

A COMPOSITION AND METHOD FOR TREATING A CONCRETE SURFACE

Related Application

[001] The present invention claims priority to Singapore provisional patent application no. 10202251334K filed on 11 October 2022, the disclosure of which is incorporated in its entirety.

Field of Invention

[002] The present invention relates to a composition for treating a concrete surface. In particular, the invention relates to a composition, a method of producing the composition, and a method for treating a concrete surface.

Background

[003] Concrete is a ubiquitous material for construction. Water exchange between an interior of concrete and the environment often causes degradation of the concrete. Hence, curing agent is usually a composition used to treat concrete surface in order to modify or protect its surface properties, such as, in terms of hydrophobicity and hardness.

[004] For instance, a China Patent Application Publication No. CN104150954A discloses a concrete seal curing agent including 50 to 70 wt % of silicate, 10 to 30 wt % of silane coupling agent, 1 to 3 wt % of nano titanium dioxide and water. The curing agent further includes silicone water repellent, surfactant and/or an antifoaming agent.

[005] Another China Patent Application Publication No. CN110482996A discloses a concrete sealing curing agent and preparation method and application thereof. Particularly, the curing agent includes a first component and a second component. The first component includes lithium silicate, potassium silicate, silica sol, penetrant, hydrophobic agent and water while the second component includes magnesium fluorosilicate, zinc sulfate, and water. According to CN 110482996A, the first component is applied before the second component on the concrete surface.

[006] Alternatively, there is a need for a way to enhance durability of a concrete with minimum maintenance effort. Particularly, there is a need for a product and method to provide prolonged treatment effect.

Summary

[007] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the present invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[008] The present invention seeks to provide a composition and method for treating concrete whereby the treatment includes but not limited to sealing, densification and hydrophobization of a concrete surface. The composition can be used alone to provide the aforementioned effect. Alternatively, the composition can be used together with one or more suitable concrete curing agent.

[009] The present invention also provides a composition and method capable of sealing cracks, such as micro cracks, on a concrete surface layer by incorporating nano-size cementitious particles therein.

[0010] The present invention also provides a composition and method capable of extending the service life of concrete with relatively large surface area, such as a pavement, a slab, a panel, a wall, a façade, or the like.

[0011] The present invention also provides a composition and method for enhancing durability of concrete used in aquatic environment, such as, an on-shore or off-shore structure, concrete piping, or the like.

[0012] In one embodiment, the present invention provides a composition for treating a concrete surface, comprising: an alkaline cured mixture comprising a cement hydrate suspension and an organosilicon composition, with the organosilicon composition

comprising silica nanoparticles, wherein the composition provides hydrophobicity to a treated concrete surface.

[0013] Preferably, the cement hydrate suspension comprises substantially 10 wt% of cement powder in an aqueous solution.

[0014] Preferably, the organosilicon composition comprises polymethylhydrogensiloxane in substantially 5 to 50 wt % of the composition; tetraethyl orthosilicate (TEOS) in substantially 10 to 30 wt % of the composition; colloidal silica in substantially 1 to 10 wt % of the composition; functional silane in substantially 5 to 10 wt % of the composition; and ethanol.

[0015] Preferably, the colloidal silica has silica nanoparticles having particle size ranging from substantially 10 to 50 nm.

[0016] Preferably, the functional silane is selected from the group consisting of *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane and γ -glycidoxypopyl trimethoxysilane.

[0017] By way of example, the functional silane is *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane in substantially 1 to 5 wt % of the composition.

[0018] By way of example, the functional silane is γ -glycidoxypopyl trimethoxysilane in substantially 1 to 5 wt % of the composition.

[0019] Preferably, the mixture is cured by an alkaline hydroxide selected from the group consisting of potassium hydroxide and sodium hydroxide.

[0020] In one embodiment, the present invention provides method of producing the above composition, the method comprising the steps of mixing the cement hydrate suspension and the organosilicon composition to form a mixture; reacting the mixture with the alkaline hydroxide at a reaction temperature between substantially -20 to -5 °C to obtain a reacted mixture; and stirring the reacted mixture in room temperature to obtain a cured mixture.

[0021] Preferably, the alkaline hydroxide used is by obtained by dissolving an alkaline hydroxide in water and reducing temperature of the dissolved alkaline hydroxide to substantially -20 to -5 °C.

[0022] Advantageously, the reaction temperature can be obtained via cryogenic cooling.

[0023] Preferably, the step of reacting the mixture is conducted in the presence of continuous stirring at a stirring speed of substantially 100 rpm to 500 rpm.

[0024] Preferably, the step of stirring the reacted mixture is conducted at substantially 25 °C.

[0025] Preferably, the step of stirring the reacted mixture is conducted at a stirring speed of substantially 100 rpm to 500 rpm.

[0026] In another embodiment, the present invention provides a method for treating a concrete surface, the method comprising the steps of: conditioning a concrete surface; coating the conditioned concrete surface with the above alkaline cured mixture; and drying the coated concrete surface to obtain a hydrophobic concrete surface.

[0027] Preferably, the step of conditioning the concrete surface is conducted by applying a concrete hardener.

[0028] By way of example, the concrete hardener is selected from the group consisting of magnesium fluorosilicate and sodium fluorosilicate.

Brief Description of the Drawings

[0029] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0030] FIG. 1 illustrates a schematic diagram showing an exemplary interaction of the composition in the preferred embodiment with a concrete surface during treatment; and

[0031] FIG. 2 illustrates a flow diagram showing a series of steps involved in a preferred embodiment of the present invention.

Detailed Description

[0032] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the present invention.

[0033] The present invention provides a composition for treating concrete surface. The composition comprises an alkaline cured mixture and an organosilicon composition; the alkaline cured mixture comprises a cement hydrate suspension whilst the organosilicon composition comprises silica nanoparticles. FIG. 1 is an illustration showing the interaction of the composition with a concrete surface upon curing.

[0034] As shown in FIG. 1, the composition is applied on a conditioned concrete surface. The 'fresh concrete' herein refers to an uncured concrete which is in a plastic, moldable state as known in the art. A 'conditioned concrete' herein refers to a fresh concrete being treated to a certain extent, but remains hydrated and uncured. For instance, a 'conditioned concrete' can be conditioned by hardening thereof, preferably by a mild concrete hardener, to avoid dehydration. An exemplary concrete hardener used herein is magnesium fluorosilicate, preferably at a low concentration such as substantially 10 wt % in water. FIG. 1 shows the application of the composition on a fresh concrete being conditioned by a mild concrete hardener having about 10 wt % of magnesium fluorosilicate in water. In another embodiment, the composition of the present invention can be applied directly on a fresh concrete surface, as desired. Optionally, the concrete surface can be roughened for a better adhesion of the composition to be applied later.

[0035] The composition can be applied on the concrete surface by a coating technique, such as, spraying, brushing, or the like, so as to form a coating over the concrete surface. During surface treatment, the composition provides cementitious and silica micro and/or

nanoparticles which can penetrate and seal existing cracks. On the other hand, molecular siloxanes from the organosilicon composition promotes adhesion and film formation. They are able to be cured at room temperature in the presence of an alkaline catalyst, thereby forming a high penetrable, hydrophobic film on the treated concrete surface. It is found that upon curing the concrete surface using the composition in the present invention, the concrete surface can achieve a contact angle of substantially more than 130°.

[0036] In one embodiment, the mixture comprises substantially 50 wt % of cement hydrate suspension and substantially 50 wt% of the organosilicon composition. Preferably, the suspension comprises cementitious particles having an average particle size between 50 to 100 nm. In another embodiment, the mixture comprises substantially 30 wt % of cement hydrate suspension and substantially 70 wt% of the organosilicon composition.

[0037] In one embodiment, the cement hydrate suspension comprises substantially 10 wt % of cement powder in an aqueous solution. Preferably, the cement hydrate suspension is obtained via hydrothermal treatment, such that cementitious particles are dispersed in the aqueous solution to form a nanosuspension. More preferably, the cement hydrate suspension is obtained by mixing 10 g of cement powder in 100 mL of water at about 90 to 100 °C (or substantially 95 °C) with stirring at a speed substantially 400 to 600 rpm, preferably about 500 rpm, for about 9 to 12 hours.

[0038] In one embodiment, the organosilicon composition comprises polymethylhydrogensiloxane in substantially 5 to 50 wt % of the composition, tetraethyl orthosilicate (TEOS) in substantially 10 to 30 wt % of the composition, colloidal silica in substantially 1 to 10 wt % of the composition, functional silane in substantially 5 to 10 wt % of the composition, and ethanol. More particularly, the organosilicon composition comprises polymethylhydrogensiloxane in substantially 20 wt % of the composition, tetraethyl orthosilicate (TEOS) in substantially 20 wt % of the composition, colloidal silica in substantially 5 wt % of the composition, functional silane in substantially 5 wt % of the composition, and ethanol. Preferably, the colloidal silica used has silica nanoparticles having particle size ranging from substantially 10 to 50 nm. Further, the functional silane used is selected from the group consisting of *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane and γ -glycidoxypentyl trimethoxysilane. More preferably, the functional

silane used comprises a combination of *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane and γ -glycidoxypopyl trimethoxysilane. By way of example, the organosilicon composition comprises *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane in substantially 1 to 5 wt %. By way of example, the organosilicon composition comprises γ -glycidoxypopyl trimethoxysilane in substantially 1 to 5 wt %.

[0039] Accordingly, the cement hydrate suspension and the organosilicon composition are mixed to obtain a homogeneous dispersion. In one embodiment, the mixture comprises substantially 100 g of the cement hydrate suspension, substantially 10 g of polymethylhydrogensiloxane, substantially 10 g of TEOS, substantially 50 g of colloidal silica, substantially 10 g of *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane, substantially 10 g of γ -glycidoxypopyl trimethoxysilane and substantially 10 g of ethanol.

[0040] In one embodiment, the method of producing the composition comprises the steps of mixing the cement hydrate suspension and the organosilicon composition to obtain a mixture, followed by curing the mixture with an alkaline hydroxide at a curing temperature between substantially -20 to -5 °C, more preferably at a temperature of substantially -10 °C, to obtain a cured mixture. Preferably, the mixture is cured by an alkaline catalyst, such as alkaline hydroxide selected from the group consisting of potassium hydroxide (KOH) and sodium hydroxide (NaOH). More preferably, substantially 10 wt % of KOH in water is used. Further, it is preferred that the alkaline hydroxide is provided at a temperature of substantially -20 to -5 °C, more preferably at a temperature of substantially -10 °C.

[0041] FIG. 2 illustrates a set up accompanied by the steps involved in producing the alkaline cured mixture from the cement hydrate suspension and the organosilicon composition. According to FIG. 2, the setup is provided in a cryogenic environment whereby the alkaline catalyst is first prepared and provided in a container equipped with a cryogenic coolant circulation at about substantially -20 to -5 °C. The cryogenic coolant is preferably a coolant in a form of liquid to be circulated by a pump. Additionally, the container is further equipped with a stirrer, preferably a rotatable stirrer which provides continuous stirring to the alkaline catalyst at a speed of substantially 100 to 500 rpm, more preferably at a speed of substantially 500 rpm.

[0042] Secondly, the alkaline catalyst reacts with the mixture of cement hydrate suspension and the organosilicon composition upon mixing in the container provided in the setup, whereby cryogenic coolant circulation and stirring continues in the reacting step. In one embodiment, substantially 10 g per 1000 mL of alkaline catalyst in water reacts with substantially 200 g of the mixture of cement hydrate suspension and the organosilicon composition upon mixing in the container. The reacting step takes place until a uniform suspension is obtained. In one embodiment, the reaction takes substantially 6 hours.

[0043] Thirdly, the cryogenic coolant circulation is preferably halted after achieving -20 to -5 °C. The reacted mixture is preferably continued to be stirred for substantially 12 hours at room temperature to obtain a cured mixture. Preferably, the reacted mixture is continued to be stirred at about 100 rpm to 500 rpm at about 25 °C to obtain a cured mixture.

[0044] The cured mixture is a uniform suspension which can be readily applied as a coating on a concrete surface. Alternatively, the cured mixture may be further added with modifiers, additives, or the like to provide in another form, such as powder, granules, beads, or the like. Optionally, the cured mixture may be added into compatible paints, shellacs, or the like to provide hydrophobicity and aesthetics upon coating or brushing onto the concrete surface.

[0045] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations of variations disclosed in the text description and drawings thereof could be made to the present invention without departing from the scope of the present invention.

CLAIMS:

1. A composition for treating a concrete surface, comprising:
an alkaline cured mixture comprising a cement hydrate suspension and an organosilicon composition comprising silica nanoparticles, wherein the composition provides hydrophobicity to a treated concrete surface.
2. The composition according to claim 1, wherein the cement hydrate suspension comprising substantially 10 wt% of cement powder in an aqueous solution.
3. The composition according to claim 1 or 2, wherein the organosilicon composition comprising:
polymethylhydrogensiloxane in substantially 5 to 50 wt % of the composition;
tetraethyl orthosilicate (TEOS) in substantially 10 to 30 wt % of the composition;
colloidal silica in substantially 1 to 10 wt % of the composition;
functional silane in substantially 5 to 10 wt % of the composition; and
ethanol.
4. The composition according to claim 3, wherein the colloidal silica has silica nanoparticles having particle size ranging from substantially 10 to 50 nm.
5. The composition according to claim 3, wherein the functional silane is selected from the group consisting of *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane and γ -glycidoxypropyl trimethoxysilane.
6. The composition according to claim 5, wherein the functional silane is *N*-(2-aminoethyl)-3-aminopropyl trimethoxysilane in substantially 1 to 5 wt % of the composition.
7. The composition according to claim 5, wherein the functional silane is γ -glycidoxypropyl trimethoxysilane in substantially 1 to 5 wt % of the composition.

8. The composition according to any one of claims 1 to 7, wherein the mixture is cured by an alkaline hydroxide selected from the group consisting of potassium hydroxide and sodium hydroxide.
9. A method of producing a coating composition according to any one of claims 1 to 8, the method comprising the steps of:
 - mixing the cement hydrate suspension and the organosilicon composition to form a mixture; and
 - reacting the mixture with the alkaline hydroxide at a reaction temperature between substantially -20 to -5 °C to obtain a cured mixture.
10. The method according to claim 9, wherein the alkaline hydroxide used is obtained by dissolving an alkaline hydroxide in water and reducing temperature of the dissolved alkaline hydroxide to substantially -20 to -5 °C.
11. The method according to claim 9 or 10, wherein the reaction temperature is obtained via cryogenic cooling.
12. The method according to any one of claims 9 to 11, wherein the step of reacting the mixture is conducted in the presence of continuous stirring at a stirring speed of substantially 100 rpm to 500 rpm.
13. A method for treating a concrete surface, the method comprising the steps of:
 - coating the conditioned concrete surface with the alkaline cured mixture according to any one of claims 1 to 8; and
 - drying the coated concrete surface to obtain a hydrophobic concrete surface.
14. The method according to claim 13 further comprising a step of conditioning the concrete surface by applying a concrete hardener.
15. The method according to claim 14, wherein the concrete hardener is selected from the group consisting of magnesium fluorosilicate and sodium fluorosilicate.