In another preferred first coating composition of the present invention the first emissivity agent is selected from an oxide of Co. Representative examples of oxides of Co include CoO, Co_2O_3 and Co_3O_4. When the first emissivity agent is an oxide of Co, it is preferably CoO.

In another preferred first coating composition of the present invention, the first emissivity agent is selected from an oxide of Ce, Co and mixtures thereof. Such coating compositions preferably comprise a first emissivity agent selected from CeO_2, CoO and mixtures thereof.

In a preferred first coating composition of the present invention, the total amount of the first emissivity agent is 3 to 15 wt%, e.g. 4 to 12 wt%, preferably 5 to 12 wt%, still more preferably 4 to 6 wt% and yet more preferably 5 to 6 wt%, based on the total weight of the first coating composition.

One preferred first coating composition of the invention comprises a single first emissivity agent. Another preferred first coating composition comprises more than one (e.g. two or three, preferably two) first emissivity agent. When the first coating composition comprises two different first emissivity agents, the weight ratio of the oxides is preferably 30:70 to 70:30, more preferably 40:60 to 60:40 and still more preferably about 50:50. For example, a preferred first coating composition comprising two first emissivity agents comprises CeO_2 to CoO or CeO_2 to MnO_2 in a weight ratio of 30:70 to 70:30, more preferably 40:60 to 60:40 and still more preferably about 50:50.

In a preferred first coating composition of the present invention, the ratio of the first emissivity agent to filler is preferably 0.15:1 to 0.4:1, more preferably 0.18:1 to 0.35:1 and still more preferably 0.25:1 to 0.32:1.

A preferred first coating composition of the present invention further comprises a second emissivity agent which is a metallic oxide, and preferably a metallic oxide selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, terbium oxide, and mixtures thereof. Particularly preferably the second emissivity agent is titanium oxide, especially TiO_2. The second emissivity agent must be a different metallic oxide to the first emissivity agent.

In a preferred first coating composition of the present invention, the total amount of the second emissivity agent which is a metallic oxide is 10 to 22 wt%, preferably 13 to 18 wt%, and still more preferably 16 to 18 wt%, based on the total weight of the first coating composition.

A preferred first coating composition of the present invention therefore comprises:

(i) 2-20 wt% of a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

(ia) 10-22 wt% of a second emissivity agent, which is a metallic oxide, preferably selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, ~~and~~ terbium oxide and mixtures thereof;

(ii) 0-5 wt%, preferably 0-1 wt%, more preferably 0-0.01 wt%, and still more preferably 0-0.001 wt% of an oxide of Cr;

(iii) 0-5 wt% Fe_2O_3;

(iv) 10-35 wt% filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof; and

(v) 10-20 wt% binder;

wherein the total content of emissivity agents in said composition is preferably 15-45 wt%, and preferably wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1.

In a preferred first coating composition of the present invention, the total amount of first emissivity agent and second emissivity agent, which is a metallic oxide, is 15 to 40 wt%, more preferably 18 to 35 wt% and still more preferably 20 to 30 wt%, based on the total weight of the first coating composition.

One preferred first coating composition of the present invention solely comprises metallic oxide emissivity agents.

Another preferred first coating composition of the present invention, further comprises a third emissivity agent, and preferably a third non-metallic oxide emissivity agent. Preferably the third non-metallic oxide emissivity agent is selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), ~~or~~and mixtures thereof. More preferably, such coating compositions of the present invention further comprise a third non-metallic oxide emissivity agent selected from boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), ~~or~~and mixtures thereof.

A particularly preferred first coating composition of the invention does not comprise silicon carbide (SiC).

Another particularly preferred first coating composition of the invention comprises silicon carbide (SiC).

In a preferred first coating composition of the present invention, the total amount of a third non-metallic oxide emissivity agent is 0 to 18 wt%, preferably 0 to 15 wt%, more

preferably 10-15 wt% and still more preferably 12-14 wt%, based on the total weight of the first coating composition.

In a preferred first coating composition of the present invention, the total amount of emissivity agents is 15 to 45 wt%, more preferably 15 to 40 wt%, still more preferably 20 to 38 wt% and yet more preferably 24 to 38 wt%, based on the total weight of the first coating composition.

A preferred first coating composition of the present invention therefore comprises:

(i) 2-20 wt% of a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

(ia) 10-22 wt% of a second emissivity agent, which is a metallic oxide, preferably selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, ~~and~~ terbium oxide and mixtures thereof;

(ib) 0-18 wt% of a third non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), ~~or~~and mixtures thereof

(ii) 0-5 wt%, preferably 0-1 wt%, more preferably 0-0.01 wt%, and still more preferably 0-0.001 wt% of an oxide of Cr;

(iii) 0-5 wt% Fe_2O_3;

(iv) 15-35~~36~~ wt% filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof; and

(v) 10-20 wt% binder;

wherein the total content of emissivity agents in said composition is preferably 15-45 wt%, and preferably wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1.

A particularly preferred first coating composition of the present invention comprises, preferably consists of, the following mixtures of emissivity agents:

MnO_2, TiO_2 and SiC;

CeO_2, CoO and TiO_2;

CoO and TiO_2;

CoO, TiO_2 and SiC

CeO_2, TiO_2 and SiC.

The first coating composition of the present invention further comprises at least one filler. The filler is selected from aluminium silicate, oxides of Al, oxides of Si and

mixtures thereof, e.g. aluminium silicate and an oxide of Al, different oxides of Al, an oxide of Al and an oxide of Si etc. Preferred fillers include aluminium silicate, alumina, silica, and mixtures thereof.

Preferably, the first coating composition comprises 15 to ~~36~~35 wt%, more preferably 15 to 33 wt%, still more preferably 19 to 33 wt% and yet more preferably 19-30 wt%, of at least one filler, based on the total weight of the first coating composition.

The first coating composition of the present invention further comprises binder. Preferably the first coating composition comprises 10 to 18 wt%, more preferably 10 to 15 wt% and still more preferably 11 to 14 wt% binder, based on the total weight of the first coating composition.

Preferably, the binder is phosphoric acid (H_3PO_4), a sodium aluminosilicate and/or a potassium aluminosilicate to form, for instance, $Al_2(H_2P_2O_7)$, $Al(PO_3)_3$, $AlPO_4$, and/or $KAlSi_3O_8$. A particularly preferred binder is phosphoric acid (H_3PO_4). The phosphoric acid is preferably in the form of an aqueous solution.

A preferred first coating composition of the present invention further comprises water. A preferred coating composition of the present invention further comprises 1 to 35 wt% water, and more preferably 20 to 35 wt% water (e.g. around 30 wt%), based on the total weight of the first coating composition.

A particularly preferred first coating composition of the present invention therefore comprises:

(i) 2-20 wt% of a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

(ia) 10-22 wt% of a second emissivity agent, which is a metallic oxide, preferably selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, ~~and~~ terbium oxide and mixtures thereof;

(ib) 0-18 wt% of a third non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), ~~or~~and mixtures thereof

(ii) 0-5 wt%, preferably 0-1 wt%, more preferably 0-0.01 wt%, and still more preferably 0-0.001 wt% of an oxide of Cr;

(iii) 0-5 wt% Fe_2O_3;

(iv) 15-3536 wt% filler, preferably 15 to 33 wt% filler, selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof;

(v) 10-20 wt% binder, preferably phosphoric acid; and

(via) 22-32 wt% of a second emissivity agent, which is a metallic oxide, preferably selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, ~~and~~ terbium oxide and mixtures thereof;

(vii) 0-5 wt%, preferably 0-1 wt%, more preferably 0-0.01 wt%, and still more preferably 0-0.001 wt% of an oxide of Cr;

(viii) 0-5 wt% Fe_2O_3; and

(ix) 30-60 wt% filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof;

wherein the total content of emissivity agents in said composition is preferably 40-75 wt%, and preferably wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1.

In a preferred second coating composition of the present invention, the total amount of first emissivity agent and second emissivity agent, which is a metallic oxide, is 20 to 55 wt%, more preferably 30 to 50 wt% and still more preferably 40 to 50 wt%, based on the total weight of the second coating composition.

A preferred second coating composition of the present invention solely comprises metallic oxide emissivity agents.

Another preferred second coating composition of the present invention, further comprises a third emissivity agent, preferably a third non-metallic oxide emissivity agent. The third non-metallic oxide emissivity agent is preferably selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), ~~or~~and mixtures thereof. More preferably, such coating compositions of the present invention further comprise a third non-metallic oxide emissivity agent selected from boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), and~~or~~ mixtures thereof.

A particularly preferred second coating composition of the invention does not comprise silicon carbide (SiC).

Another particularly preferred second coating composition of the invention comprises silicon carbide (SiC).

In a preferred second coating composition of the present invention, the total amount of a third non-metallic oxide emissivity agent is 0 to 25 wt%, preferably 10 to 25 wt%, more preferably 17-25 wt% and still more preferably 21-25 wt%, based on the total weight of the second coating composition.

In a preferred second coating composition of the present invention, the total amount of emissivity agents is 40 to 75%, more preferably 40 to 70 wt% and still more preferably 42 to 67 wt%, based on the total weight of the second coating composition.

A preferred second coating composition of the present invention therefore comprises:

(vi) 5-25 wt% of a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

(via) 22-32 wt% of a second emissivity agent, which is a metallic oxide, preferably selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, ~~and~~ terbium oxide and mixtures thereof;

(vib) 0-25 wt% of a third non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), ~~or~~and mixtures thereof

(vii) 0-5 wt%, preferably 0-1 wt%, more preferably 0-0.01 wt%, and still more preferably 0-0.001 wt% of an oxide of Cr;

(viii) 0-5 wt% Fe_2O_3; and

(ix) 30-60 wt% filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof;

wherein the total content of emissivity agents in said composition is preferably 40-75 wt%, and preferably wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1.

A particularly preferred second coating composition of the present invention comprises, preferably consists of, the following mixtures of emissivity agents:

MnO_2, TiO_2 and SiC;

CeO_2, CoO and TiO_2;

CoO and TiO_2;

CoO, TiO_2 and SiC

CeO_2, TiO_2 and SiC.

The second coating composition of the present invention further comprises at least one filler. The filler is selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof, e.g. aluminium silicate and an oxide of Al, different oxides of Al, an oxide of Al and an oxide of Si etc. Preferred fillers include aluminium silicate, alumina, silica, and mixtures thereof.

Preferably, the second coating composition comprises 30 to 52 wt%, more preferably 30 to 45 wt%, still more preferably 30 to 40 wt% and yet more preferably 30-35 wt%, of at least one filler, based on the total weight of the second coating composition.

Packages

The present invention also provides a package containing a coating composition, e.g. a first or second coating composition, as hereinbefore described. Packages of the present invention include containers, drums, bottles, boxes, tins, jars, sachets etc.

Methods and coatings

The present invention also provides a method for preparing a coating composition, e.g. a first or second coating composition, as hereinbefore described, comprising mixing:

a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

0-5 wt%, preferably 0-1 wt%, more preferably 0-0.01 wt%, and still more preferably 0-0.001 wt% of an oxide of Cr;

0-5 wt% Fe_2O_3;

a filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof; and optionally binder. A binder is used when preparing a first coating composition.

Preferably the first coating composition as hereinbefore described is prepared by mixing the second coating composition as hereinbefore described with binder, and optionally water.

Preferably, the first emissivity agent has a particle size of less than 150 μm, more preferably less than 100 μm. Even more preferably, the first emissivity agent has a particle size in the range of 10 to 60 μm, more preferably in the range of 20 to 60 μm. Such particle sizes provide the coating produced from the coating composition with good mechanical properties. If present, the second emissivity agent, which is a metallic oxide, preferably has a particle size in the range of 10 to 60 μm, more preferably in the range of 20 to 60 μm. If present, the third non-metallic oxide emissivity agent preferably has a particle size in the range of 10 to 60 μm, most preferably in the range of 20 to 60 μm. If necessary, the particle size of any of the emissivity agents may be reduced by grinding.

Preferably, filler has a particle size of less than 150 μm, more preferably less than 110 μm.

The present invention also provides a method for preparing a coated substrate, comprising the steps:

CLAIMS:

1. A coating composition, preferably a high emissivity coating composition, and more preferably a high emissivity coating composition in the form of a suspension, comprising:

(i) 2-20 wt%, preferably 3-15 wt%, of a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

(ii) 10-22 wt% of a second emissivity agent which is a metallic oxide selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, terbium oxide, and mixtures thereof;

~~(i)~~(iii) 0-18 wt% of a third emissivity agent which is a non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), zirconium diboride (ZrB_2), and mixtures thereof;

~~(ii)~~(iv) ~~0-5 wt%, preferably 0-1 wt%, more preferably~~ 0-0.01 wt% ~~and still more preferably 0-0.001 wt%~~ of an oxide of Cr;

~~(iii)~~(v) 0-1000 ppm ~~5 wt%~~ Fe_2O_3;

~~(iv)~~(vi) 10-35 wt% filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof; and

~~(v)~~(vii) 10-20 wt% binder;

wherein the total content of said first, second and third emissivity agents in said composition is ~~preferably~~ 15-45 wt%, based on the total weight of the composition~~, and preferably wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1~~.

2. A coating composition, preferably a high emissivity coating composition, ~~–~~and more preferably a high emissivity coating composition in the form of a powder, comprising:

(i) 5-25 wt% of a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

(ii) 22-32 wt% of a second emissivity agent which is a metallic oxide selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, terbium oxide, and mixtures thereof;

(iii) 0-25 wt% of a third emissivity agent which is a non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon

hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), zirconium diboride (ZrB_2), and mixtures thereof;

(iv~~i~~) ~~0-5 wt%, preferably 0-1 wt%, more preferably~~ 0-0.01 wt%, ~~and still more preferably 0-0.001 wt%~~ of an oxide of Cr;

(v~~iii~~) 0-~~-~~1000 ppm~~5 wt%~~ Fe_2O_3; and

(~~i~~vi) 30-60 wt% filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof;

wherein the total content of said first, second and third emissivity agents in said composition is ~~preferably~~ 40 to 75 wt%, based on the total weight of the composition~~, and preferably wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1~~.

3. A composition as claimed in claim 1 or 2, wherein said composition comprises 0-0.001 wt% of an oxide of Cr.

~~3~~4. A composition as claimed in claim 1 or 2, wherein said composition does not comprise an oxide of Cr selected from CrO, Cr_2O_3, CrO_2, CrO_3, CrO_5 and mixtures thereof.

~~4. A composition as claimed in any preceding claim, wherein said composition does not comprise Fe_2O_3.~~

~~5. A composition as claimed in any preceding claim, further comprising a second emissivity agent which is a metallic oxide selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, terbium oxide, and mixtures thereof.~~

~~6. A composition as claimed in any preceding claim, further comprising a third non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), and zirconium diboride (ZrB_2), or mixtures thereof.~~

~~7~~5. A composition as claimed in claim 1, and any one of claims 3~~-6~~or 4 when dependent on claim 1, wherein the total content of said first, second and third emissivity agents in said composition is 16-38 wt%, based on the total weight of the composition.

~~8~~6. A composition as claimed in claim 1, and any one of claims 3-~~7~~5 when dependent on claim 1, wherein the amount of said filler is 15 to 35 wt%, based on the total weight of the composition.

~~7~~9. A composition as claimed in claim 1, and any one of claims 3-~~8~~6 when dependent on claim 1, wherein the amount of binder is ~~12~~10 to ~~30~~15 wt%, based on the total weight of the composition and/or wherein said binder is phosphoric acid (H_3PO_4).

~~8~~10. A composition as claimed in claim 1, and any one of claims 3-~~9~~7 when dependent on claim 1, comprising water, preferably 10-40 wt% water.

9. A composition as claimed in claim 2, and any one of claims 3 or 4 when dependent on claim 2, comprising one of the following mixtures of emissivity agents:

MnO_2, TiO_2 and SiC;

CeO_2, CoO and TiO_2;

CoO and TiO_2;

CoO, TiO_2 and SiC; and

CeO_2, TiO_2 and SiC.

10. A composition as claimed in claim 2, and any one of claims 3, 4 or 9 when dependent on claim 2, wherein the total content of said first, second and third emissivity agents in said composition is 40-70 wt%, based on the total weight of the composition.

11. A composition as claimed in any preceding claim, wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1, preferably 0.15:1-0.4:1, more preferably 0.18:1-0.35:1 and still more preferably 0.25:1-0.32:1.

12. A package containing a composition as claimed in any one of claims 1-11.

13. A method for preparing a coating composition as claimed in any one of claims 1-11, comprising mixing:

a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

a second emissivity agent which is a metallic oxide selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, terbium oxide, and mixtures thereof;

a third emissivity agent which is a non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), ~~and~~ zirconium diboride (ZrB_2), and mixtures thereof;

0-0.01 wt% ~~0-5~~ wt% of an oxide of Cr;

0-1000 ppm ~~5 wt%~~ Fe_2O_3;

a filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof; and optionally binder

14. A method for preparing a coated substrate, comprising the steps:

a) providing a substrate;

b) applying a coating composition as defined in claim 1 or any one of claims 3 to 11 when dependent on claim 1, onto at least one surface of said substrate; and

c) heating said coating composition to form the coated substrate.

15. A coated substrate obtainable by or obtained by the method according to claim 14.

16. A coated substrate comprising a composition as defined in claim 1, or any one of claims 3 to 11 when dependent on claim 1, preferably a coated shaped refractory, a coated unshaped refractory, a coated insulating material or a coated ceramic fiber.

17. A coated substrate, preferably a coated refractory, wherein said coating is derived from a coating composition comprising:

(i) 2-20 wt% of a first emissivity agent selected from oxides of Mn, Ce, Co and mixtures thereof;

(ii) 10-22 wt% of a second emissivity agent which is a metallic oxide selected from titanium dioxide, nickel oxide, magnesium oxide, copper oxide, terbium oxide, and mixtures thereof;

~~(i)~~(iii) 0-18 wt% of a third emissivity agent which is a non-metallic oxide emissivity agent selected from silicon carbide (SiC), boron silicide (B_4Si), boron carbide (B_4C), silicon hexaboride (SiB_6), molybdenum disilicide ($MoSi_2$), tungsten disilicide (WSi_2), zirconium diboride (ZrB_2), and mixtures thereof;

~~(ii)~~(iv) ~~0-5 wt%, preferably 0-1 wt%, more preferably~~ 0-0.01 wt%, and still more preferably 0-0.001 wt% of an oxide of Cr;

~~(iii)~~(v) 0-1000 ppm ~~5 wt%~~ Fe_2O_3;

~~(iv)~~(vi) 10-35 wt% filler selected from aluminium silicate, oxides of Al, oxides of Si and mixtures thereof; and

~~(v)~~(vii) 10-20 wt% binder;

wherein the total content of said first, second and third emissivity agents in said composition is preferably 15-45 wt%, based on the total weight of the composition and preferably wherein the weight ratio of said first emissivity agent to said filler is 0.12:1 to 0.5:1.

18. A furnace comprising a coated substrate according to any one of claims 15 to 17.

19. Use of a coating composition as defined in claim 1 or any one of claims 3 to 11 when dependent on claim 1, to coat a substrate.