymer coatings of WO-A-93/01221 were intended to be stable, that is provide long term coatings which tended not to be removed in use. The coating conferred biocompatibility on the underlying substrates, reducing protein adsorption and platelet activation. Potential uses of the polymers were to coat implants, prostheses, membrane, catheters, contact lenses, intraocular lenses and extra corporeal circuitry. The examples of polymers for coating hydrophobic surfaces, to produce coated articles to be used in an aqueous environment, were all substantially-insoluble and were coated from solutions in an alcohol, a chlorinated solvent or a mixture thereof.

[0005] In EP-A-0537932 contact lenses formed from a cross linked polymer including residues derived from a zwitterionic monomer are described, as well as cleaning solutions containing a copolymer of the same zwitterionic monomer and suitable comonomers. The zwitterionic monomer is 2-(methacryloyloxyethyl)-2'-(trimethylammoniummethyl) phosphate inner salt. The comonomers used were n-butyl methacrylate, 2-hydroxyethyl methacrylate and styrene. The contact lens treatment solutions in each case contain ethylene glycol in the solvent mixture.

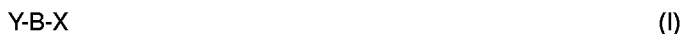
[0006] In JP-A-07-166154 contact lens cleaning solutions comprising a buffered solution containing or copolymers of 2((meth) acryloyloxyalkyl)-2'-(trialkylammoniummethyl) phosphate inner salt with comonomers, for instance butyl methacrylate are described. The solutions contain no organic solvent.

[0007] A problem with the polymers described in WO-A-93/01221 and EP-A-0537932 is that they are dispersed in a non-aqueous solvent. The presence of organic solvent in any solution for use with contact lenses is undesirable, since introduction of organic solvent into the eye must be avoided and removal of all traces from a cleaning or a soaking solution is hard. The problem with the copolymers described in JP-A-07-166154 is that they bind inadequately to the surface of the contact lens and so provide very short term benefits.

[0008] It would be desirable to provide a copolymer which can be presented in the form of an aqueous solution, but which binds sufficiently strongly to the surface of a wide variety of contact lenses so that the polymer will remain coated on the surface during storage and after insertion of the lens back into the eye to provide long term biocompatibility, resistance to protein and lipid deposition.

[0009] A new composition according to the invention for cleaning, soaking or storing contact lenses or ocular implants or containers therefor or for use as an artificial tear or ophthalmic comfort drop is aqueous, substantially free of organic solvent and contains 0.01 to 5% by weight of a copolymer obtainable by copolymerising ethylenically unsaturated monomers including:

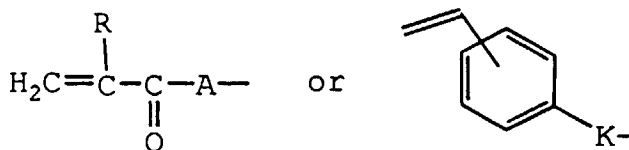
- a) 20 to 99 mole % (based on total ethylenically unsaturated monomers) of a zwitterionic monomer of the general formula I



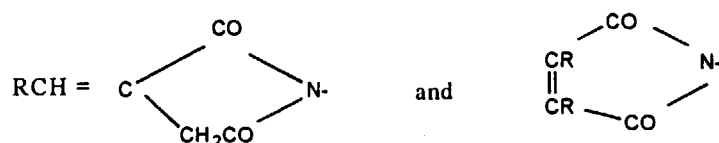
wherein B is a straight or branched alkylene, oxaalkylene or oligo-oxaalkylene chain optionally containing one or more fluorine atoms up to and including perfluorinated chains or, if X or Y contains a terminal carbon atom bonded to B, a valence bond;

X is a zwitterionic group and

Y is an ethylenically unsaturated polymerisable group selected from



$\text{CH}_2=\text{C}(\text{R})-\text{CH}_2-\text{O}-$, $\text{CH}_2=\text{C}(\text{R})-\text{CH}_2-\text{OC}(\text{O})-$, $\text{CH}_2=\text{C}(\text{R})\text{OC}(\text{O})-$, $\text{CH}_2=\text{C}(\text{R})-\text{O}-$, $\text{CH}_2=\text{C}(\text{R})\text{CH}_2\text{OC}(\text{O})\text{N}(\text{R}^1)-$, $\text{R}^{30}\text{OOC}\text{CR}=\text{C}(\text{R})\text{C}(\text{O})-\text{O}-$, $\text{RCH}=\text{CH}\text{C}(\text{O})\text{O}-$, $\text{RCH}=\text{C}(\text{COOR}^{30})\text{CH}_2-\text{C}(\text{O})-\text{O}-$,



wherein:

R is hydrogen or a C₁-C₄ alkyl group;

R³⁰ is hydrogen or a C₁₋₄ alkyl group; or BX

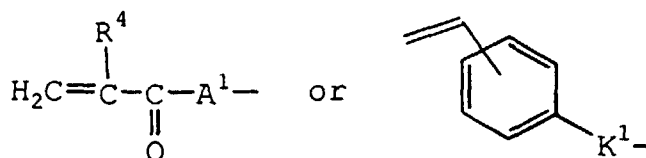
A is -O- or -NR¹-; R¹ is hydrogen or a C₁-C₄ alkyl group or R¹ is -B-X where B and X are as defined above; and K is a group (CH₂)_pOC(O)-, -(CH₂)_pC(O)O-, -(CH₂)_pOC(O)O-, -(CH₂)_pNR²-, -(CH₂)_pNR²C(O)-, -(CH₂)_pC(O)NR²-, -(CH₂)_pNR²C(O)O-, -(CH₂)_pOC(O)NR²-, -(CH₂)_pNR²C(O)NR²-, (in which the groups R² are the same or different) -(CH₂)_pO-, -(CH₂)_pSO₃-, or, optionally in combination with B, a valence bond and p is from 1 to 12 and R² is hydrogen or a C₁-C₄ alkyl group and

b) 1 to 50 mole % of a hydrophobic monomer of the formula II

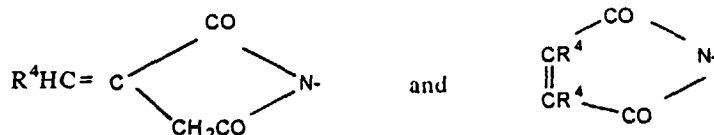


wherein

B⁴ is a straight or branched alkylene, oxaalkylene or oligo-oxaalkylene chain optionally containing one or more fluorine atoms up to and including perfluorinated chains, an alkylene-sulphonamido group, or a valence bond; Y¹ is an ethylenically unsaturated polymerisable group selected from



$\text{CH}_2=\text{C}(\text{R}^4)-\text{CH}_2-\text{O}-$, $\text{CH}_2=\text{C}(\text{R}^4)-\text{CH}_2\text{OC}(\text{O})-$, $\text{CH}_2=\text{C}(\text{R}^4)\text{OC}(\text{O})-$, $\text{CH}_2=\text{C}(\text{R}^4)-\text{O}-$, $\text{CH}_2=\text{C}(\text{R}^4)\text{CH}_2\text{OC}(\text{O})\text{N}(\text{R}^5)-$, $\text{R}^{31}\text{OOC}\text{CR}^4=\text{C}(\text{R}^4)\text{C}(\text{O})-\text{O}-$, $\text{R}^4\text{H} = \text{CHC}(\text{O})-\text{O}-$, $\text{R}^4\text{H} = \text{C}(\text{COOR}^{31})\text{CH}_2-\text{C}(\text{O})-\text{O}-$



where

R⁴ is hydrogen or C₁-C₄ alkyl;

R³¹ is hydrogen, a C₁₋₄-alkyl group or a group B⁴R³;

A¹ is -O- or -NR⁵-; R⁵ is hydrogen or a C₁-C₄ alkyl group or R⁵ is a group Q;

K¹ is a group -(CH₂)_lOC(O)-, -(CH₂)_lC(O)O-, -(CH₂)_lOC(O)O-, -(CH₂)_lNR⁶-, -(CH₂)_lNR⁶C(O)-, -(CH₂)_lC(O)NR⁶-, -(CH₂)_lNR⁶C(O)O-, -(CH₂)_lOC(O)NR⁶-, -(CH₂)_lNR⁶C(O)NR⁶- (in which the groups R⁶ are the same or different), -(CH₂)_lO-, -(CH₂)_lSO₃-, a valence bond and l is from 1 to 12 and R⁶ is hydrogen or a C₁-C₄ alkyl group;

and

R³ is a C₂₋₂₄-fluoroalkyl group or a silyl group of the formula -(CR⁷₂)_n(SiR⁸₂)(OSiR⁹₂)_mR⁹

wherein group R¹ are the same or different and each represent hydrogen, C₁₋₄ alkyl or C₇₋₁₂ aralkyl,

n is an integer in the range 1 to 6

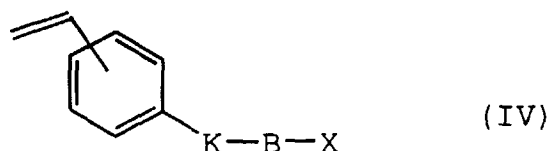
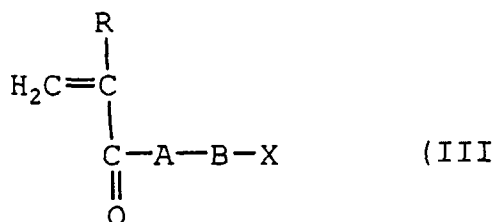
the groups R⁸ are the same or different and are each C₁₋₄-alkyl or C₇₋₁₂-aralkyl or one each OSiR⁹₃,

the groups (OSiR⁹₂) are the same or different and in each the groups R⁹ are the same or different and each represents C₁₋₄-alkyl or C₇₋₁₂-aralkyl, and

m is 0 to 49.

Zwitterionic Monomer

[0010] Preferred zwitterionic monomers are of general formula (III) or (IV)



where R, A, B, K and X are as defined with reference to formula (I).

[0011] In the zwitterionic monomer, the group X may be a betaine monomer, for instance a sulfo-, carboxy- or phospho-betaine. Preferably a betaine monomer has no overall charge and is preferably therefore a carboxy- or sulfo-betaine. Such groups may be represented by the general formula



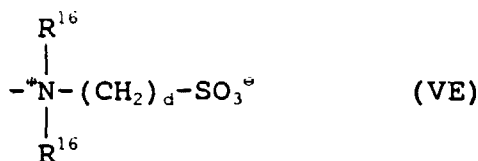
in which X³ is a valence bond, -O-, -S- or -NH-, preferably -O-;

V is a carboxylate, sulphonate or phosphate anion;

R²⁴ is a valence bond (together with X³) or alkylene - C(O)alkylene- or -C(O)NHalkylene preferably alkylene and preferably containing from 1 to 6 carbon atoms in the alkylene chain;

the groups R²⁵ are the same or different and each is hydrogen or alkyl of 1 to 4 carbon atoms or the groups R²⁵ together with the nitrogen to which they are attached form a heterocyclic ring of 5 to 7 atoms; and

R²⁶ is alkylene of 1 to 20, preferably 1 to 10, more preferably 1 to 6 carbon atoms provided that when V is a sulphonate anion, R²⁶ is alkylene of 6 or more carbon atoms. One preferred sulphobetaine monomer has the formula VE



where the groups R¹⁶ are the same or different and each is hydrogen or C₁₋₄ alkyl and d is from 2 to 4.

[0012] Preferably the groups R¹⁶ are the same. It is also preferable that at least one of the groups R¹⁶ is methyl, and more preferable that the groups R¹⁶ are both methyl.

[0013] Preferably d is 2 or 3, more preferably 3.

[0014] Alternatively the monomer may be an amino acid type derivative in which the alpha carbon atom (to which an amine group and the carboxylic acid group are attached) is joined through a linker group to the group B of the monomer of the formula I. Such groups may be represented by the general formula



in which X⁴ is a valence bond, -O-, -S- or -NH-, preferably -O-,

R²⁷ is a valence bond (optionally together with X⁴) or alkylene, -C(O)alkylene- or -C(O)NHalkylene, preferably alkylene and preferably containing from 1 to 6 carbon atoms; and the groups R²⁸ are the same or different and each is hydrogen or alkyl of 1 to 4 carbon atoms, preferably methyl, or two of the groups R²⁸, together with the nitrogen to which they are attached, form a heterocyclic ring of from 5 to 7 atoms, or the three group R²⁸ together with the nitrogen atom to which they are attached form a fused ring structure containing from 5 to 7 atoms in each ring.

[0015] Betaine and amino acid type methods for monomers and their synthesis are further described in our earlier application WO-A-9416749.

[0016] X is preferably of formula



in which the moieties X¹ and X², which are the same or different, are -O-, -S-, -NH- or a valence bond, preferably -O-, and W⁺ is a group comprising an ammonium, phosphonium or sulphonium cationic group and a group linking the anionic and cationic moieties which is preferably a C₁₋₁₂-alkylene group.

[0017] Preferably W contains as cationic group an ammonium group, more preferably a quaternary ammonium group.

[0018] The group W⁺ may for example be a group of formula -W¹-N⁺R²³₃, -W¹-P⁺R^{23a}₃, -W¹-S⁺R^{23a}₂ or -W¹-Het⁺ in which:

W¹ is alkylene of 1 or more, preferably 2-6 carbon atoms optionally containing one or more ethylenically unsaturated double or triple bonds, disubstituted-aryl, alkylene aryl, aryl alkylene, or alkylene aryl alkylene, disubstituted cycloalkyl, alkylene cycloalkyl, cycloalkyl alkylene or alkylene cycloalkyl alkylene, which group W¹ optionally contains one or more fluorine substituents and/or one or more functional groups; and either

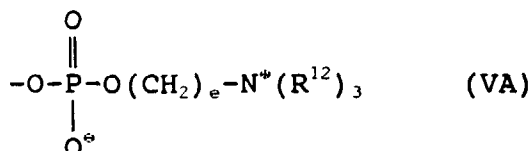
the groups R^{23} are the same or different and each is hydrogen or alkyl of 1 to 4 carbon atoms, preferably methyl, or aryl, such as phenyl or two of the groups R^{23} together with the nitrogen atom to which they are attached form a heterocyclic ring containing from 5 to 7 atoms or the three groups A^{23} together with the nitrogen atom to which they are attached form a fused ring structure containing from 5 to 7 atoms in each ring, and optionally one or more of the groups R^{23} is substituted by a hydrophilic functional group, and

the groups R^{23a} are the same or different and each is R^{23} or a group OR^{23} , where R^{23} is as defined above; or Het is an aromatic nitrogen-, phosphorus- or sulphur-, preferably nitrogen-, containing ring, for example pyridine.

[0019] Preferably W^1 is a straight-chain alkylene group, most preferably 1,2-ethylene.

[0020] Preferred groups X of the formula VI are groups of formula VA.

[0021] The groups of formula (VA) are:



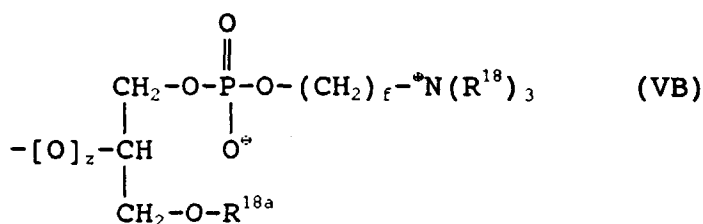
where the groups R^{12} are the same or different and each is hydrogen or C_{1-4} alkyl, and e is from 1 to 4.

[0022] Preferably the groups R^{12} are the same. It is also preferable that at least one of the groups R^{12} is methyl, and more preferable that the groups R^{12} are all methyl.

[0023] Preferably e is 2 or 3, more preferably 2. When X is a group of formula (VA) preferably B is a group of formula $-(\text{CR}^{13})_2-$ or $-(\text{CR}^{13})_2-$, eg. $-(\text{CH}_2)-$ or $-(\text{CH}_2\text{CH}_2)-$.

[0024] Alternatively the ammonium phosphate ester group VA may be replaced by a glycerol derivative of the formula VB, VC or VC defined below.

[0025] The groups of formula (VB) are:



wherein the groups R^{18} are the same or different and each is hydrogen or C_{1-4} alkyl, R^{18a} is hydrogen or, more preferably, a group $-\text{C}(\text{O})\text{B}^1\text{R}^{18b}$ where R^{18b} is hydrogen or methyl, preferably methyl, B^1 is a valence bond or straight or branched alkylene, oxaalkylene or oligo-oxaalkylene group, and f is from 1 to 4; and

if B is other than a valence bond Z is 1 and if B is a valence bond Z is O, if X is directly bonded to an oxygen or nitrogen atom and otherwise Z is 1.

[0026] Preferably the groups R^{18} are the same. It is also preferable that at least one of the groups R^{18} is methyl, and more preferable that the groups R^{18} are all methyl.

[0027] Preferably f is 1 or 2, more preferably 2.

[0028] Preferably B^1 is:

a valence bond;

an alkylene group of formula $-(\text{CR}^{13a})_2$, wherein the groups $-(\text{CR}^{13a})_2-$ are the same or different, and in each group $(\text{CR}^{13a})_2-$ the groups R^{13a} are the same or different and each group R^{13a} is hydrogen or C_{1-4} alkyl, preferably hydrogen, and aa is from 1 to 12, preferably 1 to 6;

an oxaalkylene group such as alkoxyalkyl having 1 to 6 carbon atoms in each alkyl moiety, more preferably $-\text{CH}_2\text{O}(\text{CH}_2)_4-$; or

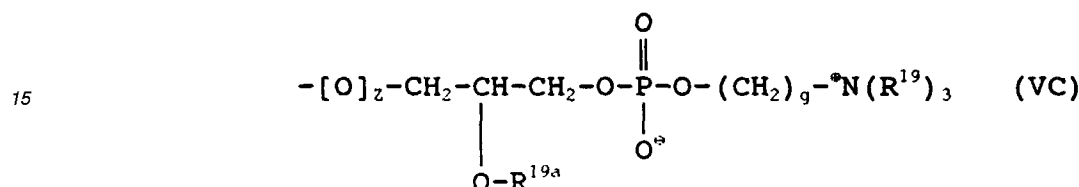
an oligo-oxaalkylene group of formula $-[(CR^{14a}_2)_{ba}O]_{ca}-$ where the groups $-(CR^{14a}_2)-$ are the same or different and in each group $-(CR^{14a}_2)-$ the groups R^{14a} are the same or different and each group R^{14a} is hydrogen or C_{1-4} alkyl, preferably hydrogen, and ba is from 1 to 6, preferably 2 or 3, and ca is from 1 to 12, preferably 1 to 6.

5 **[0029]** Preferred groups B^1 include a valence bond and alkylene, oxaalkylene and oligo-oxaalkylene groups of up to 12 carbon atoms.

[0030] Preferably B and B^1 are the same.

[0031] When X is a group of formula (VB) preferably B is a group of formula $-[(CR^{14}_2CR^{14}_2)_cO_b]CR^{14}_2CR^{14}_2-$, eg. $-(CH_2CH_2O)_c(CH_2CH_2)-$.

10 **[0032]** The groups of formula (VC) are:



20 wherein the groups R^{19} are the same or different and each is hydrogen or C_1-C_4 alkyl, R^{19a} is a hydrogen or, more preferably, a group $-C(O)B^2R^{19b}$, R^{19b} is hydrogen or methyl, preferably methyl, B^2 is a valence bond or a straight or branched alkylene, oxaalkylene or oligo-oxaalkylene group, and g is from 1 to 4; and

25 if B is other than a valence bond Z is 1 and if B is a valence bond Z is O if X is directly bonded to an oxygen or nitrogen atom and otherwise Z is 1.

[0033] Preferably the groups R^{19} are the same. It is also preferable that at least one of the groups R^{19} is methyl, and more preferable that the groups R^{19} are all methyl.

30 **[0034]** Preferably g is 1 or 2, more preferably 2.

[0035] Preferably B^2 is:

a valence bond;

35 an alkylene group of formula $-(CR^{13b}_2)_{ab}$, wherein the groups $-(CR^{13b}_2)-$ are the same or different, and in each group $-(CR^{13b}_2)-$ the groups R^{13b} are the same or different and each group R^{13b} is hydrogen or C_{1-4} alkyl, preferably hydrogen, and ab is from 1 to 12, preferably 1 to 6;

an oxaalkylene group such as alkoxyalkyl having 1 to 6, carbon atoms in each alkyl moiety, more preferably $-CH_2O(CH_2)_4-$; or

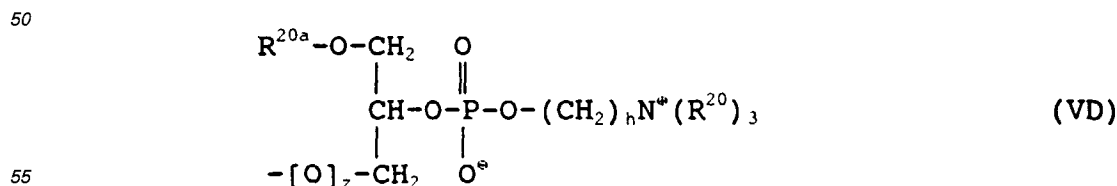
40 an oligo-oxaalkylene group of formula $-(CR^{14b}_2)_{bb}O]_{cb}-$ where the groups $-(CR^{14b}_2)-$ are the same or different and in each group $-(CR^{14b}_2)-$ the groups R^{14b} are the same or different and each group R^{14b} is hydrogen or C_{1-4} alkyl, preferably hydrogen, and bb is from 1 to 6, preferably 2 or 3, and cb is from 1 to 12, preferably 1 to 6.

[0036] Preferred groups B^2 include a valence bond and alkylene, oxalkylene and oligo-oxalkylene groups of up to 12 carbon atoms.

45 **[0037]** Preferably B and B^2 are the same.

[0038] When X is a group of formula (VC) preferably B is a group of formula $-[(CR^{14}_2CR^{14}_2)_bO]_cCR^{14}_2CR^{14}_2-$, eg. $-(CH_2CH_2O)_cCH_2CH_2-$.

[0039] The groups of formula (VD) are:



wherein the groups R^{20} are the same or different and each is hydrogen or C_{1-4} alkyl, R^{20a} is hydrogen or, more prefer-

ably, a group $-\text{C}(\text{O})\text{B}^3\text{R}^{20\text{b}}$ where $\text{R}^{20\text{b}}$ is hydrogen or methyl, preferably methyl, B^3 is a valence bond or a straight or branched - alkylene, oxaalkylene or oligo-oxaalkylene group, and h is from 1 to 4; and

if B is other than a valence bond Z is 1 and if B is a valence bond Z is O if X is directly bonded to the oxygen or nitrogen and otherwise Z is 1.

[0040] Preferably the groups R^{20} are the same. It is also preferable that at least one of the groups R^{20} is methyl, and more preferable that the groups R^{20} are all methyl.

[0041] Preferably h is 1 or 2, more preferably 2.

[0042] Preferably B^3 is:

a valence bond;

an alkylene group of formula $-(\text{CR}^{13\text{c}})_2$, wherein the groups $-(\text{CR}^{13\text{c}})_2$ are the same or different and in each group $(\text{CR}^{13\text{c}})_2$ the groups $\text{R}^{13\text{c}}$ are the same or different and each group $\text{R}^{13\text{c}}$ is hydrogen or C_{1-4} alkyl, preferably hydrogen, and ac is from 1 to 12, preferably 1 to 6;

an oxaalkylene group such as alkoxyalkyl having 1 to 6 carbon atoms in each alkyl moiety, more preferably $-\text{CH}_2\text{O}(\text{CH}_2)_4-$; or

an-oligo-oxaalkylene group of formula $-(\text{CR}^{14\text{c}})_2\text{O}-$ where the groups $-(\text{CR}^{14\text{c}})_2$ are the same or different and in each group $-(\text{CR}^{14\text{c}})_2$ the groups $\text{R}^{14\text{c}}$ are the same or different and each group $\text{R}^{14\text{c}}$ is hydrogen or C_{1-4} alkyl, preferably hydrogen, and bc is from 1 to 6, preferably 2 or 3, and cc is from 1 to 12, preferably 1 to 6.

[0043] Preferred groups B^3 include a valence bond and alkylene, oxaalkylene and oligo-oxaalkylene groups of up to 12 carbon atoms.

[0044] Preferably B and B^3 are the same.

[0045] When X is a group of formula (VD) preferably B is a group of formula $-(\text{CR}^{14}_2\text{CR}^{14}_2)_b\text{O}-$ eg. $-(\text{CH}_2\text{CH}_2\text{O})_c\text{CH}_2\text{CH}_2-$.

[0046] Monomers having group X of formula VA to D may be prepared using techniques described in WO-A-93/01221. The description of the methods of monomer synthesis of such monomers described in that document are incorporated herein by reference.

[0047] In the compounds of formula (IV) K may be a valence bond and B a group, K may be a group and B a valence bond, both K and B may be groups, or K and B may together be a valence bond.

[0048] Preferably B is a group where K is a valence bond.

[0049] Where K is a group then preferably p is from 1 to 6, more preferably 1, 2 or 3 and most preferably p is 1. When K is a group $-(\text{CH}_2)_p\text{NR}^{2-}$, $(\text{CH}_2)_p\text{NR}^{2-}\text{C}(\text{O})-$, $-(\text{CH}_2)_p\text{C}(\text{O})\text{NR}^{2-}$, $-(\text{CH}_2)_p\text{NR}^{2-}\text{C}(\text{O})\text{O}-$, $-(\text{CH}_2)_p\text{OC}(\text{O})\text{NR}^{2-}$ or $-(\text{CH}_2)_p\text{NR}^{2-}\text{C}(\text{O})\text{NR}^{2-}$ then R^2 is preferably hydrogen, methyl or ethyl, more preferably hydrogen.

[0050] In the compounds of formula (IV) preferably the vinyl group is para to the group $-\text{K}-\text{B}-\text{X}$.

Hydrophobic Monomer

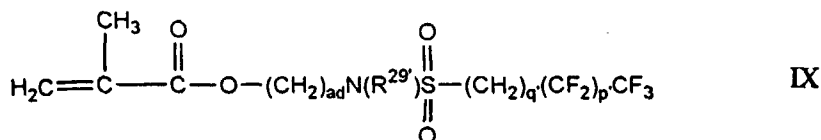
[0051] Preferably the hydrophobic monomer is an acrylic type monomer. It is preferred in such monomers for the group R^{14} to be hydrogen or more preferably, methyl, and for A^1 to be $-\text{O}-$.

[0052] Preferred groups B^4 are C_{1-4} alkylene, preferably ethylene, a valence bond or a C_{1-4} -alkylene sulphonamido group i.e. a group $-(\text{CR}^{13\text{d}})_2$ and $\text{N}(\text{R}^{29})\text{SO}_2-$ in which $\text{R}^{13\text{d}}$ is hydrogen or C_{1-4} -alkyl, and is 1 to 12, preferably 1 to 6, more preferably 2 and R^{29} is hydrogen or C_{1-4} -alkyl.

[0053] Preferably group R^3 which is a fluoroalkyl group has the formula $-(\text{CR}^{10}_2)_q(\text{CR}^{11}_2)_p\text{CR}^{11}_3$ wherein the groups (CR^{10}_2) are the same or different and in each group (CR^{10}_2) the groups R^{10} are the same or different and are fluorine, hydrogen, or C_{1-4} -alkyl or -fluoroalkyl and q is 1-23, the groups $-(\text{CR}^{11}_2)-$ are the same or different, and in each said group the groups R^{11} are the same or different and each is hydrogen, fluorine, or C_{1-4} -alkyl or fluoroalkyl and p is in the range 0 to 23, provided that at least one of the groups R^{10} and/or one of the groups R^{11} is fluorine or fluoroalkyl. Preferably p is at least 2 and no more than 12. Preferably a fluoroalkyl group R^3 contains at least 3 fluorine atoms.

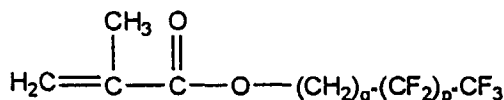
[0054] For optimum hydrolytic stability groups R^{10} are hydrogen or lower alkyl, most preferably hydrogen, and q is 1-4, most preferably 2. In these compounds at least one group, preferably all groups R^{11} are fluorine or perfluoroalkyl groups and p is 1-10, preferably 2-8.

[0055] One particularly preferred class of hydrophobic fluoroalkyl group containing monomers has the formula IX



where ad is 2 to 4, preferably 2, R^{29} is hydrogen or C_{1-4} alkyl, preferably methyl, ethyl, *n*-propyl or *n*-butyl, q is 0 to 6, and p is 1 to 9, preferably 2 to 6.

[0056] Another particularly preferred class of hydrophobic fluoroalkyl group containing monomers has the formula X



where q'' is 2 to 4 and p'' is 1 to 9, preferably 2 to 8.

[0057] Preferably in a silyl group R^3 the groups R^7 are all hydrogen and n is 2 to 4. The groups R^8 are preferably the same as one another. The groups R^9 are preferably the same as one another and are preferably the same as the groups R^8 and group R^{29} . Groups R^8 , R^9 and R^{29} are most preferably methyl.

[0058] In styrenic compounds of the formula II, the vinyl group is preferably parallel to the group $\text{K}-\text{R}^3$.

[0059] It is preferred that the zwitterionic monomer and hydrophobic comonomer should be of the same type, for optimum copolymerisation properties. Thus if the monomer of the formula I is an (alk) acrylate, it is preferred that the comonomer is also an (alk) acrylate. Furthermore it is preferred that the groups R and R^4 in the compounds III and II are the same, and are preferably hydrogen or methyl, most preferably methyl. Preferably the groups A and A' are the same, and are most preferably $-\text{O}-$.

Diluent Comonomers

[0060] In addition to a) the residues of zwitterionic monomer and b) the residues of hydrophobic comonomer the polymers of the present invention may comprise residues of a diluent comonomer.

[0061] Such diluent comonomers may be of any known conventional radical polymerisable, preferably ethylenically unsaturated, type compatible with the other comonomer(s) and the zwitterionic monomer.

[0062] Particular examples of diluent comonomers include alkyl(alk)acrylate preferably containing 1 to 4 carbon atoms in the alkyl group of the ester moiety, such as methyl (alk)acrylate; a dialkylamino alkyl(alk)acrylate, preferably containing 1 to 4 carbon atoms in each alkyl moiety of the amine and 1 to 4 carbon atoms in the alkylene chain, e.g. 2-(dimethylamino)ethyl (alk)acrylate; an alkyl (alk)acrylamide preferably containing 1 to 4 carbon atoms in the alkyl group of the amide moiety; a hydroxyalkyl (alk)acrylate preferably containing from 1 to 4 carbon atoms in the hydroxyalkyl moiety, e.g. a 2-hydroxyethyl (alk)acrylate; or a vinyl monomer such as an *N*-vinyl lactam, preferably containing from 5 to 7 atoms in the lactam ring, for instance vinyl pyrrolidone; styrene or a styrene derivative which for example is substituted on the phenyl ring by one or more alkyl groups containing from 1 to 6, preferably 1 to 4, carbon atoms, and/or by one or more halogen, such as fluorine atoms, e.g. (pentafluorophenyl) styrene.

[0063] Other suitable diluent comonomers include polyhydroxyl, for example sugar or glycerol, (alk)acrylates and (alk)acrylamides in which the alkyl group contains from 1 to 4 carbon atoms, e.g. sugar or glycerol acrylates, methacrylates, ethacrylates, acrylamides, methacrylamides and ethacrylamides. Suitable sugars include glucose and sorbitol. Particularly suitable diluent comonomers include methacryloyl glucose or sorbitol methacrylate.

[0064] Further diluents which may be mentioned specifically include polymerisable alkenes, preferably of 2-4 carbon atoms, eg. ethylene, dienes such as butadiene, alkylene anhydrides such as maleic anhydride and cyano-substituted alkynes, such as acrylonitrile.

[0065] Preferably diluent comonomers are nonionic and are substantially inert. They may, in some cases, affect, for instance increase, the water solubility of the polymers by being relatively more hydrophilic than the combination of the zwitterionic monomer and the hydrophobic comonomer. Preferred examples of diluent comonomer are hydroxy (including polyhydroxy) alkyl (alk) acrylate containing from 1 to 4 carbon atoms in the hydroxy alkyl moiety, especially 2-hydroxyalkyl (meth)acrylates and glyceryl monomethacrylate.

Polymerisation Conditions

[0066] Any conventional technique may be used for polymerisation, typically thermal or photochemical polymerisation.

5 [0067] For thermal polymerisation a temperature from 40 to 100°C, typically 50 to 80°C is used. For photochemical polymerisation actinic radiation such as gamma, U.V., Visible or microwave radiation may be used. Typically U.V. radiation of wavelength 200 to 400 nm is used.

[0068] The polymerisation is generally performed in a reaction medium, which is for instance a solution or dispersion, using as a solvent for example acetonitrile, dimethyl formamide, chloroform, dichloromethane, ethyl acetate, dimethyl
10 sulphoxide, dioxane, benzene, toluene, tetrahydrofuran, water or an alkanol containing from 1 to 4 carbon atoms, e.g. methanol, ethanol or propan-2-ol. Alternatively, a mixture of any of the above solvents may be used.

[0069] The polymerisation may be carried out in the presence of one or more polymerisation initiators, such as benzoyl peroxide, 2,2'-azo-bis(2-methylpropionitrile) (AIBN), 4,4' Azobis (4-cyano-valeric acid (ACVA) or benzoin methyl ether. Other polymerisation initiators which may be used are disclosed in "Polymer Handbook", 3rd edition, Ed. J. Brandrup and E.H. Immergut, pub. Wiley-Interscience, New York, 1989.
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[0070] Generally the copolymerisation is performed for 1 to 72 hours, preferably 8 to 48, for instance 16 to 24 hours, and under an inert atmosphere of for example nitrogen or argon. The polymer is generally purified by dialysis, precipitation in a non-solvent (e.g. diethyl ether or acetone) or ultrafiltration. The resulting polymer is generally dried under vacuum, e.g. for 5 to 72 hours and has a molecular weight from 10,000 to 10 million, preferably from 20,000 to 1 million.

20 [0071] The polymerisation usually involves monomers having the general formulae I and II. In some instances it may be possible to form a polymer having suitable derivatisable groups and reacting the polymer to introduce a group X or R³, as the case may be.

[0072] The ratio of zwitterionic monomer to hydrophobic monomer and the content of any diluent monomer should be suitable to confer upon the polymer water-solubility characteristics as well as binding characteristics onto the contact lens surface. For water solubility, the amount of zwitterionic monomer is generally at least 20 mole % (based on the total moles of ethylenically unsaturated monomer) preferably at least 50% more preferably at least 75%, for instance up to 90% or even up to 95%. For surface binding, the amount of hydrophobic monomer should be at least 1 mole %, more preferably at least 5 mole %, for instance 10 to 50 mole %. The amount of diluent monomer should be up to 49 mole % based on the total moles of monomer, for instance in the range 5 to 40 mole %.

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Compositions

[0073] The compositions of the invention have utilities which have in common the fact that the ingredients are acceptable for introduction into the eye, either by application directly into the eye or carried over with a lens or other intraocular device is introduced into the eye. In addition the surfaces which the polymers of the compositions should adsorb, are generally hydrophobic. Thus contact lenses, especially gas permeable (soft silicone and fluorosilicone-based and hard type) contact lenses, contact lens cases and containers and the cornea, are all hydrophobic. The hydrophobic group from the monomer of the formula II provides good adsorption properties to such substrates.

[0074] The novel compositions of the invention should contain other ingredients suitable for contact lens cleaning, soaking or storage solutions or artificial tears/comfort drops. Storage solutions, in this context, mean solutions in a sealed sterilised package, in which the contact lenses are supplied to the consumer. The composition generally contains 0.01 to 5%, preferably in the range 0.1 to 2.5%, for instance in the range 0.5 to 2% by weight of the polymer. The concentration generally depends upon the use for which the solution is intended. Cleaning solutions may have concentrations at the upper end of the range, for instance more than 1% by weight. Soaking solutions and storage solutions
45 may have concentrations at the lower end of the range, for instance less than 2%, often less than 1% by weight. Artificial tears and comfort drops may contain the polymer in an amount of at least 1% by weight, preferably at least 2% by weight, up to 10% preferably no

[0075] more than 5%. Other components of the compositions depend upon the intended use. The composition is preferably buffered, for instance at physiological pH, around 7.2. The compositions may contain surfactants especially non ionic surfactants, sequestrants (eg EDTA), preservatives e.g. quaternary ammonium disinfectants, pharmaceutically active ingredients, viscosity modifiers (for instance soluble cellulosic polymers or polyvinyl pyrrolidone wetting agents (for instance polyvinylalcohol or salts), etc. The compositions preferably are in physiological saline, that is 0.9% sodium chloride.

[0076] The present invention provides also a sealed package containing the novel composition, which is a storage composition, and a contact lens or an ocular implant. The contact lens may be a hard (gas permeable) lens or a soft lens, for instance a hydrogel or a silicone based lens, for instance a daily wear lens, an extended wear lens or a disposable lens. An ocular implant may be an intraocular lens, a glaucoma filtration implant or a drug delivery gel for laying on or in the eye. The container generally contains the novel composition in amounts such that the composition is not all

imbibed in the contact lens or implant.

[0077] According to the invention there is also provided a method in which a contact lens is treated by contacting it with the novel aqueous compositions. The method may be for cleaning, rinsing or soaking a contact lens, for instance prior to insertion or reinsertion in the eye. The polymer may be adsorbed or absorbed on or in the lens upon insertion in the eye. The composition may alternatively be used as comfort drops for application directly into the eye (which may contain a contact lens, or not) to alleviate the symptoms of dry eye.

[0078] The polymers used in the compositions, products and methods of the invention, whilst being water soluble, provide a coating on the surface of a lens or implant which appears to remain adhered over a substantial period of time, for instance after reinsertion of a treated lens into the eye. The coating thus provides extended periods over which there is a reduction in protein deposition, this reduction being attributed to the presence of zwitterionic groups. The coatings confer improved comfort on a lens immediately after insertion and for extended periods following insertion into the eye. The improved comfort is believed to be due to improved surface wettability, improved water retention at the surface of the lens, improved lubricity, as well as reduced protein deposition and lipid deposition as compared to the untreated lens. The zwitterionic groups in the polymers may also contribute to the avoidance of adverse interactions with preservatives and/or surfactants.

[0079] The polymers are hydrolytically stable and can be subjected to sterilising in the aqueous compositions for instance by being subjected to elevated temperatures of at least 80°C preferably at least 100°C for periods of at least 10s., preferably at least 1 min.

[0080] The compositions of the present invention may also be useful for rinsing contact lens storage containers and contact lens soaking containers, for instance for use by the contact lens wearer following removal of a daily wear or extended wear lens. The polymers coat the surfaces of such containers, thereby reducing protein deposition as well as microbial adhesion which could otherwise lead to carrying of infective microorganisms into the eye and subsequent infection.

[0081] The compositions may also be used to store intraocular lenses or other implants, or drug delivery gels prior to insertion in the eye

[0082] The invention is further illustrated in the following examples. The results of the examples are shown in the accompanying figures in which:

Figure 1 illustrates the performance of the copolymer of Example 1 on one substrate as compared to a comparison polymer;

Figure 2 illustrates the performance of the copolymer of Example 1 against a comparison polymer, on a second substrate;

Figure 3 shows the performance of the copolymer of Example 2 and a comparison polymer on the first substrate;

Figure 4 shows the performance of the copolymer of Example 2 and a comparison polymer on the second substrate;

Figure 5 shows the performance of the copolymer of Example 3 and a comparison polymer on the first substrate;

Figure 6 shows the performance of the copolymer of Example 3 and a comparison polymer on the second substrate;

Figure 7 a and b show the comparative performance of a polymer as disclosed in the prior art on two lens substrates.

EXAMPLES

General Methods of Analysis

[0083] Test sheets representative of hard lens formulations were prepared from methyl methacrylate (MMA), tris(trimethylsiloxy silyl)propyl methacrylate (TRIS), a hydroxy analogue and a dimer form of TRIS used as a crosslinker, methacrylic acid (MAA), and trifluoroethyl methacrylate (TFEMA). The mixture of TRIS, its hydroxy-analogue and the dimer is commercially available from Vickers as Optomer 2417. 2,2'-Azobisisobutyronitrile (AIBN) was used as a free radical initiator. The formulation of monomers and initiator were mixed, placed between two glass plates lined with PET sheet with a PTFE spacer and then placed in an oven at 60°C for 12 hours and at 100°C for 2 hours. The sheets were then removed from the moulds and washed in water for 2 hours. All sheets were then hydrated in water for at least 7 days. Two formulations were used, one without trifluoroethyl methacrylate (the silicone RGP material) and one containing trifluoroethylmethacrylate (the fluorosilicone RGP material).

[0084] The effectiveness of the soluble polymer (synthesised as described below) at imparting wettability and hydrophilicity to the surface was assessed by Dynamic Contact Angle analysis as follows. A solution of the test polymer was prepared in water at 1% w/v. The surface tension of the solution was then measured using a Cahn Instruments DCA 312 with a flame-cleaned glass slide as the solid surface; assuming a contact angle of zero, the surface tension

could then be calculated.

[0085] Dynamic contact angles (advancing and receding) of this solution on a sample of the hydrated test sheet were then measured over 7 immersion/emersion cycles using a Cahn instruments DCA312 with a stage speed of 100µm/s. Computer analysis of the force- displacement curve yields the average contact angle for each cycle. A low advancing angle, and a low hysteresis (the difference between the advancing and receding contact angle in the same cycle) is indicative of good wettability of the polymer solution on the surface.

[0086] The test solution was then changed to water and the dynamic contact angles measured for a further 7 cycles on the same test sheet. A low advancing angle, and a low hysteresis is now indicative that the polymer is strongly adsorbed onto the surface and can therefore impart hydrophilicity to the surface. The test solution was then changed for fresh water and the contact angles measured for a further 7 cycles. Again, low advancing angle, and a low hysteresis is indicative of good retention of the polymer on the surface.

[0087] The contact angle data for each sample is attached in graphical form; for simplicity, only the advancing angle is shown and compared for each sample to a homopolymer of HEMA-PC (described in Comparative Example 1). Both advancing and receding angles are shown for the styrene HEMA-PC comparative copolymer described in comparative Example 2.

Example 1

Copolymer of 2-(methacryloyloxyethyl)-2'-(trimethylammonium)ethyl phosphate inner salt (HEMA-PC) and hexafluoroisopropyl methacrylate (HFIPMA) 5:1 mole ratio

[0088] The title copolymer was prepared according to the following procedure. 8.6g HEMA-PC and 1.38g HFIPMA were placed in a round bottom flask equipped with a reflux condenser and 120ml of ethanol added. 0.02g AIBN were added and the solution degassed with nitrogen for 20 minutes. Then temperature was then raised to 60°C and maintained at this temperature for 48 hours. The solution was then cooled and the solvent removed under reduced pressure. The polymer was redissolved in methanol/chloroform and precipitated into acetone before drying under vacuum.

[0089] The results of the DCA analysis on silicone and fluorosilicone are shown in Figures 1 and 2, respectively, in comparison with a homopolymer of HEMA-PC, and with water as a control.

[0090] The polymer in aqueous solution could be sterilised without any observable change in performance.

Example 2

Copolymer of HEMA-PC and 1H,1H,2H,2H-heptadecafluorodecyl methacrylate (HFDMA) (about 10:1)

[0091] The title copolymer was prepared according to the following procedure. 19.9g HEMA-PC and 3.06g HFDMA were placed in a round bottom flask equipped with a reflux condenser and 200ml of trifluoro ethanol added. 0.089g azobis(cyanovaleric acid) were added and the solution degassed with nitrogen for 20 minutes. The temperature was then raised to 60°C and maintained at this temperature for 48 hours. The solution was then cooled and the solvent removed under reduced pressure. The polymer was redissolved in methanol/chloroform and precipitated into acetone before drying under vacuum.

[0092] The results of the DCA of the copolymer coated into silicone and fluoro-silicone materials analysis are shown below in Figures 3 and 4, respectively, in comparison with HEMA-PC homopolymer and with water as a control.

[0093] The polymers in aqueous solution can be sterilised without any observable change in performance.

Example 3

Copolymer of HEMA-PC and trimethylsilylmethyl methacrylate (about 4:1)

[0094] The title copolymer was prepared according to the following procedure 21.71g of HEMA-PC was placed in a round bottom flask and dissolved in 250ml ethanol. 3.58g trimethylsilylmethyl methacrylate and 0.0135g AIBN were added and the solution degassed with nitrogen for 15 minutes. The solution was then stirred at 63°C for 36 hours and the solvent removed under removed pressure. The solid was dissolved in dichloromethane/methanol (70:30) and precipitated in acetone. The precipitation step was repeated and the polymer dried under vacuum at ambient temperature. The results of the DCA analysis on the silicone and fluorosilicone materials are shown below, in Figures 5 and 6, respectively, compared to HEMA-PC homopolymer using water as a control.

[0095] The polymer in aqueous solution could be sterilised without any change in performance.

Comparative Example 1Homopolymer of HEMA-PC

- 5 [0096] The homopolymer was prepared in a similar manner to that described in Example 1 except that only HEMA-PC was used as the polymerisable monomer. This contact angle data is included in each graph showing the data for the three hydrophobically-modified polymers.

Comparative Example 2

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Copolymer of HEMA-PC and styrene (2.5:1)

- [0097] A copolymer of HEMA-PC and styrene was made using the technique described in Preparation Example 3 for contact lens treatment solutions as in EP-A-0537972. It was subjected to the contact angle test (applied from aqueous solution) as described above on the two membranes on which the polymers of the invention have been tested. The advancing and receding contact angles ("ACA and "RCA", respectively) are shown in Figs 7a and 7b compared to water control ("con").

Summary

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[0098] These data show that HEMA-PC homopolymer is not strongly adsorbed onto the surface of the test sheet and therefore cannot be used to impart hydrophilicity to the surface of a contact lens for a significant period of time.

- [0099] Hydrophobically modified copolymers of a phosphoryl choline-containing methacrylate according to the invention are strongly adsorbed onto a hydrophobic surface. A copolymer synthesised according to the prior art but applied to the lens using the techniques in accordance with the present invention adsorbs to a lesser extent. It provides some change in contact angle at least before replacement of the test solution by water, but adsorption appears to be weaker. Unmodified PC homopolymer is easily removed from the surface.

- [0100] Thus the results show that, whilst a homopolymer of HEMA-PC gives some performance improvement in terms of the wettability of the underlying surface, especially for the fluorosilicone material, the polymer is not stably adsorbed onto the surface and it is removed when the test solution is changed to water. Incorporation of the hydrophobic comonomer styrene gives some improvement. The copolymer of the invention with the hydrophobic fluoro alkyl or silyl monomer, whilst being water soluble, remains adsorbed on the surface even after replacement of the test solution by water on two occasions.

Claims

1. A composition for cleaning, soaking or storing contact lenses or ocular implants or containers therefor is aqueous, substantially free of organic solvent and contains 0.01 to 10% by weight of a copolymer obtainable by copolymerising ethylenically unsaturated monomers including:

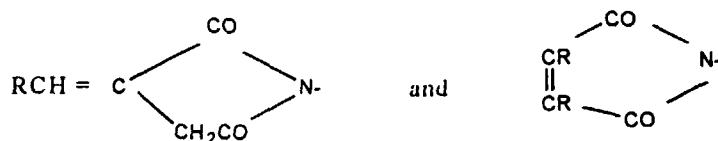
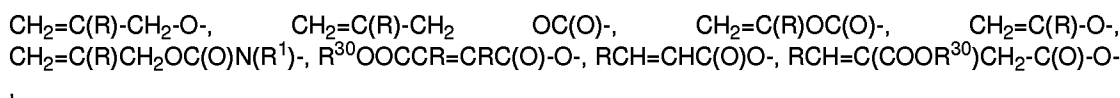
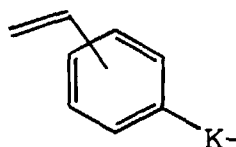
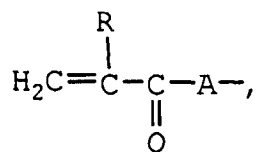
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- a) 20 to 99 mole % of a zwitterionic monomer of the general formula I



- wherein B is a straight or branched alkylene, oxaalkylene or oligo-oxaalkylene chain optionally containing one or more fluorine atoms up to and including perfluorinated chains or, if X contains a carbon-carbon chain between B and the centre of permanent positive charge or if Y contains a terminal carbon atom bonded to B, a valence bond;
X is a zwitterionic group and
Y is an ethylenically unsaturated polymerisable group selected from

55



wherein:

R is hydrogen or a C₁-C₄ alkyl group;

R³⁰ is hydrogen, C₁₋₄-alkyl or BX;

A is -O- or -NR¹-;

R¹ is hydrogen or a C₁-C₄ alkyl group or R¹ is -B-X where B and X are as defined above; and

K is a group -(CH₂)_pOC(O)-, -(CH₂)_pC(O)O-, -(CH₂)_pOC(O)O-, -(CH₂)_pNR²-, -(CH₂)_pNR²C(O)-, -(CH₂)_pC(O)NR²-, -(CH₂)_pNR²C(O)O-, -(CH₂)_pOC(O)NR²-, -(CH₂)_pNR²C(O)NR²-, (in which the groups R² are the same or different) -(CH₂)_pO-, -(CH₂)_pSO₃⁻, or, optionally in combination with B, a valence bond and p is from 1 to 12 and R² is hydrogen or a C₁-C₄ alkyl group and

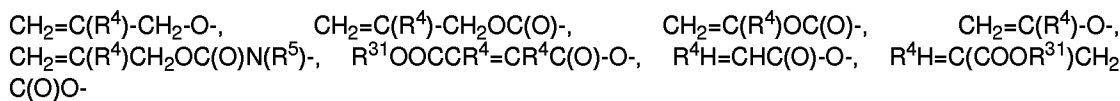
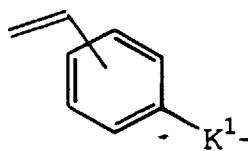
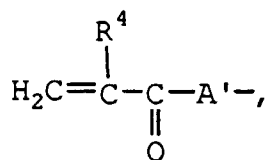
b) 1 to 50 mole % of a hydrophobic monomer of the formula II

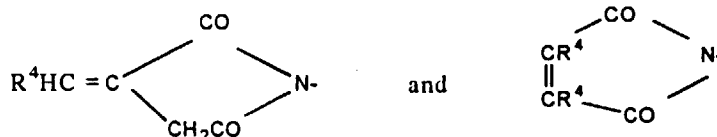


wherein

B⁴ is a straight or branched alkylene, oxaalkylene or oligo-oxaalkylene chain optionally containing one or more fluorine atoms up to and including perfluorinated chains, an alkylene-sulphonamido group, or a valence bond;

Y¹ is an ethylenically unsaturated polymerisable group selected from





where

R⁴ is hydrogen or C₁-C₄ alkyl,

R³¹ is hydrogen, C₁₋₄ alkyl or B⁴R³;

A¹ is -O- or -NR⁵-; R⁵ is hydrogen or a C₁-C₄ alkyl group or R⁵ is a group Q;

K¹ is a group -(CH₂)_lOC(O)-, -(CH)_lC(O)O-, -(CH₂)_lOC(O)O-, (CH₂)_lNR⁶-, -(CH₂)_lNR⁶C(O)-, -(CH₂)_lC(O)NR⁶-, -(CH₂)_lNR⁶C(O)O-, -(CH₂)_lOC(O)NR⁶-, -(CH₂)_lNR⁶C(O)NR⁶- (in which the groups R¹⁶ are the same or different), -(CH₂)_lO-, -(CH₂)_lSO₃-, a valence bond and l is from 1 to 12 and R⁶ is hydrogen or a C₁-C₄ alkyl group; and

R³ is a C₂₋₂₄-fluoroalkyl group or a silyl group of the formula -(CR⁷)_n(SiR⁸)₂(OSiR⁹)_mR⁹

wherein group R¹ are the same or different and each represent hydrogen, C₁₋₄ alkyl or C₇₋₁₂ aralkyl,

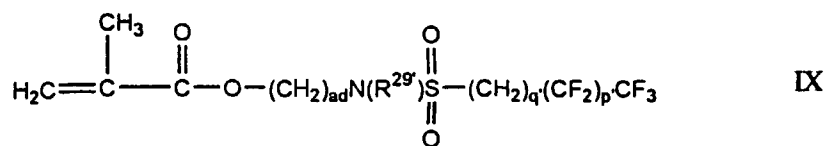
n is an integer in the range 1 to 6

the groups R⁸ are the same or different and are each C₁₋₄-alkyl or C₇₋₁₂-aralkyl, or are each OSiR⁹₃

the groups (OSiR⁹)₂ are the same or different and in each the groups R⁹ are the same or different and each represents C₁₋₄-alkyl or C₇₋₁₂-aralkyl, and

m is 0 to 49.

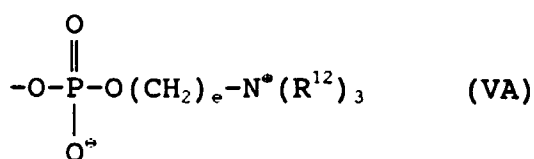
2. A composition according to claim 1 in which R³ is a fluoroalkyl group which has the formula -(CR¹⁰)_q(CR¹¹)_pCR¹¹₃ wherein the groups (CR¹⁰)₂ are the same or different and in each group (CR¹⁰)₂ the groups R¹⁰ are the same or different and are fluorine, hydrogen, or C₁₋₄-alkyl or -fluoroalkyl and q is 1-23, the groups -(CR¹¹)₂- are the same or different, and in each said group the groups R¹¹ are the same or different and each is hydrogen, fluorine, or C₁₋₄-alkyl or fluoroalkyl and p is in the range 10 to 23, provided that at least one of the groups R¹⁰ and/or one of the groups R¹¹ is fluorine or fluoroalkyl.
3. A composition according to claim 2 in which the groups R¹⁰ are hydrogen or C₁₋₄-alkyl and q is 1-4, preferably 2.
4. A composition according to claim 3 in which all the groups R¹¹ are fluorine or fluoroalkyl and p is in the range 1 to 10, preferably 2 to 8.
5. A composition according to claim 1 in which the comonomer II has the general formula IX



where ad is 2 to 4, preferably 2, R²⁹ is hydrogen or C₁₋₄ alkyl, preferably methyl, ethyl, n-propyl or n-butyl, q is 0 to 6, preferably 2, and p is 1 to 9, preferably 2 to 8.

6. A composition according to claim 1 in which R³ is a silyl group in which the groups R⁷ are all hydrogen and n is 2 to 4.
7. A composition according to claim 6 in which the groups R⁸ are all the same as one another, and the groups R⁹ are all the same as one another and, preferably are the same as the groups R⁸.
8. A composition according to claim 7 in which the groups R⁸ and R⁹ are all methyl.
9. A composition according to any preceding claim in which the zwitterionic monomer the group X is a group of for-

mula VA



where the groups R^{12} are the same or different and each is hydrogen or C_{1-4} alkyl, and e is from 1 to 4.

10. A composition according to claim 9 in which the groups R^{12} are the same and are preferably all methyl, and e is preferably 2 or 3.
11. A composition according to any preceding claim in which the ethylenically unsaturated monomers include a diluent comonomer.
12. A composition according to claim 11 in which the diluent comonomer is selected from alkyl(alk)acrylate preferably containing 1 to 4 carbon atoms in the alkyl group of the ester moiety, such as methyl (alk)acrylate; a dialkylamino alkyl(alk)acrylate, preferably containing 1 to 4 carbon atoms in each alkyl moiety of the amine and 1 to 4 carbon atoms in the alkylene chain, e.g. 2--(dimethylamino)ethyl (alk)acrylate; an alkyl (alk)acrylamide preferably containing 1 to 4 carbon atoms in the alkyl group of the amide moiety; a hydroxyalkyl (alk)acrylate preferably containing from 1 to 4 carbon atoms in the hydroxyalkyl moiety, e.g. a 2-hydroxyethyl (alk)acrylate; a vinyl monomer such as an N-vinyl lactam, preferably containing from 5 to 7 atoms in the lactam ring, for instance vinyl pyrrolidone; styrene or a styrene derivative which for example is substituted on the phenyl ring by one or more alkyl groups containing from 1 to 6, preferably 1 to 4, carbon atoms, and/or by one or more halogen, such as fluorine atoms, e.g. (pentafluorophenyl)styrene; polyhydroxyl, for example sugar, (alk)acrylates and (alk)acrylamides in which the alkyl group contains from 1 to 4 carbon atoms, e.g. sugar acrylates, methacrylates, ethacrylates, acrylamides, methacrylamides and ethacrylamides; polymerisable alkenes, preferably of 2-4 carbon atoms, eg. ethylene; dienes such as butadiene; alkylene anhydrides such as maleic anhydride; and cyano-substituted alkylenes, such as acrylonitrile.
13. A composition according to any preceding claim in which the zwitterionic monomer was present in the ethylenically unsaturated monomers in a molar amount in the range 50 to 95%, preferably in the range 65 to 90%.
14. A composition according to any preceding claim which comprises physiological buffered saline.
15. A sealed package containing a composition according to any preceding claim and a contact lens or ocular implant.
16. A sealed package according to claim 15 which has been sterilised.
17. A method in which a contact lens or a contact lens storage case is contacted with a composition according to any of claims 1 to 14, preferably by rubbing, dipping and/or rinsing.
18. A method according to claim 17 in which a contact lens is treated and is subsequently placed directly into the eye whilst still having the novel composition on its surface or imbibed into its body.
19. A method of treating dry eye in which a composition according to any of claims 1 to 14 is applied directly to the eye, preferably an eye containing a contact lens.

**Comparison of HEMA-PC and HEMA-PC/HFIPMA
Adsorption to Silicone RGP Material**

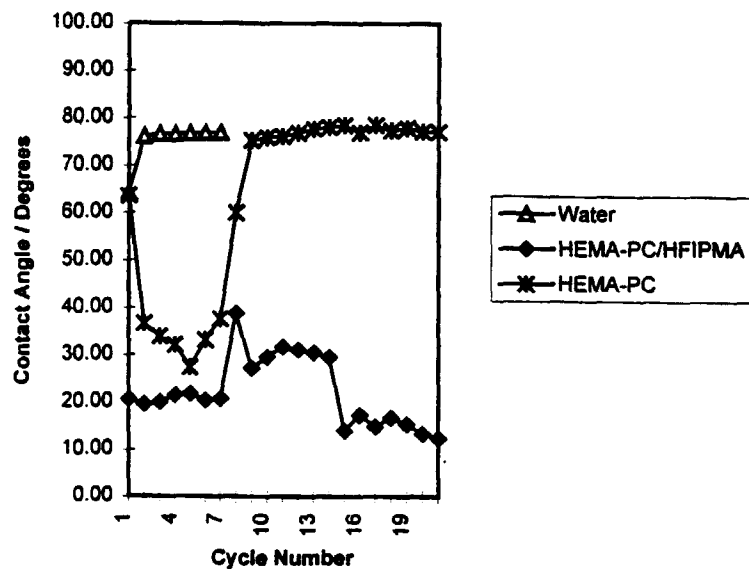


Figure 1

**Comparison of HEMA-PC and HEMA-PC/HFIPMA
Adsorption to Fluorosilicone RGP Material**

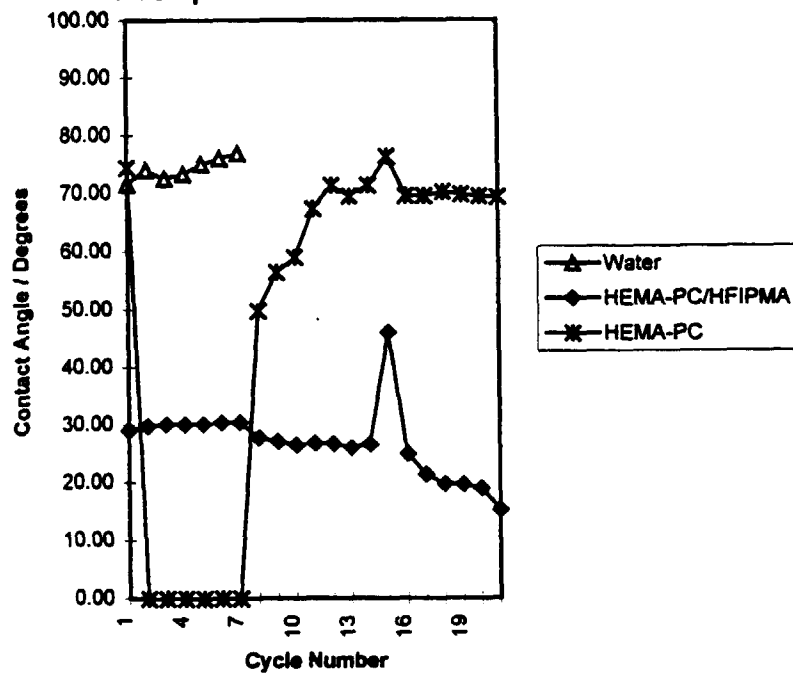


Figure 2

**Comparison of HEMA-PC and HFDMA Adsorption
to Silicone RGP Material**

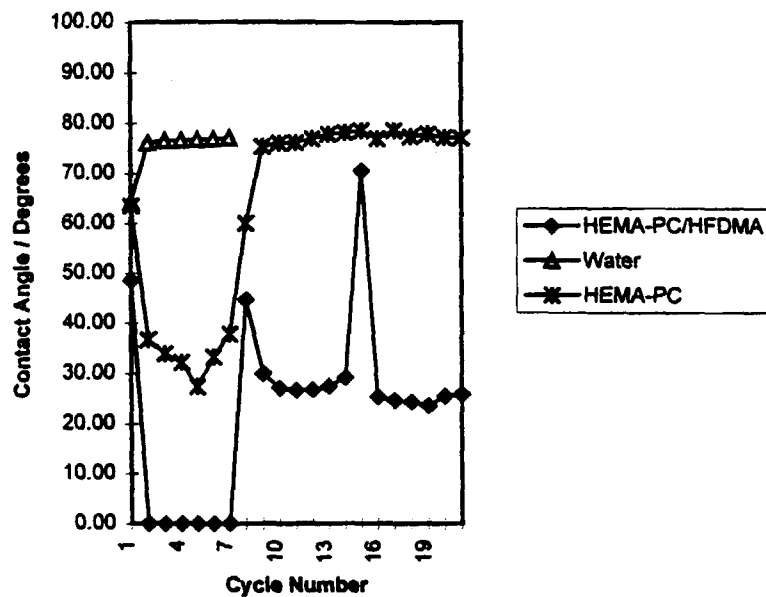


Figure 3

**Comparison of HEMA-PC and HFDMA Adsorption to
Fluorosilicone RGP Material**

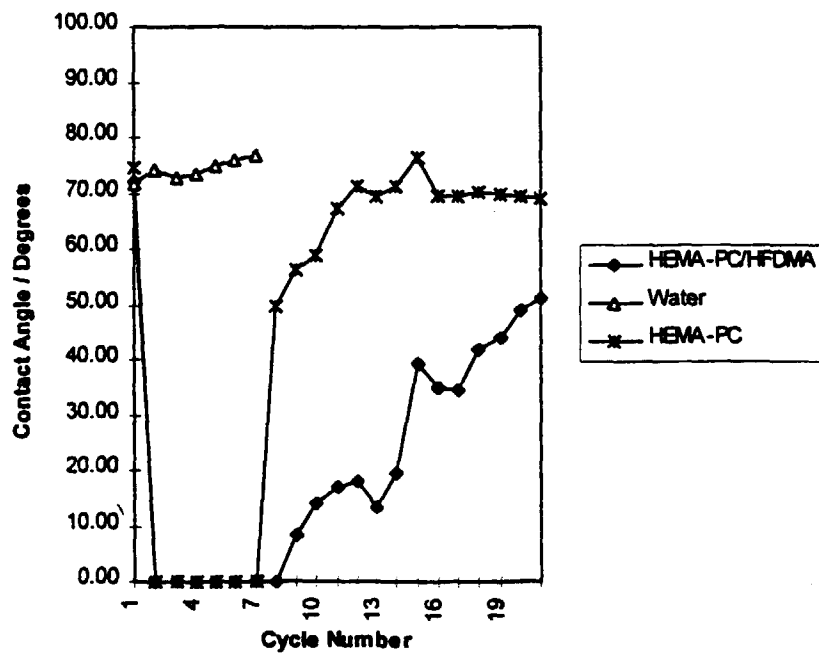


Figure 4

Comparison of HEMA-PC and HEMA-PC/SMA
Adsorption to Silicone RGP Material

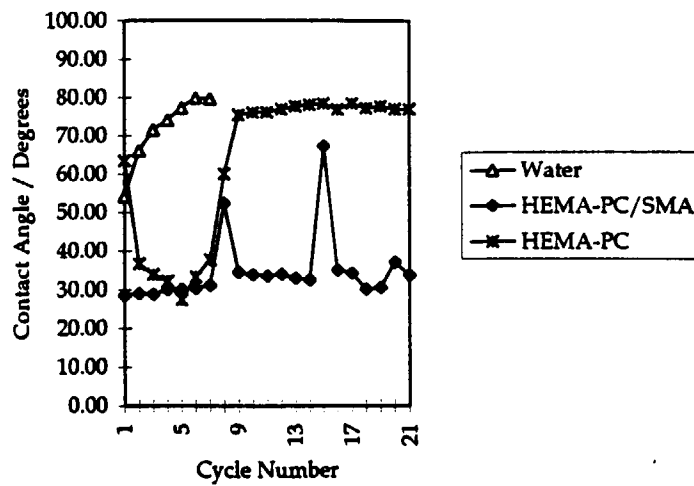


Figure 5

Comparison of Adsorption of HEMA-PC and HEMA-PC/SMA to Fluorosilicone RGP Material

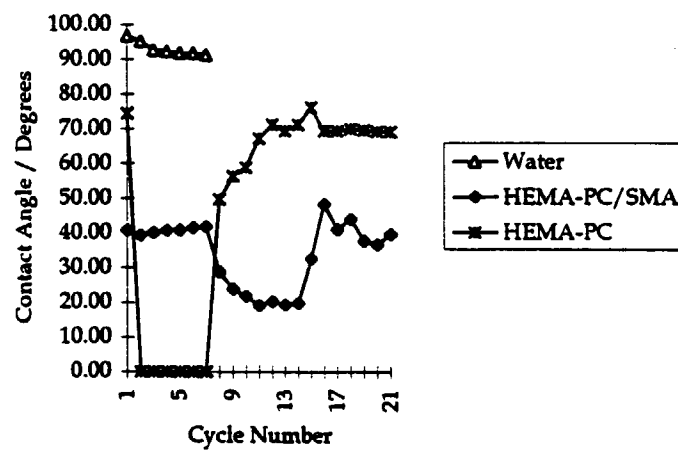


Figure 6

Figure 5.3.10A : Si/Mm membrane dipped into 1% w/v
HEMA-PC/Styrene

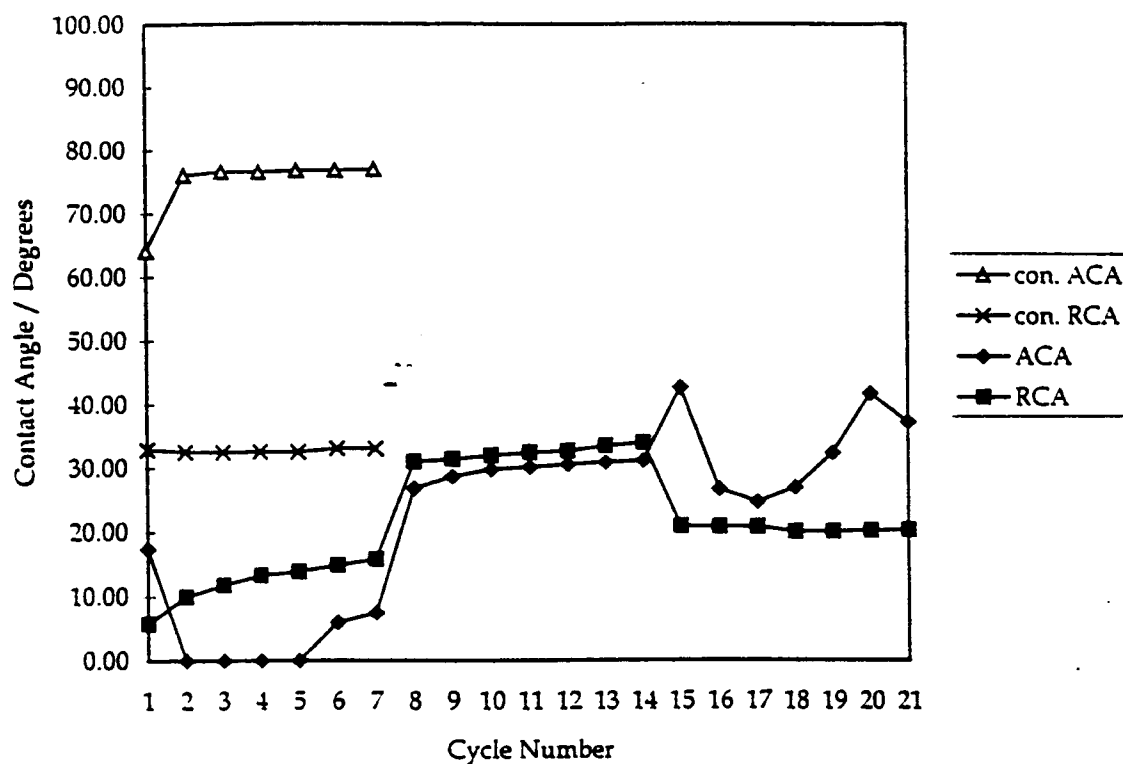


Figure 7a

Figure 5.3.10B : F/Si membrane dipped into 1% w/v
HEMA-PC/Styrene

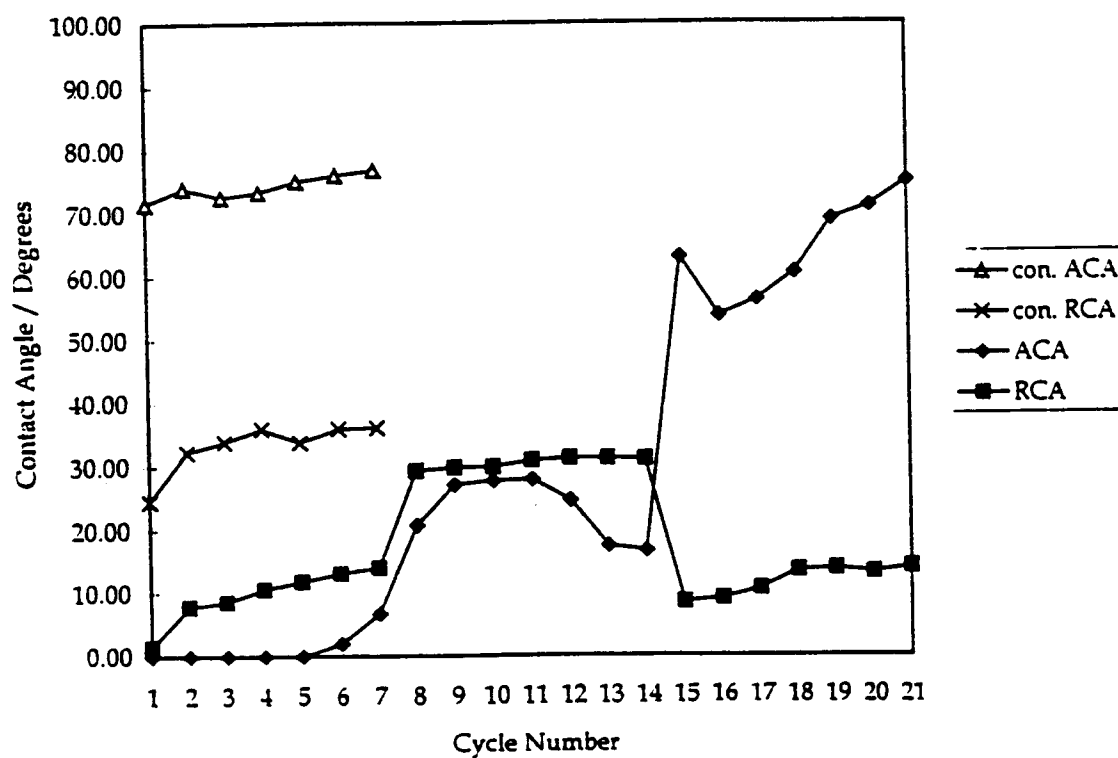


Figure 7b



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 9921

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
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