Claims:

1. A hydrogel ocular insert that is placed into the conjunctival sac of an eye when being used by a patient and is made of a hydrogel material,

wherein the hydrogel ocular insert is stored in a packaging aqueous solution in a sealed and sterilized package, wherein the packaging aqueous solution has a pH of from 7.5 to 9.0, wherein the hydrogel ocular insert has an on-eye dissolution time of from 4 to 24 hours,

wherein the hydrogel ocular insert has a shape of a rod, a sphere, an oval, a ring, a square, a rectangle, a triangle, or an irregular shape and a thickness of from 50 to 400 μm, wherein the shape of the hydrogel ocular insert has a maximum size of 5-6 mm in any single dimension,

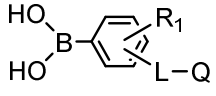
wherein the hydrogel material is a crosslinked polymeric material which is a crosslinking product of at least one arylborono-containing hydrophilic copolymer and at least one mucoadhesive polymer including repeating units each having a moiety selected from the group consisting of 1,2-diol moiety, 1,3-diol moiety, α-hydroxycarboxylic acid moiety, and β-hydroxycarboxylic acid moiety,

wherein said at least one arylborono-containing hydrophilic copolymer comprises (a) from 2% to 18% by mole of the arylborono-containing repeating units, (b) from 70% to 95% by mole of repeating units of at least one phosphorylcholine-containing vinylic monomer, and (c) from 3% to 15% by mole of acrylic monomeric units of at least one acrylic monomer having 3 to 16 carbon atoms, provided that the sum of the mole percentages of components (a), (b) and (c) and other components not listed above is 100%,

wherein said at least one mucoadhesive polymer is present in an amount of from 70% to 98% by weight relative to the dry weight of the hydrogel ocular insert,

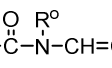
wherein said at least one arylborono-containing hydrophilic copolymer and said at least one mucoadhesive polymer are crosslinked in the crosslinked polymeric material through crosslinks each formed between one of arylborono groups of said at least one arylborono-containing hydrophilic copolymer and one 1,2-diol, 1,3-diol, α-hydroxycarboxylic acid, or β-hydroxycarboxylic acid moiety of said at least one mucoadhesive polymer.

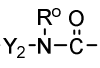
2. The hydrogel ocular insert of claim 1, wherein said at least one arylborono-containing vinylic monomer is represented by formula (II)



(II)

in which: R_1 is H, NO_2, F, Cl, Br, CF_3, CH_2OH, or $CH_2NR^oR^{o'}$;

Q is a monovalent radical of , , , , , , , or ;

L is a direct bond, a C_1-C_4 alkylene divalent radical, a divalent radical of , , , , , ,  or  in which Y_1 is CH(OH) or a C_1-C_4 alkylene divalent radical, Y_2 is a C_1-C_4 alkylene divalent radical, p1 is an integer of 0 to 3, and R^o is H or a C_1-C_4 alkyl.

3. The hydrogel ocular insert of claim 2, wherein said at least one arylborono-containing vinylic monomer is selected from the group consisting of 3-vinylphenylboronic acid, 4-vinylphenylboronic acid, 3-(meth)acrylamidophenylboronic acid, 4-(meth)acrylamidophenylboronic acid, 3-(meth)acrylamido-5-nitrophenylboronic acid, 4-(meth)acrylamido-5-nitrophenylboronic acid, 4-(meth)acrylamido-3-nitrophenyl-boronic acid, 3-[(meth)acrylamido-C_2-C_5-alkylaminocarbonyl]-5-nitrophenylboronic acid, 3-[(meth)acryloyloxy-C_2-C_5-alkylaminocarbonyl]-5-nitrophenylboronic acid, 3-(meth)acrylamido-6-hydroxymethylphenylboronic acid, 3-(meth)acrylamido-6-dimethylaminomethylphenylboronic acid, 4-(meth)acrylamido-6-hydroxymethylphenyl-boronic acid, 4-(meth)acrylamido-6-dimethylaminomethylphenyl-boronic acid, 4-(1,6-Dioxo-2,5-diaza-7-oxamyl)phenylboronic acid, 4-(N-allylsulfamoyl)phenylboronic acid, 4-(3-butenylsulfonyl)phenylboronic acid, a reaction production of an amino-containing phenylboronic acid derivative with (meth)acrylic acid halide, a reaction product of an amino-containing phenylboronic acid derivative with a carboxy-containing vinylic monomer in the presence of a carbodiimide and N-hydroxysuccinimide, a reaction production of a carboxy-containing phenylboronic acid derivative with an amino-containing vinylic monomer in the presence of a carbodiimide and N-hydroxysuccinimide, and combinations thereof, wherein the carboxy-containing phenylboronic acid derivative is selected from the group consisting of 3-carboxyphenylboronic acid, 4-carboxyphenylboronic acid, 3-boronophenylacetic acid, 4-boronophenylacetic acid, 2-(4-boronophenyl)-2-methylpropanoic acid, 3-(4-boronophenyl)propanoic acid, 3-(3-boronophenyl)propanoic acid, 5-(3-boronophenyl)-pentanoic acid, 5-(4-boronophenyl)pentanoic acid, 4-(2-carboxyethyl)-3-nitrophenyl-boronic acid, 3-carboxy-5-nitrophenylboronic acid, 4-carboxy-3-chlorophenylboronic acid, 3-carboxy-4-fluorophenylbornic acid, 3-(3-carboxypropyonylamino)phenylboronic acid, 3-amino-3-(4-boronophenyl)propanoic acid, and combinations thereof, wherein the amino-containing phenylboronic acid derivative is selected from the group

consisting of 3-aminophenylboronic acid, 4-aminophenylboronic acid, 4-amino-3-nitrophenylboronic acid, 3-amino-6-hydroxymethylphenylboronic acid, 3-amino-6-(dimethylaminomethyl)phenylboronic acid, 4-amino-2-hydroxymethylphenylboronic acid, 4-amino-2-(dimethylaminomethyl)phenylboronic acid, 3-amino-4-fluorophenyl-boronic acid, 4-(aminomethyl)-5-nitrophenylboronic acid, 3-(aminomethyl)-phenyl-boronic acid, 3-amino-5-nitrophenylboronic acid, 3-amino-3-(4-boronophenyl)propanoic acid, and combinations thereof,

wherein the carboxyl-containing vinylic monomer is selected from the group consisting of 2-acrylamidoglycolic acid, 3-acrylamidopropionic acid, 4-acrylamidobutanoic acid, 5-acrylamidopentanoic acid, 3-acryloyloxypropanoic acid, 4-acryloyloxybutanoic acid, 5-acryloyloxypentanoic acid, and combinations thereof,

wherein the amino-containing vinylic monomers is selected from the group consisting of amino–C_2-C_4 alkyl (meth)acrylate, C_1-C_3 alkylamino–C_2-C_4 alkyl (meth)acrylate, amino–C_2-C_4 alkyl (meth)acrylamide, C_1-C_3 alkylamino–C_2-C_4 alkyl (meth)acrylamide, vinylamine, allylamine, and combinations thereof.

4. The hydrogel ocular insert of any one of claims 1 to 3, wherein said at least one acrylic monomer is selected from the group consisting of a C_1–C_{12} alkyl (meth)acrylate, a hydroxy-substituted C_2–C_{12} alkyl (meth)acrylate, a carboxy-substituted C_2–C_{12} alkyl (meth)acrylate, an NH_2-substituted C_2–C_{12} alkyl (meth)acrylate, a methylamino-substituted C_2–C_{12} alkyl (meth)acrylate, a dimethylamino-substituted C_2–C_{12} alkyl (meth)acrylate, an ethylamino-substituted C_2–C_{10} alkyl (meth)acrylate, a diethylamino-substituted C_2–C_8 alkyl (meth)acrylate, a C_2–C_{12} alkyl (meth)acrylamide, a hydroxy-substituted C_2–C_{12} alkyl (meth)acrylamide, a carboxy-substituted C_2–C_{12} alkyl (meth)acrylaide, an NH_2-substituted C_2–C_{12} alkyl (meth)acrylamide, a methylamino-substituted C_2–C_{12} alkyl (meth)acrylamide, a dimethylamino-substituted C_2–C_{12} alkyl (meth)acrylamide, an ethylamino-substituted C_2–C_{10} alkyl (meth)acrylamide, a diethylamino-substituted C_2–C_8 alkyl (meth)acrylamide, ethylene glycol (meth)acrylate, di(ethylene glycol) (meth)acrylate, tri(ethylene glycol) (meth)acrylate, tetra(ethylene glycol) (meth)acrylate, ethylene glycol methyl ether (meth)acrylate, di(ethylene glycol) methyl ether (meth)acrylate, tri(ethylene glycol) methyl ether (meth)acrylate, tetra(ethylene glycol) methyl ether (meth)acrylate, and combinations thereof,

wherein the phosphorylcholine-containing vinylic monomer is selected from the group consisting of (meth)acryloylox-yethyl phosphorylcholine, (meth)acryloyloxypropyl phosphorylcholine, 4-((meth)acryloyloxy)butyl-2'-(trimethylammonio)ethylphosphate, 2-[(meth)acryloylamino] ethyl-2'-(trimethylammonio)-ethylphosphate, 3-[(meth)acryloyl-amino]propyl-2'-(trimethylammonio)ethylphosphate, 4-[(meth)acryloylamino]butyl-2'-(trimethylammonio) ethylphosphate, 5-((meth)acryloyloxy)pentyl-2'-

(trimethylammonio)ethyl phosphate, 6-((meth)acryloyloxy)hexyl-2'-(trimethylammonio)-ethylphosphate, 2-((meth)acryloyloxy) ethyl-2'-(triethylammonio)ethylphosphate, 2-((meth)acryloyloxy)ethyl-2'-(tripropylammonio)ethylphosphate, 2-((meth)acryloyloxy)ethyl-2'-(tributylammonio)ethyl phosphate, 2-((meth)acryloyloxy)propyl-2'-(trimethylammonio)-ethylphosphate, 2-((meth)acryloyloxy)butyl-2'-(trimethylammonio)ethylphosphate, 2-((meth)acryloyloxy) pentyl-2'-(trimethylammonio)ethylphosphate, 2-((meth)acryloyloxy)hexyl-2'-(trimethyl-ammonio)ethyl phosphate, 2-(vinyloxy)ethyl-2'-(trimethylammonio)ethyl-phosphate, 2-(allyloxy)ethyl-2'-(trimethylammonio)ethylphosphate, 2-(vinyloxycarbonyl) ethyl-2'-(trimethylammonio)ethyl phosphate, 2-(allyloxycarbonyl)ethyl-2'-(trimethylammonio)-ethylphosphate, 2-(vinylcarbonylamino)ethyl-2'-(trimethylammonio) ethylphosphate, 2-(allyloxycarbonylamino)ethyl-2'-(trimethylammonio)ethyl phosphate, 2-(butenoyloxy)ethyl-2'-(trimethylammonio)ethylphosphate, and combinations thereof.

5. The hydrogel ocular insert of claim 4, wherein said at least one acrylic monomer is n-butyl (meth)acrylate and/or di(ethylene glycol) methyl ether (meth)acrylate.
6. The hydrogel ocular insert of any one of claims 1 to 5, wherein the arylborono groups independent of one another have a pKa of from 7.2 to 9.0, wherein said at least one arylborono-containing hydrophilic copolymer has a number average molecular weight of from 5,000 Daltons to 500,000 Daltons.
7. The hydrogel ocular insert of any one of claims 1 to 6, wherein said at least one mucoadhesive polymer comprises a galactomannan polymer, dextran, mannan, hyaluronic acid, polyvinyl alcohol.
8. The hydrogel ocular insert of any one of claims 1 to 6, wherein said at least one mucoadhesive polymer comprises a guar and/or a chemically-modified galactomannan selected from the group consisting of Hydroxyethyl guar, hydroxypropyl guar, methyl guar, ethyl guar, propyl guar, carboxymethyl guar, carboxymethylhydroxypropyl guar, hydroxypropyltrimonium chloride guar, and combinations thereof.
9. The hydrogel ocular insert of any one of claims 1 to 8, wherein said at least one mucoadhesive polymer is present in an amount of from 80% to 98% by weight relative to the dry weight of the hydrogel ocular insert.
10. The hydrogel ocular insert of any one of claims 1 to 9, wherein the hydrogel ocular insert is hydrolytically stable in an aqueous solution at a pH of from 7.5 to 9.5 and has an equilibrium water content of from 10% to 70% by weight at room temperature, 22°C to 28°C, when being fully hydrated.
11. The hydrogel ocular insert of any one of claims 1 to 10, wherein the hydrogel ocular insert has a layered structure and comprises a first hydrogel layer sandwiched between two second hydrogel layers, wherein the first hydrogel layer has a first crosslinking

density of first crosslinks and the second hydrogel layers have a second crosslinking density of second crosslinks, wherein the first crosslinking density is higher than the second crosslinking density and/or the first crosslinks hydrolyze more slowly than the second crosslinks in the tear of the eye.

12. The hydrogel ocular insert of any one of claims 1 to 11, wherein the hydrogel ocular insert comprises one or more additional pharmaceutical active agents.
13. The hydrogel ocular insert of claim 12, wherein said one or more additional pharmaceutical active agents are selected from the group consisting of ocular lubricants, anti-redness relievers, cooling agents, steroids and nonsteroidal anti-inflammatory agents to relieve ocular pain and inflammation, antibiotics, anti-histamines, anti-virals, antibiotics and anti-bacterials for infectious conjunctivitis, anti-muscarinics for myopia treatment, and glaucoma drugs, and therapeutically suitable combinations thereof.
14. The hydrogel ocular insert of claim 13, wherein the anti-redness relievers are brimonidine tartrate, tetrahydrozoline, naphazoline, wherein the cooling agents are menthol, wherein the anti-histamines are olopatadine, wherein the anti-muscarinics are atropine and derivatives thereof, wherein the glaucoma drugs are prostaglandin and prostaglandin analogs.