Claims

What is claimed is:

1. A formulation comprising:

(i) at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,

(ii) at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;

(iii) at least one chelating agent; and

(iv) water.

~~**2.** A formulation consisting essentially of:~~

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;~~

~~**(iii)** at least one chelating agent; and~~

~~**(iv)** water.~~

~~**3.** A formulation consisting of:~~

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;~~

~~**(iii)** at least one chelating agent; and~~

~~**(iv)** water.~~

42. ~~A~~ The formulation of claim 1 further comprising:

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately12.~~

~~**(iii)** at least one chelating agent;~~

~~**(iv)** water; and~~

(v) at least one water miscible solvent.

~~**5.** A formulation consisting essentially of:~~

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;~~

~~**(iii)** at least one chelating agent;~~

~~**(iv)** water; and~~

~~**(v)** at least one water miscible solvent.~~

~~**6.** A formulation consisting of:~~

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;~~

~~**(iii)** at least one chelating agent;~~

~~**(iv)** water; and~~

~~**(v)** at least one water miscible solvent.~~

~~7~~**3.** ~~A~~ The formulation of claim 1 further comprising:

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;~~

~~**(iii)** at least one chelating agent;~~

~~**(iv)** water;~~

(v) at least one water miscible solvent; and

(vi) at least one wettability adjusting material.

~~**8.** A formulation consisting essentially of:~~

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;~~

~~**(iii)** at least one chelating agent;~~

~~**(iv)** water;~~

~~**(v)** at least one water miscible solvent; and~~

~~**(vi)** at least one wettability adjusting material.~~

~~**9.** A formulation consisting of:~~

~~**(i)** at least one alkanolamine having at least two carbon atoms, at least one amino substituent and at least one hydroxyl substituent with the amino and hydroxyl substituents attached to two different carbon atoms,~~

~~**(ii)** at least one pH adjuster for adjusting the pH of the formulation to between approximately 9 and approximately 12;~~

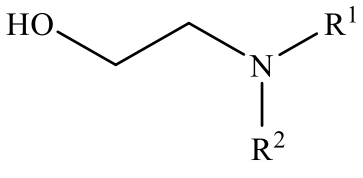
~~**(iii)** at least one chelating agent;~~

~~**(iv)** water;~~

~~**(v)** at least one water miscible solvent; and~~

~~**(vi)** at least one wettability adjusting material.~~

~~**10**~~**4.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one alkanolamine comprises a compound of formula (I):



(I)

wherein each of R^1 and R^2 is independently selected from H, an unsubstituted C_1-C_6 alkyl, a substituted C_1-C_6 alkyl, a branched C_3-C_6 alkyl and a C_1-C_6 alkylamino.

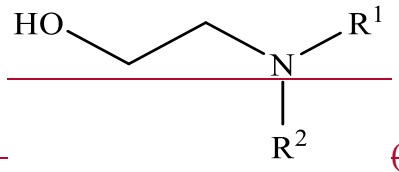
~~**11.** The formulation of any of claims 1-9, wherein the at least one alkanolamine consists essentially of a compound of formula (I):~~



~~(I)~~

~~wherein each of R^1 and R^2 is independently selected from H, an unsubstituted C_1-C_6 alkyl, a substituted C_1-C_6 alkyl, a branched C_3-C_6 alkyl and a C_1-C_6 alkylamino.~~

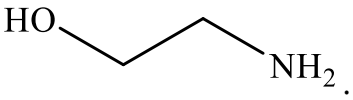
~~**12.** The formulation of any of claims 1-9, wherein the at least one alkanolamine consists of a compound of formula (I):~~



~~(I)~~

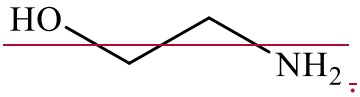
~~wherein each of R^1 and R^2 is independently selected from H, an unsubstituted C_1-C_6 alkyl, a substituted C_1-C_6 alkyl, a branched C_3-C_6 alkyl and a C_1-C_6 alkylamino.~~

~~13~~**5.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one alkanolamine comprises



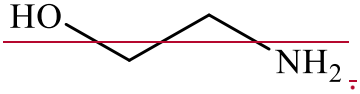
.

~~**14.** The formulation of any of claims 1-9, wherein the at least one alkanolamine consists essentially of~~



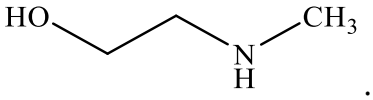
~~.~~

~~**15.** The formulation of any of claims 1-9, wherein the at least one alkanolamine consists of~~



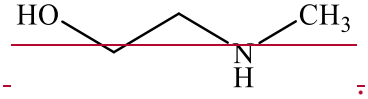
~~.~~

~~16~~**6.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one alkanolamine comprises



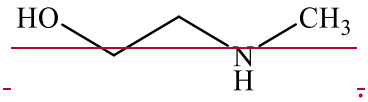
.

~~**17.** The formulation of any of claims 1-9, wherein the at least one alkanolamine consists essentially of~~

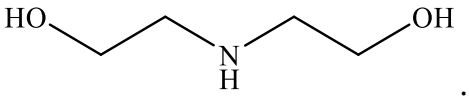


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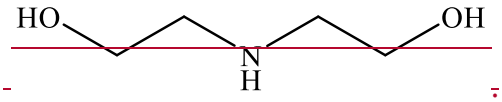
~~**18.** The formulation of any of claims 1-9, wherein the at least one alkanolamine consists of~~



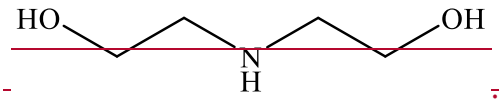
~~19~~7. The The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one alkanolamine comprises



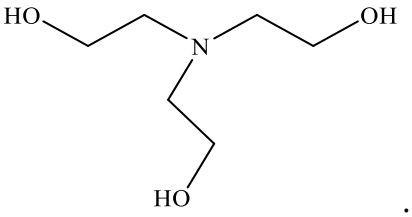
~~20. The formulation of any of claims 1-9, wherein the at least one alkanolamine consists essentially of~~



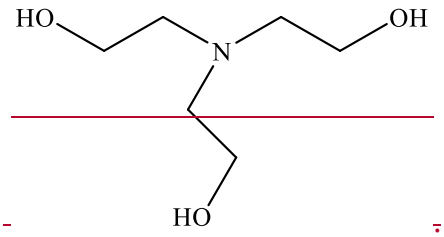
~~21. The formulation of any of claims 1-9, wherein the at least one alkanolamine consists of~~



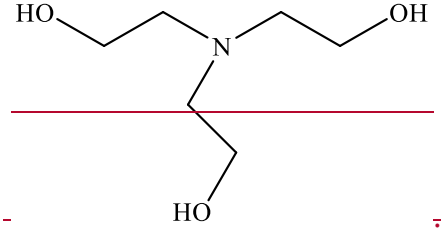
~~22~~8. The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one alkanolamine comprises



~~23. The formulation of any of claims 1-9, wherein the at least one alkanolamine consists essentially of~~



~~24. The formulation of any of claims 1-9, wherein the at least one alkanolamine consists of~~



~~25~~**9.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one pH adjuster comprises one or more of citric acid, sulfuric acid, phosphoric acid, oxalic acid, malonic acid, lactic acid, adipic acid, acetic acid, trifluoroacetic acid, methanesulfonic acid, toluenesulfonic acid, and halogen acids of the formula H-X where X = F, Cl, Br, or I.

~~26~~**10.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one pH adjuster comprises hydrofluoric acid.

~~**27. The formulation of any of claims 1-9, wherein the at least one pH adjuster consists essentially of hydrofluoric acid.**~~

~~**28. The formulation of any of claims 1-9, wherein the at least one pH adjuster consists of hydrofluoric acid.**~~

~~29~~**11.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one pH adjuster comprises methanesulfonic acid.

~~**30. The formulation of any of claims 1-9, wherein the at least one pH adjuster consists essentially of methanesulfonic acid.**~~

~~**31. The formulation of any of claims 1-9, wherein the at least one pH adjuster consists of methanesulfonic acid.**~~

~~32~~**12.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one chelating agent is one or more of ethylenediaminetetraacetic acid (EDTA), butylenediaminetetraacetic acid, (1,2-cyclohexylenediamine)tetraacetic acid (CyDTA), diethylenetriaminepentaacetic acid (DETPA), ethylenediaminetetrapropionic acid, (hydroxyethyl)ethylenediaminetriacetic acid (HEDTA), N, N, N', N'-ethylenediaminetetra(methylenephosphonic) acid (EDTMP), triethylenetetraminehexaacetic acid (TTHA), 1,3-diamino-2-hydroxypropane-N,N,N',N'-tetraacetic acid (DHPTA), iminodiacetic acid, methyliminodiacetic acid, propylenediaminetetraacetic acid, nitrotriacetic acid (NTA), citric acid, tartaric acid, gluconic acid, saccharic acid, glyceric acid, oxalic acid, phthalic acid, maleic acid, mandelic acid, malonic acid, lactic acid, salicylic acid, propyl gallate, pyrogallol, 8-hydroxyquinoline, and cysteine.

~~33~~**13.** The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one chelating agent comprises EDTA.

~~**34. The formulation of any of claims 1-9, wherein the at least one chelating agent consists essentially of EDTA.**~~

~~**35. The formulation of any of claims 1-9, wherein the at least one chelating agent consists of EDTA.**~~

~~36~~14. The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one chelating agent comprises CyDTA.

~~**37.** The formulation of any of claims 1-9, wherein the at least one chelating agent consists essentially of CyDTA.~~

~~**38.** The formulation of any of claims 1-9, wherein the at least one chelating agent consists of CyDTA.~~

~~39~~15. The formulation of ~~any of claims 1-9~~ claim 1, wherein the at least one chelating agent comprises iminodiacetic acid.

~~**40.** The formulation of any of claims 1-9, wherein the at least one chelating agent consists essentially of iminodiacetic acid.~~

~~**41.** The formulation of any of claims 1-9, wherein the at least one chelating agent consists of iminodiacetic acid.~~

~~**42.** The formulation of any of claims 1-9, wherein the at least one chelating agent comprises about 0.1 wt. % of EDTA.~~

~~**43.** The formulation of any of claims 1-9, wherein the at least one chelating agent consists essentially of about 0.1 wt. % of EDTA.~~

~~**44.** The formulation of any of claims 1-9, wherein the at least one chelating agent consist of about 0.1 wt. % of EDTA.~~

~~**45.** The formulation of any of claims 1-9, wherein the at least one chelating agent comprises about 0.1 wt. % of iminodiacetic acid.~~

~~**46.** The formulation of any of claims 1-9, wherein the at least one chelating agent consists essentially of about 0.1 wt. % of iminodiacetic acid.~~

~~**47.** The formulation of any of claims 1-9, wherein the at least one chelating agent consists of about 0.1 wt. % of iminodiacetic acid.~~

~~48~~16. The formulation of ~~any of claims 4-9~~ claim 4, wherein the at least one water miscible solvent comprises one or more of ethylene glycol, propylene glycol (PG), 1,4-butanediol, tripropylene glycol methyl ether, propylene glycol propyl ether, diethylene gycol n-butyl ether (BDG), dipropylene glycol methyl ether (DPM), hexyloxypropylamine, poly(oxyethylene)diamine, dimethyl sulfoxide (DMSO), tetrahydrofuran, tetrahydrofurfuryl alcohol, glycerol, alcohols, sulfolane, sulfoxides, and mixtures thereof.

~~**49.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises one or more of propylene glycol, sulfolane and diethylene glycol butyl ether.~~

~~**50.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises propylene glycol.~~

~~**51.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises sulfolane.~~

~~**52.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises diethylene glycol butyl ether.~~

~~**53.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent consists essentially of propylene glycol.~~

~~**54.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent consists essentially of sulfolane.~~

~~**55.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent consists essentially of diethylene glycol butyl ether.~~

~~**56.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent consists of propylene glycol.~~

~~**57.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent consists of sulfolane.~~

~~**58.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent consists of diethylene glycol butyl ether.~~

~~59~~**17.** The formulation of ~~any of claims 4-9~~ claim 4, wherein the at least one water miscible solvent comprises from about 10 wt. % to about 20 wt. % of propylene glycol.

~~**60.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises from about 15 wt. % to about 20 wt. % of propylene glycol.~~

~~**61.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises about 20 wt. % of propylene glycol.~~

~~**62.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises from about 10 wt. % to about 20 wt. % of sulfolane.~~

~~**63.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises from about 15 wt. % to about 20 wt. % of sulfolane.~~

~~**64.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises about 20 wt. % of sulfolane.~~

~~65~~**18.** The formulation of ~~any of claims 4-9~~ claim 1, wherein the at least one water miscible solvent comprises from about 10 wt. % to about 20 wt. % of diethylene glycol butyl ether.

~~**66.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises from about 15 wt. % to about 20 wt. % of diethylene glycol butyl ether.~~

~~**67.** The formulation of any of claims 4-9, wherein the at least one water miscible solvent comprises about 20 wt. % of diethylene glycol butyl ether.~~

~~**68.** The formulation of any of claims 7-9, wherein the at least one wettability adjusting material comprises a surfactant.~~

~~**69.** The formulation of any of claims 7-9, wherein the at least one wettability adjusting material consist essentially of a surfactant.~~

~~**70.** The formulation of any of claims 7-9, wherein the at least one wettability adjusting material consists of a surfactant.~~

~~**71**~~**19.** The formulation of ~~any of claims 1-70~~ claim 1, wherein the formulation has a copper etching rate of greater than ~~that~~ approximately 50Å/minute and a cobalt etching rate of greater than ~~that~~ approximately 50Å/minute when copper and cobalt are coupled.

~~**72**~~**20.** The formulation of ~~any of claims 1-70~~ claim 1, wherein the formulation has a copper to cobalt etching rate ratio of approximately 0.9 to approximately 2.25 when copper and cobalt are coupled.

~~**73.** The formulation of any of claims 1-70, wherein the formulation has a copper to cobalt etching rate ratio of approximately 1.0 to approximately 2.20 when copper and cobalt are coupled.~~

~~**74.** The formulation of any of claims 1-70, wherein the formulation has a copper to cobalt etching rate ratio of approximately 0.95 to approximately 1.25 when copper and cobalt are coupled.~~

~~**75.** The formulation of any of claims 1-70, wherein the formulation has a copper to cobalt etching rate ratio of approximately 0.95 to approximately 1.1 when copper and cobalt are coupled.~~

~~**76.** The formulation of any of claims 1-70, wherein the formulation has a copper to cobalt etching rate ratio of approximately 1.0 to approximately 1.1 when copper and cobalt are coupled.~~

~~**77**~~**21.** The formulation of ~~any of claims 1-70~~ claim 1, wherein the formulation has a copper to cobalt etching rate ratio of approximately 1.0 when copper and cobalt are coupled.

~~**78.** The formulation of any of claims 1-70, wherein (i) the formulation has a copper etching rate of greater that approximately 50Å/minute and a cobalt etching rate of greater that approximately 50Å/minute when copper and cobalt are coupled and (ii) the formulation has a copper to cobalt etching rate ratio of approximately 0.95 to approximately 1.25 when copper and cobalt are coupled.~~

~~**79.** The formulation of any of claims 1-70, wherein (i) the formulation has a copper etching rate of greater that approximately 50Å/minute and a cobalt etching rate of greater that approximately~~

~~50Å/minute when copper and cobalt are coupled and (ii) the formulation has a copper to cobalt etching rate ratio of approximately 0.95 to approximately 1.1 when copper and cobalt are coupled.~~

~~**80.** The formulation of any of claims 1-70, wherein (i) the formulation has a copper etching rate of greater that approximately 50Å/minute and a cobalt etching rate of greater that approximately 50Å/minute when copper and cobalt are coupled and (ii) the formulation has a copper to cobalt etching rate ratio of approximately 1 when copper and cobalt are coupled.~~

~~**81**~~**22.** A method of etching a substrate comprising copper and cobalt, the method comprising:

(i) applying a composition comprising the formulation ~~any~~ of ~~claims 1-80~~ claim 1 onto the substrate.