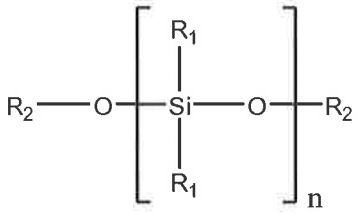
CLAIMS

We claim:

1. An epoxy-polysiloxane polymer coating composition comprising:

water;

a polysiloxane having the formula

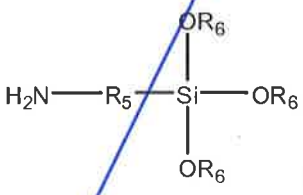


where each R_1 is independenly a hydroxy group or alkyl, aryl, or alkoxy group having up to six carbon atoms, each R_2 is independently hydrogen, or an alkyl or aryl group having up to six carbon atoms, and n is selected so that the molecular weight for the polysiloxane is 400 to 10,000;

a non-aromatic epoxide resin having more than one 1,2-epoxide group per molecule with an epoxide equivalent weight of 100 to 5,000; and

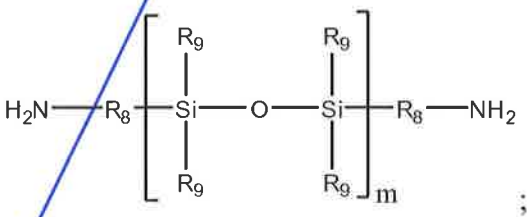
a cure system comprising a blend comprising at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin, where the blend has an alkoxy content of 10% by weight to 25% by weight.

2. The coating composition of claim 1, wherein the trialkoxy functional aminosilane has a general formula



; and

the amino functional polysiloxane resin has a general formula



;

where R_5 is a difunctional organic radical selected from aryl, an alkyl, an dialkylaryl, an alkoxyalkyl, an alkylaminoalkyl, or a cycloalkyl radical, each R_6 is independently an alkyl,

a hydroxyalkyl, an alkoxyalkyl, or a hydroxyalkoxyalkyl group containing less than six carbon atoms, each R_8 is a difunctional organic radical independently selected from an aryl, alkyl, dialkylaryl, alkoxyalkyl, alkylaminoalkyl, or cycloalkyl radical, each R_9 is independently an aryl, phenyl, $(C_1$-$C_4)$alkyl, $(C_1$-$C_4)$alkoxy, or $-OSi(R_9)_2R_8NH_2$ group, and m is selected so that the blend has an amine equivalent weight ranging from 112 to 250 g/NH.

3. The composition of claim 2, wherein R_5 is a difunctional organic radical selected from $(C_1$-$C_6)$alkyl or $(C_1$-$C_6)$alkylamino$(C_1$-$C_6)$alkyl groups and each R_6 is independently a $(C_1$-$C_6)$alkyl group.

4. The composition of claim 1, wherein the at least one trialkoxy functional aminosilane comprises aminopropyltrimethoxysilane, aminopropyltriethoxysilane, aminopropyltripropoxysilane, aminoneohexyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltriethoxysilane, N-phenylaminopropyl trimethoxysilane, trimethoxysilylpropyl diethylene triamine, 3-(3-aminophenoxy)propyl trimethoxysilane, aminoethyl aminomethyl phenyl trimethoxysilane, 2-aminoethyl-3-aminopropyl-tris-2-ethylhexoxysilane, N-aminohexyl aminopropyl trimethoxysilane, and/or trisaminopropyl trismethoxyethoxysilane

5. The composition of claim 1, wherein the at least one amino functional polysiloxane resin has a structure where R_9 includes greater than 70% of phenyl groups, less than 30% of $(C_1$-$C_4)$alkyl groups and less than 2.0% $(C_1$-$C_4)$alkoxy groups.

6. The composition of claim 5, wherein R_9 includes less than 0.5% of $(C_1$-$C_4)$alkoxy groups.

7. The composition of claim 1, wherein the at least one amino functional polysiloxane resin comprises an amino-functional phenyl methyl polysiloxane resin.

8. The composition of claim 7, wherein the at least one amino functional polysiloxane resin has an amine equivalent weight of 240 to 280 g/NH.

9. The composition of claim 1, wherein the cure system comprises 15% to 85% by weight of the at least one trialkoxy functional aminosilane and 85% to 15% of the at least one amino functional polysiloxane resin.

10. The composition of claim 1, wherein the cure system comprises a blend having an average alkoxy functionality value of 2.2 to 2.8.

11. The coating composition of claim 1, wherein the coating composition comprises from 20% to 80% by weight of the polysiloxane, from 20% to 80% by weight of the non-aromatic epoxy resin, and from 5% to 40% by weight of the cure system.

12 The coating compositions of claim 1, wherein the coating composition comprises a ratio of amine equivalents to epoxide equivalents ranging from 0.7:1.0 to 1.3:1.0.

13. The coating composition of claim 1, wherein the non-aromatic epoxide resin comprises a cycloaliphatic epoxide resins comprising a hydrogenated cyclohexane dimethanol or diglycidyl ether of a hydrogenated Bisphenol A epoxide resin.

14. The coating composition of claim 1, further comprising a flexible epoxy resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000.

15. The coating composition of claim 14, wherein the coating composition comprises up to 15% by weight of the flexible epoxy resin.

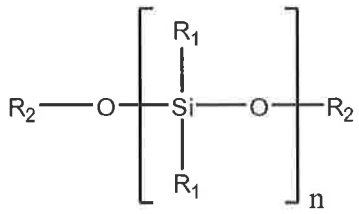
16. The coating composition of claim 1, further comprising up to 15% of a cure accelerator comprising a zinc, manganese, zirconium, titanium, cobalt, iron, lead, and/or tin catalyst, each in the form of octanoates, neodecanoates, or naphthanates.

17. The coating composition of claim 1, further comprising one or more corrosion inhibitor comprising zinc or phosphate based corrosion inhibitors or organic corrosion inhibitors.

18. An epoxy-polysiloxane polymer coating composition comprising:

water;

from 20% to 80% by weight of a polysiloxane having the formula



where each R_1 is independently a hydroxy group or an alkyl, aryl, or alkoxy group having up to six carbon atoms, each R_2 is independently hydrogen or an alkyl or aryl group having up to six carbon atoms, and n is selected so that the molecular weight for the polysiloxane is 400 to 10,000;

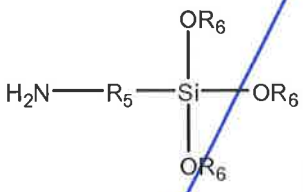
from 20% to 80% by weight of a non-aromatic epoxide resin comprising more than one 1,2-epoxide group per molecule and an epoxide equivalent weight of 100 to 5,000;

up to 15% by weight of a cure accelerator comprising a tin catalyst in the form of an octanoate, a dodecanoate or a naphthanate;

up to 15% by weight of a flexible epoxy resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000; and

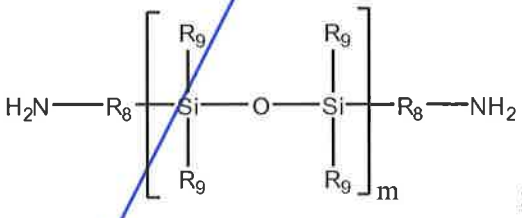
from 5% to 40% by weight of a cure system comprising a blend of at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin,

wherein the trialkoxy functional aminosilane has a general formula



; and

the amino functional polysiloxane resin has a general formula



;

where R_5 is a difunctional organic radical selected from an aryl, an alkyl, a dialkylaryl, an alkoxyalkyl, an alkylaminoalkyl, or a cycloalkyl radical, each R_6 is independently an alkyl, a hydroxyalkyl, an alkoxyalkyl, or a hydroxyalkoxyalkyl group containing less than six carbon atoms, each R_8 is a difunctional organic radical independently selected from an aryl, alkyl,

dialkylaryl, alkoxyalkyl, alkylaminoalkyl, or cycloalkyl radical, each R_9 is independently an aryl, phenyl, $(C_1\text{-}C_4)$alkyl, $(C_1\text{-}C_4)$alkoxy, or $-OSi(R_9)_2R_8NH_2$ group, and m is selected so that the blend has an amine equivalent weight of 112 to 250 g/NH, and where the blend has an average alkoxy functionality value of 2.2 to 2.8 and is added in an amount sufficient to provide an amine equivalent to epoxide equivalent of 0.7:1.0 to 1.3:1.0 in the coating composition.

19. The coating composition of claim 18, wherein each R_6 is independently a $(C_1\text{-}C_6)$alkyl group, R_5 is a $(C_1\text{-}C_6)$alkyl group or $(C_1\text{-}C_6)$alkylamino$(C_1\text{-}C_6)$alkyl group, and each R_9 is methyl or phenyl.

20. The coating composition of claim 18, wherein the at least one trialkoxy functional aminosilane comprises aminopropyltrimethoxysilane, aminopropyltriethoxysilane, aminopropyltripropoxysilane, aminoneohexyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltriethoxysilane, N-phenylaminopropyl trimethoxysilane, trimethoxysilylpropyl diethylene triamine, 3-(3-aminophenoxy)propyl trimethoxysilane, aminoethyl aminomethyl phenyl trimethoxysilane, 2-aminoethyl-3-aminopropyl-tris-2-ethylhexoxysilane, N-aminohexyl aminopropyl trimethoxysilane, and/or trisaminopropyl trismethoxyethoxysilane; and

the at least one amino functional polysiloxane resin is an amino functional phenyl methyl polysiloxane resin.

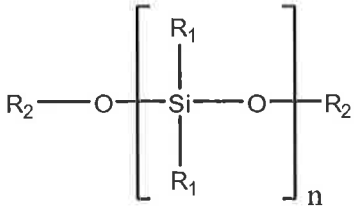
21. A coated substrate comprising at least one surface coated with the coating composition according to claim 1.

22. A method for protecting a surface of a substrate from the undesired effects of one or more of chemicals, corrosion and weather by coating the surface with a coating composition prepared by the method comprising:

preparing a resin component comprising:

water;

a polysiloxane having the formula



where each R_1 is a hydroxy group or an alkyl, aryl, or alkoxy group having up to six carbon atoms, each R_2 is hydrogen or an alkyl or aryl group having up to six carbon atoms, and where n is selected so that the molecular weight for the polysiloxane is 400 to 10,000;

a non-aromatic epoxide resin comprising more than one 1,2-epoxide group per molecule and an epoxide equivalent weight in the range of 100 to 5,000;

adding a cure system to the resin component to form a fully cured epoxy-modified polysiloxane coating composition, the cure system comprising:

a blend of at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin; and

optionally a cure accelerator comprising at least one metal catalyst,

where the blend has an average alkoxy functionality value of 2.2 to 2.8; and

applying the coating composition to the surface of a substrate to be protected before the coating composition becomes fully cured.

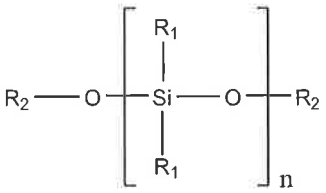
23. The coating composition of claim 22, wherein the resin component further comprises a flexible epoxy resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000.

CLAIMS

We claim:

1. An epoxy-polysiloxane polymer coating composition comprising: water;

a polysiloxane having the formula



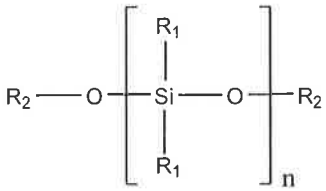
where (a) each R_1 is independently a hydroxy group, an alkyl group having up to six carbon atoms, an aryl group having up to six carbon atoms, or an alkoxy group having up to six carbon atoms, (b) each R_2 is independently hydrogen, or an alkyl group having up to six carbon atoms, or an aryl group having up to six carbon atoms, and (c) n is selected so that the molecular weight for the polysiloxane is in the range of 400 to 10,000;

a non-aromatic epoxide resin having more than one 1,2-epoxide group per molecule with an epoxide equivalent weight of 100 to 5,000; and

a cure system comprising a blend comprising at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin, where the blend has an alkoxy content of 10% by weight to 25% by weight.

2. An epoxy-polysiloxane polymer coating composition comprising: water;

from 20 to 80 percent by weight of a polysiloxane having the formula



where (a) each R_1 is independently a hydroxy group, an alkyl group having up to six carbon atoms, an aryl group having up to six carbon atoms, or an alkoxy group having up to six carbon atoms, (b) each R_2 is independently hydrogen, or an alkyl group having up to six carbon atoms, or an aryl group having up to six carbon atoms, and (c) n is selected so that the molecular

weight for the polysiloxane is in the range of 400 to 10,000;

from 20 to 80 percent by weight of a non-aromatic epoxide resin having more than one 1,2-epoxide group per molecule with an epoxide equivalent weight of 100 to 5,000; and

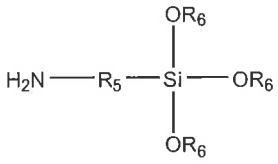
from 2 to 15 percent by weight of a flexible epoxy resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1000; and from 5 to 40 percent by weight of a cure system blend, wherein the percent by weight is based on the total weight of the coating composition.

3. The coating composition of claim 2 wherein the cure system blend comprises at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin.

4. The coating composition of claim 3 wherein the cure system blend has an alkoxyl content of 10% by weight to 25% by weight.

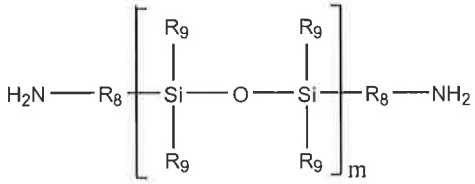
5. The coating composition of claim 3 wherein the cure system blend has an average alkoxy functionality value of 2.2 to 2.8.

6. The coating composition of claim 1 or 3, wherein the at least one trialkoxy functional aminosilane has a general formula



and

the at least one amino functional polysiloxane resin has a general formula



where (a) R_5 is a difunctional organic radical selected from an aryl, an alkyl, a dialkylaryl, an alkoxyalkyl, an alkylaminoalkyl, or a cycloalkyl radical, (b) each R_6 is independently an alkyl, a hydroxyalkyl, an alkoxyalkyl, or a hydroxyalkoxyalkyl group containing less than six carbon atoms, (c) each R_8 is a difunctional organic radical independently selected from an aryl, alkyl, dialkylaryl, alkoxyalkyl, alkylaminoalkyl, or cycloalkyl radical, (d) each R_9 is independently an aryl, phenyl, (C_1-C_4)alkyl, (C_1-C_4)alkoxy, or

-$OSi(R_{10})_2R_8NH_2$ group,

wherein R_8 of the formula -$OSi(R_{10})_2R_8NH_2$ is a difunctional organic radical independently selected from an aryl, alkyl, dialkylaryl, alkoxyalkyl, alkylaminoalkyl, or cycloalkyl radical, and each R_{10} of the formula -$OSi(R_{10})_2R_8NH_2$ is independently an aryl, phenyl, (C_1-C_4)alkyl, or (C_1-C_4)alkoxy, and

(e) m is selected so that the blend has an amine equivalent weight ranging from 112 to 250 g/NH.

7. The coating composition of claim 6, wherein R_5 is a difunctional organic radical selected from (C_1-C_6)alkyl or (C_1-C_6)alkylamino(C_1-C_6)alkyl groups and each R_6 is independently a (C_1- C_6)alkyl group.

8. The composition of claim 1 or 3, wherein the at least one trialkoxy functional aminosilane comprises aminopropyltrimethoxysilane, aminopropyltriethoxysilane, aminopropyltripropoxysilane, aminoneohexyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltriethoxysilane, N-phenylaminopropyl trimethoxysilane, trimethoxysilylpropyl diethylene triamine, 3-(3-aminophenoxy)propyl trimethoxysilane, aminoethyl aminomethyl phenyl trimethoxysilane, 2-aminoethyl-3-aminopropyl-tris-2-ethylhexoxysilane, N-aminohexyl aminopropyl trimethoxysilane, and/or trisaminopropyl trismethoxyethoxysilane.

9. The composition of claim 1 or 6, wherein the at least one amino functional polysiloxane resin has a structure where R_9 includes greater than 70% of phenyl groups, less than 30% of(C_1-C_4)alkyl groups and less than 2.0% (C_1-C_4)alkoxy groups.

10. The composition of claim 9, wherein R_9 includes less than 0.5% of (C_1-C_4)alkoxy groups.

11. The composition of claim 1 or 3, wherein the at least one amino functional polysiloxane resin comprises an amino-functional phenyl methyl polysiloxane resin.

12. The composition of claim 11, wherein the at least one amino functional

polysiloxane resin has an amine equivalent weight of 240 to 280 g/NH.

13. The coating composition of claim 1 or 2, wherein the cure system comprises 15% to 85% by weight of the at least one trialkoxy functional aminosilane and 85% to 15% by weight of the at least one amino functional polysiloxane resin.

14. The composition of claim 1, wherein the cure system comprises a blend having an average alkoxy functionality value of 2.2 to 2.8.

15. The coating composition of claim 1, wherein the coating composition comprises from 20% to 80% by weight of the polysiloxane, from 20% to 80% by weight of the non-aromatic epoxy resin, and from 5% to 40% by weight of the cure system.

16. The coating compositions of claim 1 or 3, wherein the coating composition comprises a ratio of amine equivalents to epoxide equivalents ranging from 0.7:1.0 to 1.3:1.0.

17. The coating composition of claim 1 or 2, wherein the non-aromatic epoxide resin comprises a cycloaliphatic epoxide resin comprising a hydrogenated cyclohexane dimethanol or diglycidyl ether of a hydrogenated Bisphenol A epoxide resin.

18. The coating composition of claim 1, further comprising a flexible epoxy resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000.

19. The coating composition of claim 18, wherein the coating composition comprises up to 15% by weight of the flexible epoxy resin.

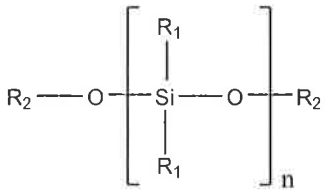
20. The coating composition of claim 1 or 2, further comprising up to 15% of a cure accelerator comprising a zinc, manganese, zirconium, titanium, cobalt, iron, lead, and/or tin catalyst, each in the form of octanoates, neodecanoates, or naphthanates, wherein the percent by weight is based on the total weight of the coating composition.

21. The coating composition of claim 1 or 2, further comprising one or more corrosion inhibitor comprising zinc or phosphate based corrosion inhibitors or organic corrosion inhibitors.

22. An epoxy-polysiloxane polymer coating composition comprising:

water;

from 20% to 80% by weight of a polysiloxane having the formula



where (a) each R_1 is independently a hydroxy group or an alkyl group having up to six carbon atoms, an aryl group having up to six carbon atoms, or an alkoxy group having up to six carbon atoms, (b) each R_2 is independently selected from hydrogen or an alkyl having up to six carbon atoms or aryl group having up to six carbon atoms, and (c) n is selected so that the molecular weight for the polysiloxane is 400 to 10,000;

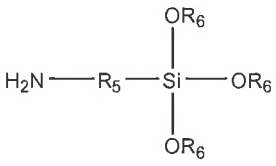
from 20% to 80% by weight of a non-aromatic epoxide resin comprising more than one 1,2-epoxide group per molecule and an epoxide equivalent weight of 100 to 5,000;

up to 15% by weight of a cure accelerator comprising a tin catalyst in the form of an octanoate, a dodecanoate or a naphthanate;

up to 15% by weight of a flexible epoxy resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000; and

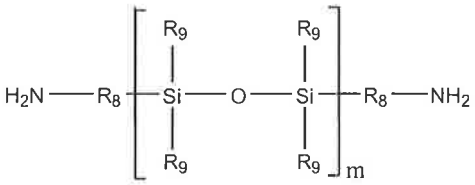
from 5% to 40% by weight of a cure system comprising a blend of at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin,

wherein the trialkoxy functional aminosilane has a general formula



and

the amino functional polysiloxane resin has a general formula



where (a) R_5 is a difunctional organic radical selected from an aryl, an alkyl, a dialkylaryl, an alkoxyalkyl, an alkylaminoalkyl, or a cycloalkyl radical, (b) each R_6 is independently an alkyl, ahydroxyalkyl, an alkoxyalkyl, or a hydroxyalkoxyalkyl group containing less than six carbon atoms, (c) each R_8 is a difunctional organic radical independently selected from an aryl, alkyl, dialkylaryl, alkoxyalkyl, alkylaminoalkyl, or cycloalkyl radical, (d) each R_9 is independently an aryl, phenyl, (C_1-C_4)alkyl, (C_1-C_4)alkoxy, or $-OSi(R_{10})_2R_8NH_2$ group,

wherein R_8 of the formula $-OSi(R_{10})_2R_8NH_2$ is a difunctional organic radical independently selected from an aryl, alkyl, dialkylaryl, alkoxyalkyl, alkylaminoalkyl, or cycloalkyl radical, and each R_{10} of the formula $-OSi(R_{10})_2R_8NH_2$ is independently an aryl, phenyl, (C_1-C_4)alkyl, or (C_1-C_4)alkoxy,

and (e) m is selected so that the blend has an amine equivalent weight of 112 to 250 g/NH, and has an average alkoxy functionality value of 2.2 to 2.8 and wherein the blend is added in an amount sufficient to provide an amine equivalent to epoxide equivalent of 0.7:1.0 to 1.3:1.0 in the coating composition.

23. The coating composition of claim 22, wherein each R_6 is independently a (C_1-C_6)alkyl group, R_5 is a (C_1-C_6)alkyl group or (C_1-C_6)alkylamino(C_1-C_6)alkyl group, and each R_9 is methyl or phenyl.

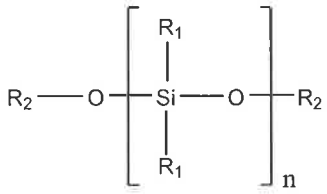
24. The coating composition of claim 22, wherein the at least one trialkoxy functional aminosilane comprises aminopropyltrimethoxysilane, aminopropyltriethoxysilane, aminopropyltripropoxysilane, aminoneohexyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltrimethoxysilane, N-β-aminoethyl-γ-aminopropyltriethoxysilane, N-phenylaminopropyl trimethoxysilane, trimethoxysilylpropyl diethylene triamine, 3-(3-aminophenoxy)propyl trimethoxysilane, aminoethyl aminomethyl phenyl trimethoxysilane, 2-aminoethyl-3-aminopropyl-tris-2-ethylhexoxysilane, N-aminohexyl aminopropyl trimethoxysilane, and/or trisaminopropyl trismethoxyethoxysilane; and

the at least one amino functional polysiloxane resin is an amino functional phenyl methyl polysiloxane resin.

25. An epoxy-polysiloxane polymer coating composition comprising:

water;

a polysiloxane having the formula



where,

(a) each R_1 is independently selected from a hydroxy group or an alkyl group having up to six carbon atoms, an aryl group having up to six carbon atoms, or an alkoxy group having up to six carbon atoms,

(b) each R_2 is independently selected from hydrogen, or an alkyl having up to six carbon atoms or an aryl group having up to six carbon atoms, and

(c) n is selected so that the molecular weight for the polysiloxane is in the range of 400 to 10,000,

a non-aromatic epoxide resin having more than on 1,2-epoxide group per molecule with an epoxide equivalent weight of 100 to 5,000;

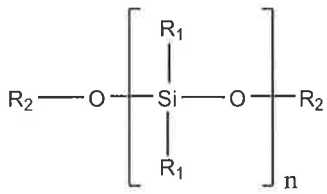
a flexible epoxy resin base on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000; and

a cure system blend having an alkoxy content of 10% by weight to 25% by weight.

26. An epoxy-polysiloxane polymer coating composition comprising:

water;

a polysiloxane having the formula



where,

(a) each R1 is independently selected from a hydroxy group or an alkyl group having up to six carbon atoms, an aryl group having up to six carbon atoms, or an alkoxy group having up to six carbon atoms,

(b) each R_2 is independently selected from hydrogen, or an alkyl or aryl group having up to six carbon atoms, and

(c) n is selected so that the molecular weight for the polysiloxane is 400 to 10, 000,

a non-aromatic epoxide resin having more than on 1,2-epoxide group per molecule with an epoxide equivalent weight of 100 to 5,000;

a flexible epoxy resin base on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000; and

a cure system comprising a blend comprising at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin, where the blend has an alkoxy content of 10% by weight to 25% by weight.

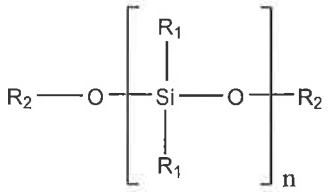
27. A coated substrate comprising at least one surface coated with the coating composition according to anyone of claims 1 to 26.

28. A method for coating a surface of a substrate with a coating composition, the method comprising:

preparing a resin component comprising:

water;

a polysiloxane having the formula



(a) where each R_1 is independently selected from a hydroxy group or an alkyl group having up to six carbon atoms, an aryl group having up to six carbon atoms, or an alkoxy group having up to six carbon atoms, (b) each R_2 is hydrogen or an alkyl or aryl group having up to six carbon atoms, and (c) where n is selected so that the molecular weight for the polysiloxane is 400 to 10,000;

a non-aromatic epoxide resin comprising more than one 1,2-epoxide group per molecule and an epoxide equivalent weight in the range of 100 to 5,000;

adding a cure system to the resin component to form a fully cured epoxy-modified polysiloxane coating composition, the cure system comprising:

a blend of at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin; and

optionally a cure accelerator comprising at least one metal catalyst,

where the blend has an average alkoxy functionality value of 2.2 to 2.8; and

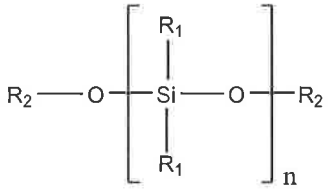
applying the coating composition to the surface of a substrate to be protected before the coating composition becomes fully cured.

29. The method according to claim 28, wherein the resin component further comprises a flexible epoxy resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1,000.

30. A method for coating a surface of a substrate with a coating composition, the method comprising:

preparing a resin component comprising:

from 20 to 80 percent by weight of a polysiloxane having the formula



(a) where each R_1 is independently selected from a hydroxy group or an alkyl group having up to six carbon atoms, an aryl group having up to six carbon atoms, or an alkoxy group having up to six carbon atoms, (b) each R_2 is hydrogen or an alkyl group having up to six carbon atoms or an aryl group having up to six carbon atoms, and (c) where n is selected so that the molecular weight for the polysiloxane is 400 to 10,000;

from 20 to 80 percent by weight of a non-aromatic epoxide resin comprising more than one 1,2-epoxide group per molecule and an epoxide equivalent weight in the range of 100 to 5,000; and from 2 to 15 percent by weight of a flexible epoxide resin based on the glycidyl ether of castor oil having an epoxide equivalent weight of 200 to 1000;

adding from 5 to 40 percent by weight of a cure system blend to the resin component to form a cured epoxy-modified polysiloxane coating composition and applying the coating composition to a surface of a substrate to be protected before the coating composition become fully cured wherein the percent by weight based on the total weight of the coating composition.

31. The method of claim 30 wherein the cure system blend comprises:

at least one trialkoxy functional aminosilane and at least one amino functional polysiloxane resin; and

optionally a cure accelerator comprising at least one metal catalyst, wherein the blend has an alkoxy content of 10% by weight to 25% by weight.