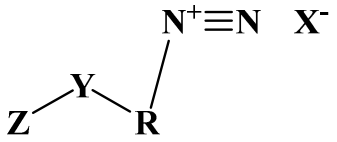
CLAIMS

1. An electroactive biocompatible polymer comprising a biocompatible polymer comprising a single strand of repeating units and up to 5,000 electroactive groups covalently attached to said strand, wherein ~~said electroactive polymer has a molecular weight~~precursors of ~~up to 3 million Daltons, and wherein~~ said electroactive groups are ~~derivatives~~selected from the group consisting of a diazonium~~,~~ derivative, an arylsulfonium~~, or~~ derivative, a diaryliodonium~~.~~ derivative, and combinations thereof;

~~2. The electroactive polymer according to claim 1,~~ wherein ~~said~~the biocompatible polymer is selected from the group consisting of ~~polyethylene glycol (PEG), PEG fatty acid esters,~~ poly-L-lactic acid (PLLA), poly(lactide-co-glycolide) (PLGA), poly caprolactone (PCL), polyvinyl pyrrolidone (PVP), polyvinyl alcohol (PVA), collagen, ~~chitosan,~~ hydroxy propyl cellulose, ~~polyamides,~~ polyglycerol esters of fatty acids, polysaccharides~~, polyesters~~, and combinations thereof.

~~3~~2. The electroactive biocompatible polymer according to claim ~~2~~1, wherein ~~said polysaccharide is~~the polysaccharides are selected from the group consisting of dextran, chitosan, heparin, hyaluronic acid, alginates, starch, glycogen, amylose, amylopectin, cellulose, ~~xylan, and numerous other natural and synthetic polysaccharides~~and xylan.

~~4~~3. The electroactive biocompatible polymer according to ~~any one of claims~~claim 1~~-3~~, wherein said diazonium derivative is a compound of the following formula:



wherein

X is an inorganic or organic anion selected from the group consisting of anions of F^-, Cl^-, Br^-, I^-, BF_4^-, BF_3, $ZnCl_2$, HSO_4^-, PF_6, $HgBr_2$, $HgBr_2Cl_2$, NO_3^-, nonafluoro-1-butanesulfonate, trifluoromethanesulfonate, dimethoxy-2-anthracenesulfonate, and methylbenzenesulfonate;

R is a bond ~~or~~, 5-7 membered saturated cyclic ~~or~~ ring, 5-7 membered heterocyclic~~,~~ ring, 5-7 membered aromatic ~~or~~ring or 5-7 membered heteroaromatic ring, each of which is

unsubstituted ~~or,~~ mono-, di- or tri- substituted with:

C_1-C_8 straight-chain ~~or~~ alkyl group, C_3-C_8 branched-chain alkyl group, C_2-C_8 straight-chain ~~or branched~~ alkenyl ~~or~~group, C_3-C_8 branched-chain alkenyl group, C_2-C_8 straight-chain alkynyl group, C_3-C_8 branched-chain alkynyl group, or phenyl group substituted at any ring position with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, phenyl ring or heterocyclic ring, each of which ~~may be~~is optionally substituted with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, C_1-C_8 alkoxy group, C_1-C_8 alkoxycarbonyl group, carboxyl group, hydroxyl group, nitro group, halogen atom or amino group, each of which is optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

methyl group substituted with 1-3 halogen atoms;

amino group optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

thiol or thioether group having the same or a different C_1-C_8 straight-chain ~~or branched~~ alkyl group~~;~~ or C_3-C_8 branched-chain alkyl group;

sulfone or sulfate group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

nitro, cyano, halogen, hydroxy, carboxylic acid or sulfonic acid group; or

alkoxy or alkoxycarbonyl group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

Y is a bond ~~or,~~ saturated ~~and unsaturated~~ C_1-C_{500} straight-chain ~~or~~ alkyl group, C_3-C_{500} branched ~~alkyl~~ chain alkyl group, unsaturated C_2-C_{500} straight-chain alkyl group, unsaturated C_3-C_{500} branched-chain alkyl group, alkenyl group or alkynyl group, wherein any of said ~~chain may~~C_1-C_{500} straight-chain alkyl group, C_3-C_{500} branched-chain alkyl group, unsaturated C_2-C_{500} straight-chain alkyl group, unsaturated C_3-C_{500} branched-chain alkyl group, alkenyl group or alkynyl group optionally ~~incorporate~~incorporates at least one hetero atom, and ~~may also comprise~~wherein any of said C_1-C_{500} straight-chain alkyl group, C_3-C_{500} branched-chain alkyl group, unsaturated C_2-C_{500} straight-chain alkyl group, unsaturated C_3-C_{500} branched-chain alkyl group, alkenyl group or alkynyl group optionally comprises at least one substituent; and

Z is any suitable functional group selected from the group consisting of halogen, amino, cyano, hydroxy, aldehyde, alkoxycarbonyl, N-amide, N-hydroxysuccinimide ester,

maleimide, and thiol.

~~5~~4. The electroactive biocompatible polymer according to claim ~~4~~3, wherein said diazonium derivative is 4-(dimethylamino)-benzene-diazonium salt;

2-chloro-benzene-diazonium salt;

1-naphthalene-diazonium salt;

4-anilino-benzene-diazonium salt;

3,5-dichloro-benzene-diazonium salt;

1-pyrene-diazonium salt;

4-methoxy-benzene-diazonium salt;

4-bromo-benzene-diazonium salt;

4-formyl-benzene-diazonium salt;

4-~~Nitro~~nitro-benzene-diazonium salt;

Fast Red TR salt;

Variamine blue B salt;

4-[ethyl(2-hydroxyethyl)amino]-benzene-diazonium salt;

4-(diethylamino)-2-methyl-benzene-diazonium salt;

4-(ethylamino)-3-methyl-benzene-diazonium salt;

5-chloro-2-methoxy-benzene-diazonium salt;

3-methyl-4-nitro-benzene-diazonium salt;

bis[4-(diethylamino)-2-methyl-benzene-diazonium] salt;

2,4-dichloro-benzene-diazonium salt;

2-methoxy-4-nitro-benzene-diazonium salt;

2-chloro-4-nitro-benzene-diazonium 2-naphthalenesulfonate salt;

2,5-diethoxy-4-[(4-methylphenyl)sulfanyl]benzenediazonium salt;

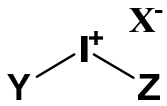
Fast Blue B salt;

9H-fluorene-2-diazonium salt;

9,10-dioxo-9,10-dihydro-1-anthracenediazonium salt; or

2-~~Methoxy~~methoxy-4-morpholinobenzenediazonium salt.

~~6~~5. The electroactive biocompatible polymer according to ~~any one of claims~~claim 1~~-3~~, wherein said diaryliodonium derivative is a compound of the following formula:



~~Wherein~~

wherein

X is an inorganic or organic anion selected from the group consisting of anion of F^-, Cl^-, Br^-, I^-, BF_4^-, BF_3, $ZnCl_2$, HSO_4^-, PF_6, $HgBr_2$, $HgBr_2Cl_2$, NO_3^-, nonafluoro-1-butanesulfonate, trifluoromethanesulfonate, dimethoxy-2-anthracenesulfonate, and methylbenzenesulfonate;

Y is a 5-7 membered saturated cyclic ~~or~~ ring, 5-7 membered heterocyclic~~,~~ ring, 5-7 membered aromatic ~~or~~ring or 5-7 membered heteroaromatic ring, each of which is unsubstituted ~~or~~, mono-, di- or tri- substituted with:

C_1-C_8 straight-chain ~~or~~ alkyl group, C_3-C_8 branched-chain alkyl group, C_2-C_8 straight-chain ~~or~~ alkenyl group, C_3-C_8 branched ~~alkenyl or~~ -chain alkenyl group, C_2-C_8 straight-chain alkynyl group, C_3-C_8 branched-chain alkynyl group, or phenyl group substituted at any ring position with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, phenyl ring or heterocyclic ring, each of which ~~may be~~is optionally substituted with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, C_1-C_8 alkoxy group, C_1-C_8 alkoxycarbonyl group, carboxyl group, hydroxyl group, nitro group, halogen atom or amino group, each of which is optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

methyl group substituted with 1-3 halogen atoms;

amino group optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

thiol or thioether group having the same or a different C_1-C_8 straight-chain ~~or branched~~ alkyl group~~;~~ or C_3-C_8 branched-chain alkyl group;

sulfone or sulfate group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

nitro, cyano, halogen, hydroxy, carboxylic acid or sulfonic acid group; or

alkoxy or alkoxycarbonyl group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group; and

Z is a 5-7 membered saturated cyclic ~~or~~ ring, 5-7 membered heterocyclic~~,~~ ring, 5-7

membered aromatic ~~or~~ring or 5-7 membered heteroaromatic ring, each of which is unsubstituted ~~or,~~ mono-, di- or tri- substituted with:

C_1-C_8 straight-chain ~~or~~ alkyl group, C_3-C_8 branched-chain alkyl group, C_2-C_8 straight-chain ~~or~~ alkenyl group, C_3-C_8 branched-chain alkenyl ~~or~~group, alkynyl group, or phenyl group substituted at any ring position with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, phenyl ring or heterocyclic ring, each of which ~~may be~~is optionally substituted with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, C_1-C_8 alkoxy group, C_1-C_8 alkoxycarbonyl group, carboxyl group, hydroxyl group, nitro group, halogen atom or amino group, each of which is optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

methyl group substituted with 1-3 halogen atoms;

amino group optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

thiol or thioether group having the same or a different C_1-C_8 straight-chain ~~or branched~~ alkyl group~~;~~ or C_3-C_8 branched-chain alkyl group;

sulfone or sulfate group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

nitro, cyano, halogen, hydroxy, carboxylic acid or sulfonic acid group; or

alkoxy or alkoxycarbonyl group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group.

~~7~~6. The electroactive biocompatible polymer according to claim ~~6~~5, wherein said diaryliodonium derivative is ~~Diphenyliodonium~~diphenyliodonium iodide salt;

bis(4-methoxyphenyl)iodonium salt;

bis(4-methylphenyl)iodonium salt;

bis(4-tert-butylphenyl)iodonium salt;

4-(phenyliodonio)benzoate salt;

bis(4-fluorophenyl)iodonium salt;

bis(4-bromophenyl)iodonium salt;

bis(4-tert-butylphenyl)iodonium salt;

mesityl(4-methylphenyl)iodonium salt;

2-(phenyliodonio)benzoate salt;

2-(phenyliodonio)benzoate;

(4-nitrophenyl)(phenyl)iodonium;

phenyl[3-(trifluoromethyl)phenyl]iodonium salt;

(3-bromophenyl)(mesityl)iodonium salt;

(2-bromophenyl)(mesityl)iodonium salt;

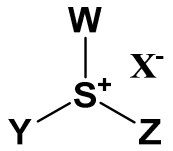
mesityl[3-(trifluoromethyl)phenyl]iodonium salt;

mesityl(4-nitrophenyl)iodonium salt;

~~Diphenyleneiodonium~~diphenyleneiodonium salt; or

3,7-dinitrodibenziodolium salt.

~~8~~7. The electroactive biocompatible polymer according to ~~any one of claims~~claim 1~~-3~~, wherein said arylsulfonium derivative is a compound of the following formula:



~~Wherein~~

wherein

X is an inorganic or organic anion selected from the group consisting of anion of F^-, Cl^-, Br^-, I^-, BF_4^-, BF_3, $ZnCl_2$, HSO_4^-, PF_6, $HgBr_2$, $HgBr_2Cl_2$, NO_3^-, nonafluoro-1-butanesulfonate, trifluoromethanesulfonate, dimethoxy-2-anthracenesulfonate, and methylbenzenesulfonate;

Y is a bond, C_1-C_8 straight-chain ~~or branched~~ alkyl group, ~~or~~ C_3-C_8 branched-chain alkyl group, 5-7 membered saturated cyclic ~~or~~ring, 5-7 membered heterocyclic~~,~~ ring, 5-7 membered aromatic ~~or~~ring or 5-7 membered heteroaromatic ring, each of which is unsubstituted ~~or,~~ mono-, di- or tri- substituted with:

C_1-C_8 straight-chain ~~or~~ alkyl group, C_3-C_8 branched-chain alkyl group, C_2-C_8 straight-chain ~~or~~alkenyl group, C_3-C_8 branched ~~alkenyl or~~ -chain alkenyl group, C_2-C_8 straight-chain alkynyl group, C_3-C_8 branched-chain alkynyl group, or phenyl group substituted at any ring position with one or more the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group, phenyl ring or heterocyclic ring, each of which ~~may be~~is optionally substituted with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, C_1-C_8 alkoxy group, C_1-C_8 alkoxycarbonyl group, carboxyl group, hydroxyl group, nitro group, halogen atom or amino group optionally mono

or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

methyl group substituted with 1-3 halogen atoms;

amino group optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

thiol or thioether group having the same or a different C_1-C_8 straight-chain ~~or branched~~ alkyl group~~;~~ or C_3-C_8 branched-chain alkyl group;

sulfone or sulfate group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

nitro, cyano, halogen, hydroxy, carboxylic acid or sulfonic acid group; or

alkoxy or alkoxycarbonyl group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

Z is a bond, C_1-C_8 straight-chain ~~or branched~~ alkyl group, ~~or~~ C_3-C_8 branched-chain alkyl group, 5-7 membered saturated cyclic ~~or~~ring, 5-7 membered heterocyclic~~,~~ ring, 5-7 membered aromatic ~~or~~ring or 5-7 membered heteroaromatic ring, each of which is unsubstituted ~~or,~~ mono-, di- or tri- substituted with:

C_1-C_8 straight-chain ~~or~~ alkyl group, C_3-C_8 branched-chain alkyl group, C_2-C_8 straight-chain ~~or~~alkenyl group, C_3-C_8 branched ~~alkenyl or~~-chain alkenyl group, C_2-C_8 straight-chain alkynyl group, C_3-C_8 branched-chain alkynyl group, or phenyl group substituted at any ring position with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, phenyl ring or heterocyclic ring, each of which ~~may be~~is optionally substituted with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, C_1-C_8 alkoxy group, C_1-C_8 alkoxycarbonyl group, carboxyl group, hydroxyl group, nitro group, halogen atom or amino group, each of which is optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

methyl group substituted with 1-3 halogen atoms;

amino group optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain ~~or branched~~ alkyl group~~;~~ or C_3-C_8 branched-chain alkyl group;

thiol or thioether group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

sulfone or sulfate group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

nitro, cyano, halogen, hydroxy, carboxylic acid or sulfonic acid group; or

alkoxy or alkoxycarbonyl group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group; and

W is a bond, C_1-C_8 straight-chain ~~or~~ alkyl group, C_3-C_8 branched-chain alkyl group, ~~or~~ 5-7 membered saturated cyclic ~~or~~ring, 5-7 membered heterocyclic~~,~~ ring, 5-7 membered aromatic ~~or~~ring or 5-7 membered heteroaromatic ring, each of which is unsubstituted~~ or~~, mono-, di- or tri- substituted with:

C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, C_2-C_8 straight-chain ~~or~~alkenyl group, C_3-C_8 branched~~-alkenyl or~~-chain alkenyl group, C_2-C_8 straight-chain alkynyl group, C_3-C_8 branched-chain alkynyl group, or phenyl group substituted at any ring position with one or more the same or different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, phenyl ring or heterocyclic ring, each of which ~~may be~~is optionally substituted with one or more the same or a different C_1-C_8 straight-chain ~~or~~alkyl group, C_3-C_8 branched-chain alkyl group, C_1-C_8 alkoxy group, C_1-C_8 alkoxycarbonyl group, carboxyl group, hydroxyl group, nitro group, halogen atom or amino group, each of which is optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

methyl group substituted with 1-3 halogen atoms;

amino group optionally mono or di-substituted with the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

thiol or thioether group having the same or a different C_1-C_8 straight-chain ~~or branched~~ alkyl group~~;~~ or C_3-C_8 branched-chain alkyl group;

sulfone or sulfate group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

nitro, cyano, halogen, hydroxy, carboxylic acid or sulfonic acid group; or

alkoxy or alkoxycarbonyl group having the same or a different C_1-C_8 straight-chain alkyl group or C_3-C_8 branched-chain alkyl group;

wherein at least two of **W**, **Y** and **Z** are not a bond, C_1-C_8 straight-chain ~~or branched~~ alkyl group~~.~~ or C_3-C_8 branched-chain alkyl group.

~~9~~8. The electroactive biocompatible polymer according to claim ~~8~~7, wherein said arylsulfonium derivative is ~~Triphenylsulfonium~~triphenylsulfonium salt;

diphenyl[4-(phenylsulfanyl)phenyl]sulfonium salt;

(4-fluorophenyl)(diphenyl)sulfonium salt;
tris(4-tert-butylphenyl)sulfonium salt;
tris(4-chlorophenyl)sulfonium salt;
(4-chlorophenyl)diphenylsulfonium salt;
tri-p-tolylsulfonium salt;
tris(4-methoxyphenyl)sulfonium salt;
(4-methoxyphenyl)diphenylsulfonium salt;
ethyl(4-methoxyphenyl)(phenyl)sulfonium salt;
(3-chloropropyl)diphenylsulfonium salt; or
(5-chloropentyl)diphenylsulfonium salt.

9. The electroactive biocompatible polymer according to claim 1, wherein the electroactive biocompatible polymer forms covalent crosslinking groups thereon once the electroactive biocompatible polymer is activated with a voltage potential ranging from negative 10 Volts to positive 10 Volts.

10. The electroactive biocompatible polymer according to claim 1, wherein the electroactive biocompatible polymer forms covalent crosslinking groups thereon once the electroactive biocompatible polymer is activated with a voltage potential applied constantly.

11. The electroactive biocompatible polymer according to claim 1, wherein the electroactive biocompatible polymer forms covalent crosslinking groups thereon once the electroactive biocompatible polymer is activated with a voltage potential applied variably.

12. The electroactive biocompatible polymer according to claim 1, wherein the diazonium derivative, arylsulfonium derivative, diaryliodonium derivative, and combinations thereof comprise Cl^-, Br^-, I^-, trifluoromethanesulfonate, dimethoxy-2-anthracenesulfonate, or methylbenzenesulfonate.

~~10. An electroactive bioadhesive composition comprising the electroactive polymer of any one of claims 1-9 and suitable solvents, surfactants, stabilizers, fillers and other additives.~~

11. The composition according to claim 10, wherein said additives are anti inflammatory drugs, anti proteases, antibiotics, or anti restenosis compounds.

12. The composition according to claim 10 or 11, wherein said composition is in a form of hydrogel.

13. The composition according to claim 10 or 11, wherein said composition is in a form of biocompatible film, patch or bondage.

14. The composition according to any one of claims 10-13, further comprising conductive particles or polymers of less than 50 micron comprised of gold, iron, iron oxides, platinum, magnesium, graphene, carbon black, carbon nanotubes, polyacetylene, poly(3-alkyl-thiophene), polyaniline, polyisothianaphthalene, poly-(p-phenylene), poly-(p-phenylene vinylene), polypyrole, polythiophene, or combinations thereof.

15. The composition according to 14, wherein said composition is electrically conductive with conductivity greater than 0.01 siemen per centimeter.

16. The composition according to 14, wherein the conductive particles are coated with anionic or cationic coating comprising fatty acids, silica, polyethylene glycol, pluronics, poloxamers, polydopamine, polylysine or any suitable peptide.

17. The composition according to claim 14, wherein said conductive particles are coated with anionic or cationic coating.

18. The composition according to any one of claims 10-17 for use in surgery, such as gastrointestinal surgery towards cancer removal, anastomoses procedures, such as blood vessel anastomoses wherein two tubes or lumens must be joined, tissue fixation, suture sealing and replacement, treatment of lung punctures, body lumen punctures or leaks, cerebrospinal fluid membrane damages, obesity treatments, and bowel obstructions.

19. A method for the preparation of the electroactive polymer of any one of claims 1-9, comprising the steps of:

(a) Preparing a solution of said biocompatible polymer having concentration of 0.1 to

100 mg/ml at pH 7.2;

(b) Dissolving said diazonium, arylsulfonium, or diaryliodonium derivative in a suitable organic solvent within the concentration range of 0.01 to 100 mM;

(c) Mixing and reacting the solution of said biocompatible polymer prepared in a) with the solution of the derivative prepared in b), in order to covalently attach the derivative to the polymer strand that is in the form of a thin film on a conductive material;

(d) Purifying said polymer modified in c) on a Sephadex G-25 column or using other conventional purification and separation techniques in order to remove the unbound derivative molecules.

20. Method of tissue fixation comprising the steps of:

(a) Applying the electroactive bioadhesive composition of any one of claims 10-18 to a tissue to be fixed; and

(b) Activation of a voltage potential applied to an electrode on which the electroactive polymer is placed, across the composition and tissue area with negative 10 to positive 10 Volts vs. a reference electrode that can be of any type such as Ag/AgCl or Ag wire or any other electrode that has a constant potential, which depends on the composition, in an electrolyte having a concentration of between 0.01 and 1 M.

21. The method according to claim 20, wherein the applied voltage is between negative 10 and positive 10 Volts, time of applied voltage is less than 20 minutes.

22. The method according to claim 20, wherein the application of voltage potential is in the form of a constant or variable potential including AC.