unsatisfactory, the coating will easily be washed off with the result that the properties provided by the coating are lost within a short period of time. Satisfactory durability is therefore of most importance to ensure a prolonged effect.

In spite of the recent significant advances within this field of technology, there is still a continued need to find new features that i) reduce the water absorption capabilities of low density particulate inorganic materials; ii) improve the mechanical strength of low density particulate inorganic materials; and iii) improve the mechanical strength of low density particulate inorganic material-based end products.

SUMMARY

In a first aspect, the present disclosure relates to a method for manufacturing a surface-treated particulate inorganic material, the method comprising the following steps:

- providing a particulate inorganic material; and
- bringing the particulate inorganic material into contact with a composition comprising at least one surface treating agent and thereby obtain a surface-treated particulate inorganic material;

wherein

- the at least one surface treating agent is an organic-inorganic hybrid polymer;
- the organic-inorganic hybrid polymer being selected from the group of polymers obtainable by a process comprising the following step(s):
  a) forming a polymer by controlled hydrolysis and condensation of one type of silane selected from the group of silanes represented by the following general formula: $(X\text{-}L\text{-})_n Si(\text{-}Y)_{4-n}$; or

     forming a polymer by controlled hydrolysis and condensation of at least two different types of silanes independently selected from the group of silanes represented by the following general formula: $(X\text{-}L\text{-})_n Si(\text{-}Y)_{4-n}$;

     wherein

X	is –NR1R2, –N=C=O, SH or OH
R1 and R2	are residues independently selected from the group consisting of hydrogen; non-substituted or substituted, saturated or unsaturated C1-C25 hydrocarbon radical which may be straight, branched or cyclic; aliphatic or aromatic carbonyl; and substituted or non-substituted aryl; wherein the carbon chains of said residues

optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron; or R1 and R2 are independently selected from the group consisting of condensation products, addition products of one or more type of chemical substances such as acids, alcohols, phenols, amines, aldehydes or epoxides;

n is 1 or 2;

L is a direct bond; or a residue selected from the group consisting of non-substituted or substituted, saturated or unsaturated C_1-C_{25} hydrocarbon radical which may be straight, branched or cyclic; and substituted or non-substituted arylene; wherein the carbon chains of said residues optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron; and

Y is a hydrolysable group or OH;

and

b) if X is $-NR_1R_2$ and at least one of R_1 and R_2 is H for the selected silane(s) or for at least one of the selected silanes; or X is –N=C=O, SH or OH for the selected silane(s) or for at least one of the selected silanes

– adding at least one reactant capable of forming a covalent bond between an atom of the X group and at least one atom of the reactant;

the at least one reactant being a compound selected from the group consisting of cyclic anhydride and a compound of formula R-Z,

wherein

R is a residue selected from the group consisting of a non-substituted or substituted, saturated or unsaturated C1-C25 hydrocarbon radical which may be straight, branched or cyclic; aliphatic or aromatic carbonyl; and substituted or non-substituted aryl; wherein the carbon chains of said residues optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron; or a residue selected from the group consisting of condensation products, addition products of one or more type of chemical substances such as acids, alcohols, phenols, amines, aldehydes or epoxides; and

Z is a residue selected from the group consisting of alkoxyl, aryloxyl,cycloalkoxyl, carboxyl, formyl, acyl halide, isocyanate, hydroxyl, amine, epoxide, ester and halogen;

and

c) if X is $-NR_1R_2$ for the selected silane(s) or for at least one of the selected silanes
   - optionally, adding an acid that is capable of converting the N-atom of the X group to quaternary nitronium ions.

Also described is a method for manufacturing a surface-treated particulate inorganic material, the method comprising the following steps:

- providing a particulate inorganic material; and
- bringing the particulate inorganic material into contact with a composition comprising at least one surface treating agent;

wherein

- the at least one surface treating agent is an organic-inorganic hybrid polymer;
- the organic-inorganic hybrid polymer being selected from the group of polymers obtainable by a process comprising the following step(s):
  a) forming a polymer by controlled hydrolysis and condensation of one type of silane selected from the group of silanes represented by the following general formula: $(X\text{-}L\text{-})_n Si(\text{-}Y)_{4-n}$; or

     forming a polymer by controlled hydrolysis and condensation of at least two different types of silanes independently selected from the group of silanes represented by the following general formula: $(X\text{-}L\text{-})_n Si(\text{-}Y)_{4-n}$;

     wherein

     X is $-NR_1R_2$, –N=C=O, SH or OH

     R_1 and R_2 are residues independently selected from the group consisting of hydrogen; non-substituted or substituted, saturated or unsaturated C_1-C_{25} hydrocarbon radical which may be straight, branched or cyclic; aliphatic or aromatic carbonyl; and substituted or non-substituted aryl; wherein the carbon chains of said residues optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron; or R_1 and R_2 are independently selected from the group consisting of condensation products, addition products of one or more type of chemical substances such as acids, alcohols, phenols, amines, aldehydes

or epoxides;

n is 1 or 2;

L is a direct bond; or a residue selected from the group consisting of non-substituted or substituted, saturated or unsaturated C_1-C_{25} hydrocarbon radical which may be straight, branched or cyclic; and substituted or non-substituted arylene; wherein the carbon chains of said residues optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron; and

Y is a hydrolysable group or OH;

and

b) if X is $-NR_1R_2$ and at least one of R_1 and R_2 is H for the selected silane(s) or for at least one of the selected silanes; or X is –N=C=O, SH or OH for the selected silane(s) or for at least one of the selected silanes

– adding at least one reactant capable of forming a covalent bond between an atom of the X group and at least one atom of the reactant;

the at least one reactant being a compound selected from the group consisting of cyclic anhydride and a compound of formula R-Z,

wherein

R is a residue selected from the group consisting of a non-substituted or substituted, saturated or unsaturated C_1-C_{25} hydrocarbon radical which may be straight, branched or cyclic; aliphatic or aromatic carbonyl; and substituted or non-substituted aryl; wherein the carbon chains of said residues optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron; or a residue selected from the group consisting of condensation products, addition products of one or more type of chemical substances such as acids, alcohols, phenols, amines, aldehydes or epoxides; and

Z is a residue selected from the group consisting of alkoxyl, aryloxyl,cycloalkoxyl, carboxyl, formyl, acyl halide, isocyanate, hydroxyl, amine, epoxide, ester and halogen;

and

c) if X is $-NR_1R_2$ for the selected silane(s) or for at least one of the selected silanes

– optionally, adding an acid that is capable of converting the N-atom of the X group to quaternary nitronium ions.

In a first example according to the first aspect of the present disclosure, the particulate inorganic material is selected from the group consisting of perlite, expanded perlite, bentonite, diatomite, silica, barite, gypsum, limestone, kaolin, clay, expanded clay, biochar, mica, talc, vermiculite, synthetic calcium silicate hydrate, natural silicates, volcanic ash and other volcanic products such as fly ash and glass, slag, pumice, shale, synthetic silicates, alumino silicates, diatomaceous earth, wollastonite, slate, expanded slate; or any mixture thereof.

In a second example according to the first aspect of the present disclosure, the particulate inorganic material has an effective particle density or a loose bulk density in the range 10-950 kg/m^3, preferably in the range 30-150 kg/m^3.

In a third example according to the first aspect of the present disclosure the step of bringing the particulate inorganic material into contact with a composition comprising at least one surface treating agent involves applying at least one layer of the composition comprising at least one surface treating agent onto the particulate inorganic material.

In a fourth example according to the first aspect of the present disclosure, the ratio of particulate inorganic material : surface treating agent(s) is in the range 99,9:0,1 pbw to 70:30 pbw.

In a fifth example according to the first aspect of the present disclosure, X is $-NR_1R_2$ for at least one of the selected silanes.

In a sixth example according to the first aspect of the present disclosure, L is a residue selected from the group consisting of non-substituted or substituted, saturated or unsaturated C_1-C_{25} hydrocarbon radical which may be straight, branched or cyclic; and substituted or non-substituted arylene; wherein the carbon chains of said residues optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron. In another example, L is a residue selected from the group consisting of non-substituted or substituted, saturated or unsaturated C_1-C_{25} hydrocarbon radical which may be straight, branched or cyclic; and substituted or non-

substituted arylene; wherein the carbon chains of said residues optionally can include one or more of the elements oxygen, nitrogen, sulphur, phosphorous, silicon or boron for at least one of the selected silanes.

In a seventh example according to the first aspect of the present disclosure, Y is OH; or a hydrolysable group selected from the group consisting of alkoxyl, aryloxyl, carboxyl, and halogen. In another example, Y is OH or a hydrolysable group selected from the group consisting of alkoxyl, aryloxyl, carboxyl, and halogen for at least one of the selected silanes.

In an eighth example according to the first aspect of the present disclosure, the at least one reactant is selected from the group consisting of a cyclic anhydride such as phthalic anhydride, a C_1-C_{25} salicylate such as methyl salicylate, saturated or unsaturated C_1-C_{25} fatty acid, C_1-C_{25} 4-hydroxybenzoate such as methyl 4-hydroxybenzoate, a monobasic ester formed from an organic acid such as methyl lactate, and an epoxide.

In a ninth example according to the first aspect of the present disclosure,

- the particulate inorganic material is expanded perlite;
- step a) involves forming a polymer by controlled hydrolysis and condensation of one type of silane selected from the group of silanes represented by the following general formula: $(X\text{-}L\text{-})_n Si(\text{-}Y)_{4-n}$;
- X is $–NH_2$;
- n is 1;
- L is$–CH_2\text{-}CH_2\text{-}CH_2\text{-}$; and
- Y is $\text{-}O\text{-}CH_2\text{-}CH_3$.

In a tenth example according to the first aspect of the present disclosure,

- the particulate inorganic material is expanded perlite;
- step a) involves forming a polymer by controlled hydrolysis and condensation of one type of silane selected from the group of silanes represented by the following general formula: $(X\text{-}L\text{-})_n Si(\text{-}Y)_{4-n}$;
- X is $–NH_2$;
- n is 1;
- L is$–CH_2\text{-}CH_2\text{-}CH_2\text{-}$;

- Y is -O-CH_2-CH_3; and
- the at least one reactant is behenic acid.

In a further example according to the present disclosure, the composition comprising at least one surface treating agent is a water-based composition comprising at least one surface treating agent. Preferably, the water-based composition comprising at least one surface treating agent further comprises at least one emulsifier.

In a yet further disclosure according to the present disclosure, the composition comprising at least one surface treating agent is emulsified in water with the aid of at least one emulsifier.

In a further example according to the present disclosure, the particulate inorganic material is not a transparent material, in particular not glass.

In a yet further example according to the present disclosure, the X-groups of the polymer obtained by process steps a) to c) provides the polymer with a hydrophobic surface; and the polymer obtained by process steps a) to c) is not subjected to heat treatment which would decompose the hydrophobic surface of the polymer.

In a further example according to the present disclosure, the X-groups of the polymer obtained by process steps a) to c) provides the polymer with a hydrophobic surface; and the surface-treated particulate inorganic material is not subjected to heat treatment which would decompose the hydrophobic surface of the polymer.

In a yet further example according to the present disclosure, the surface-treated particulate inorganic material is not subjected to calcination.

In a further example according to the present disclosure, the surface-treated particulate inorganic material and/or the polymer obtained by process steps a) to c) is not subjected to heat treatment at temperatures above 300 °C.

In a further example according to the present disclosure, the process comprising steps a) to c) does not include a subsequent step of adding a metal alkoxide.

In a further example according to the present disclosure, a metal alkoxide is not added to the composition comprising at least one surface treating agent.

In a further example according to the present disclosure, the organic-inorganic hybrid polymer has an average particle diameter of less than 30nm, such as 1nm to 29nm or 1nm to 20nm.

In a further example according to the present disclosure, the organic-inorganic hybrid polymer prepared by step a) to c) is not covalently attached to other polymers that have an average particle diameter that is less than 80% of the average particle diameter of the at least one surface treating agent.

A **second aspect** of the present disclosure relates to a surface-treated particulate inorganic material obtainable by the method as described herein.

A **third aspect** of the present disclosure relates to use of a surface-treated particulate inorganic material according to the second aspect of the present disclosure, in admixture with construction materials or as additive in construction materials, the construction materials preferably being selected from the group consisting of plasters, cement, lightweight concrete, mortar, artificial stone, bricks, plastic, composite materials, paint, coating, thermoplastic foam and thermoset foam.

A **fourth aspect** of the present disclosure relates to a construction material comprising the surface-treated particulate inorganic material according to the second aspect of the present disclosure, the construction material preferably being selected from the group consisting of plasters, cement, lightweight concrete, mortar, artificial stone, bricks, plastic, composite materials, paint, coating, thermoplastic foam and thermoset foam.