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PATENTABILITY SEARCH REPORT

TITLE: Self-Healing Surface Coating Systems For Passive Pollutant Degradation, Optional Acoustic Damping, And Environmental Sensing

CASE: TURNaIR.1

JUL 09, 2025

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1. SEARCH

1.1 Key Features

The below key features are prepared based on the Invention Disclosure Form titled as “TURNaiR.1”

Key Features	
1	A multifunctional self-healing surface coating system for combating air pollution.
2	The coating system includes a photocatalytic top layer that uses UV light or visible light to decompose pollutants such as nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs), PM2.5, PM10.
2a	The mechanism of action for degradation is by gas phase degradation
2b	The photocatalytic layer includes a photocatalyst selected from titanium dioxide (anatase), graphene oxide, zinc oxide, tungsten trioxide, or ferric oxide.
2b1	The layer is a sticky hydrophilic layer
3	The surface coating system includes a self-healing/regenerative intermediate layer, which facilitates the generation/repair/healing of the top layer upon degradation.
3a	The layer includes nano-encapsulated photocatalytic agents.

Key Features	
3a1	The nano-capsules include silica-encapsulated or similar photocatalytic agents, such as TiO_2 and graphene composites, ensuring sustained performance.
3a2	Fresh TiO_2 + graphene released stays anchored near the surface so it stays UV-accessible
3b	The layer includes a polyurethane-based matrix with healing agents.
3b1	The healing agents include isocyanate-terminated prepolymers, epoxy-amine dual-reactants, dynamic covalent networks such as Diels–Alder systems, and supramolecular hydrogen bonding networks.
3b2	The healing agents are microencapsulated agents that rupture upon abrasion.
3b3	The healing agents can include in-matrix healing chemistries.
3c	The self-healing regenerative layer includes optional acoustic-damping fillers such as cork powder, rubber crumb, or polymer microspheres, for acoustic damping.
4	The surface coating system includes a primer layer, which is applied to prepared substrates.
4a	The primer layer is composed of polyurethane-epoxy resin or similar to provide appropriate adhesion to broad range of substrates

Key Features	
4b	The primer layer is compatible with substrates including concrete, metal, asphalt, composites, and glass.
5	The surface coating system can also be in a single-layer-based structure with a self-healing layer and a photocatalytic (pollutant degradation) layer incorporated into one.
6	The surface coating(s) can be applied by spray-on or roll-on
7	The surface coating system operates under passive, ambient triggers like humidity or moisture with no external heat or power requirement.

1.2 Summary of Relevant References

The search uncovered 2 central patent references and 7 additional patent references and 5 additional non patent references. These references are listed below in order of their relevance, meaning the closest mapped reference is listed on the top and so on. Bibliographic details of these references along with the key feature matrix is provided in the subsequent tables.

Based on the analysis of the identified references, it can be concluded that the references, either individually or in combination, disclose a multilayer composition that facilitates self-healing and incorporates photocatalytic agents to combat air pollution. However, the references do not explicitly disclose features such as “The layer is a sticky hydrophilic layer”, “The layer includes nano-encapsulated photocatalytic agents.”, “Fresh TiO_2 + graphene released stays anchored near the surface so it stays UV-accessible”, etc.

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1.3 Bay Feature-wise Suggestions

This section presents our suggestions, specifically our proposed edits to the key features to differentiate over the identified references, based on our search.

Key Features		Bay Comments/Suggestions
1	A multifunctional self-healing surface coating system for combating air pollution.	The feature appears to be covered in both the central references; however, none of the identified references are focused on urban application. Therefore, we suggest the addition of urban application related limitations. See example language below. A multifunctional self-healing surface coating composition for urban applications to combat air pollution.
2	The coating system includes a photocatalytic top layer that uses UV light or visible light to decompose pollutants such as nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs), PM2.5, PM10.	The feature appears to be broadly covered in the Chinese central reference; however, the reference does not explicitly disclose that the photocatalytic top layer can decompose volatile organic compounds (VOCs) and particulate pollutants, including PM2.5, PM10, etc. Therefore, we suggest the addition of limitations related to VOC and particulate pollutants. See example language below.

Key Features		Bay Comments/Suggestions
		The coating composition includes a top layer designed to combat gaseous pollutants, volatile organic compounds (VOCs), and particulate pollutants.
2a	The mechanism of action for degradation is by gas phase degradation.	The feature appears to be broadly disclosed in the Chinese central reference; hence, no specific recommendation.
2b	The photocatalytic layer includes a photocatalyst selected from titanium dioxide (anatase), graphene oxide, zinc oxide, tungsten trioxide, or ferric oxide.	The feature appears to be broadly covered in both the central references; however, the references do not explicitly disclose the combination of more than one photocatalyst. Therefore, we suggest changes related to the use of a combination of more than one photocatalyst. Also, we can emphasize the feature that the use of different types of photocatalysts in combination may help in combating different types of pollutants (if technically correct). See example language below. The top layer includes a photocatalyst comprising titanium dioxide, graphene oxide, zinc oxide, tungsten trioxide, ferric oxide, or a combination thereof, to combat different types of pollutants.
2b1	The layer is a sticky hydrophilic layer.	None of the references explicitly discloses the use of a hydrophilic top layer for the mitigation of particulate pollutants. Therefore, we recommend the

Key Features		Bay Comments/Suggestions
		addition of limitations related to particulate pollutants. See example language below. The top layer exhibits sticky and hydrophilic properties to aid in the mitigation of particulate pollutants.
3	The surface coating system includes a self-healing/regenerative intermediate layer, which facilitates the generation/repair/healing of the top layer upon degradation.	The feature appears to be broadly covered in both the central references; however, none of the references explicitly disclose that the intermediate layer also enhances the photocatalytic properties of the top layer. Therefore, we suggest the following language. The coating composition includes an intermediate layer that facilitates repair of the top layer and enhances the photocatalytic properties of the top layer upon degradation.
3a	The layer includes nano-encapsulated photocatalytic agents.	None of the references disclose the use of nano-encapsulated/encapsulated photocatalytic agents. Therefore, we propose broadening the scope of this feature. See example language below. The intermediate layer includes encapsulated photocatalytic agents, which may be nano-encapsulated.

Key Features		Bay Comments/Suggestions
3a1	The nano-capsules include silica-encapsulated or similar photocatalytic agents, such as TiO_2 and graphene composites, ensuring sustained performance.	None of the references disclose the use of nano-encapsulated photocatalytic agents, specifically the use of TiO_2 and graphene composites. We made a slight language change; see below. The nano-capsules contain photocatalytic agents, such as TiO_2 and graphene composites.
3a2	Fresh TiO_2 + graphene released stays anchored near the surface so it stays UV-accessible	None of the references disclose that the released fresh photocatalyst (Fresh TiO2 + graphene) stays anchored near the surface. Therefore, we propose broadening the scope of this feature. See example language below. The photocatalysts released from the intermediate layer remain anchored to the top layer upon release, wherein the photocatalyst can be TiO2 and graphene complex.
3b	The layer includes a polyurethane-based matrix with healing agents.	The feature appears to be inferentially disclosed in the Chinese central reference; hence, no specific recommendation.
3b1	The healing agents include isocyanate-terminated prepolymers, epoxy-amine	The feature appears to be broadly disclosed in both the central references; hence, no specific recommendation.

Key Features		Bay Comments/Suggestions
	dual-reactants, dynamic covalent networks such as Diels–Alder systems, and supramolecular hydrogen bonding networks.	
3b2	The healing agents are microencapsulated agents that rupture upon abrasion.	The feature appears to be broadly disclosed in both the central references; hence, no specific recommendation.
3b3	The healing agents can include in-matrix healing chemistries.	None of the references disclose that the healing agents can include in-matrix healing chemistries. We made a slight language change; see example language below. The intermediate layer includes healing agents, which can include in-matrix healing chemistries.
3c	The self-healing regenerative layer includes optional acoustic-damping fillers such as cork powder, rubber crumb, or polymer microspheres, for acoustic damping.	The feature appears to be broadly covered in one of the additional references (EP1642643B1), however, the reference does not explicitly disclose that the acoustic-damping fillers are part of the intermediate layer. Therefore, we suggest the following:

Key Features		Bay Comments/Suggestions
		The intermediate layer includes acoustic-damping fillers such as cork powder, rubber crumb, or polymer microspheres, for acoustic damping.
4	The surface coating system includes a primer layer, which is applied to prepared substrates.	None of the references disclose the multi-layered coating system, including a primer that can be applied to different types of substrates. Therefore, we suggest the following changes. The coating composition includes a bottom layer which is applied to prepared substrates associated with different urban infrastructures, including building exteriors, glass, facades, roads, etc.
4a	The primer layer is composed of polyurethane-epoxy resin or similar to provide appropriate adhesion to broad range of substrates	None of the references disclose a composition of primer that can provide appropriate adhesion to a broad range of substrates. Therefore, we suggest changes as below. The composition of the bottom layer is selected to facilitate strong adhesion to different types of applications, including building walls, roads, bridges, and similar structures.

Key Features		Bay Comments/Suggestions
4b	The primer layer is compatible with substrates including concrete, metal, asphalt, composites, and glass.	None of the references explicitly discloses the feature. Therefore, we made a slight language change to highlight the feature; see example language below. The composition of the bottom layer is compatible with various substrates, including concrete, metal, asphalt, composites, and glass.
5	The surface coating system can also be in a single-layer-based structure with a self-healing layer and a photocatalytic (pollutant degradation) layer incorporated into one.	The feature appears to be inferentially disclosed in the Korean central reference. However, the reference does not disclose encapsulation of photocatalytic agents. Therefore, we suggest adding limitations related to the encapsulated photocatalytic agents. See example language below. A multifunctional self-healing surface coating composition can be incorporated in a single-layer structure wherein the single layer of surface coating composition includes encapsulated/nano-encapsulated photocatalytic agents and micro-encapsulated self-healing agents.
6	The surface coating(s) can be applied by spray-on or roll-on	None of the references explicitly discloses the feature. However, the feature appears to be generic, so we suggest the addition of limitations related to

Key Features		Bay Comments/Suggestions
		self-healing agents and photocatalytic agents. See example language below. The coating composition, including self-healing agents and photocatalytic agents, can be applied using spray-on or roll-on.
7	The surface coating system operates under passive, ambient triggers like humidity or moisture with no external heat or power requirement.	The feature appears to be inferentially/explicitly disclosed, so we do not suggest changes.

1.4 Patent References

S. No.	Publication No.	Title	Assignee	Publication Date
1	CN119910973A	Moisture-absorbing and moisture-proof composite film	YUNNAN MINGBO IND CO LTD	May 02, 2025
2	KR102040964B1	coating composition manufacturing method of silica aerogel for radon mitigation	SEONG HWA FINE CERAM CO LTD	Nov 06, 2019

1.5 Feature Matrix

S. No.	Key Features	CN119910973A	KR102040964B1
1	A multifunctional self-healing surface coating system for combating air pollution.	✓	☑

S. No.	Key Features	CN119910973A	KR102040964B1
2	The coating system includes a photocatalytic top layer that uses UV light or visible light to decompose pollutants such as nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs), PM2.5, PM10.	✓	X
2a	The mechanism of action for degradation is by gas phase degradation	✓	X
2b	The photocatalytic layer includes a photocatalyst selected from titanium dioxide (anatase), graphene oxide, zinc oxide, tungsten trioxide, or ferric oxide.	✓	✓*
2b1	The layer is a sticky hydrophilic layer	X	X
3	The surface coating system includes a self-healing/regenerative intermediate layer, which facilitates the generation/repair/healing of the top layer upon degradation.	✓	✓*

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S. No.	Key Features	CN119910973A	KR102040964B1
3a	The layer includes nano-encapsulated photocatalytic agents.	✓*	X
3a1	The nano-capsules include silica-encapsulated or similar photocatalytic agents, such as TiO_2 and graphene composites, ensuring sustained performance.	X	X
3a2	Fresh TiO_2 + graphene released stays anchored near the surface so it stays UV-accessible	X	X
3b	The layer includes a polyurethane-based matrix with healing agents.	☑	X
3b1	The healing agents include isocyanate-terminated prepolymers, epoxy-amine dual-reactants, dynamic covalent networks such as Diels–Alder systems, and supramolecular hydrogen bonding networks.	☑	☑
3b2	The healing agents are microencapsulated agents that rupture upon abrasion.	✓	✓

S. No.	Key Features	CN119910973A	KR102040964B1
3b3	The healing agents can include in-matrix healing chemistries.	X	X
3c	The self-healing regenerative layer includes optional acoustic-damping fillers such as cork powder, rubber crumb, or polymer microspheres, for acoustic damping.	X	X
4	The surface coating system includes a primer layer, which is applied to prepared substrates.	X	X
4a	The primer layer is composed of polyurethane-epoxy resin or similar to provide appropriate adhesion to broad range of substrates	X	X
4b	The primer layer is compatible with substrates including concrete, metal, asphalt, composites, and glass.	✓*	☑
5	The surface coating system can also be in a single-layer-based structure with a self-healing layer and a photocatalytic (pollutant degradation) layer incorporated into one.	X	☑

S. No.	Key Features	CN119910973A	KR102040964B1
6	The surface coating(s) can be applied by spray-on or roll-on	X	X
7	The surface coating operates under passive, ambient triggers like humidity or moisture with no external heat or power requirement.	✓	X

LEGENDS:

✓: Complete mapping
☑: Inferential mapping
✓*: Partial mapping
X: No mapping

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2. CENTRAL REFERENCES

Central Patent References

RESULT 1: CN119910973A

Title	Moisture-absorbing and moisture-proof composite film		
Publication No.	CN119910973A	**Publication Date**	May 02, 2025
Application No.	CN202510176225A	**Application Date**	Feb 18, 2025
Assignee	YUNNAN MINGBO IND CO LTD	**Priority Date**	Feb 18, 2025
Abstract	The invention discloses a moisture-absorbing and moisture-proof composite film, and relates to the technical field of film materials, the moisture-absorbing and moisture-proof composite film comprises an inner layer, a middle layer and an outer layer, the inner layer is a moisture-absorbing layer, the middle layer is a moisture-proof layer, and the outer layer is a protective layer; the moisture-absorbing and moisture-proof composite film further comprises the following additives, wherein the additives comprise photocatalytic nanoparticles; a negative ion releasing agent; a high strength bio-based polymer; a self-repairing polymer; and the natural antioxidant is encapsulated by microcapsules. According to the moisture-absorbing and moisture-proof composite film, innovative materials such as the high-strength bio-based polymer, the negative ion releasing agent, the self-repairing polymer and the natural antioxidant		

	microcapsules are adopted, and the comprehensive performance of the film is enhanced. Not only is excellent moisture absorption and moisture prevention functions achieved, but also the air purification and antibacterial performance is improved by adding the negative ion releasing agent; the self-repairing polymer can automatically repair cracks when the surface of the film is damaged, so that the service life is prolonged; the microcapsules of natural antioxidants can effectively resist oxidation and ensure that the membrane material keeps excellent performance for a long time.

S. No.	Key Features	Relevant Text for CN119910973A
1	A multifunctional self-healing surface coating system for combating air pollution.	[Excerpt 1] The invention discloses a **moisture-absorbing and moisture-proof composite film**, and relates to the technical field of film materials… [Excerpt 2] **Mix titanium alloy, zinc oxide and iron oxide** according to their mass fractions, add an appropriate amount of organic solvent (such as isopropyl alcohol) to disperse and form a uniform slurry. **This mixture will play a negative ion release function in the outer and middle layers of the membrane, purify the air and enhance the antibacterial ability of the membrane**. In particular, zinc oxide can decompose harmful substances in the air under ultraviolet light, while titanium alloy

S. No.	Key Features	Relevant Text for CN119910973A
		and iron oxide continuously release negative ions, effectively improving the quality of ambient air. [Excerpt 3] The moisture-absorbing and moisture-proof composite membrane overcomes the problems of poor durability and insufficient antioxidant properties in the existing technology through a reasonable hierarchical structure design and a combination of multiple innovative materials. **The composite membrane uses innovative materials such as high-strength bio-based polymers, negative ion releasers, self-healing polymers**, and natural antioxidant microcapsules to enhance the comprehensive performance of the membrane. Not only does it have excellent moisture-absorbing and moisture-proof functions, **but it also improves air purification** and antibacterial properties **through the addition of negative ion releasers**; **the self-healing polymer can automatically repair cracks when the membrane surface is damaged**, extending the service life; the natural antioxidant microcapsules can effectively resist oxidation, ensuring that the membrane material maintains excellent performance for a long time. In addition, the raw materials of the membrane mainly come from renewable bio-based polymers, which have good environmental friendliness and degradability, and meet current environmental

S. No.	Key Features	Relevant Text for CN119910973A
		protection requirements. Therefore, while improving performance, the composite membrane has a high market application prospect. **Analyst comment:** The reference discloses a composite film which is capable of self-healing and purifying air to combat air pollution.
2	The coating system includes a photocatalytic top layer that uses UV light or visible light to decompose pollutants such as nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs), PM2.5, PM10.	[Excerpt 1] **Outer layer** (protective layer): **Negative ion releasers** and natural antioxidants encapsulated in microcapsules give the **membrane air purification** and antioxidant protection functions, enhancing the membrane's adaptability in harsh environments. [Excerpt 2] Furthermore, the **negative ion releaser provides a continuous air purification function in the outer layer** of the membrane, which is particularly suitable for environments with poor air quality. Compared with the single moisture-proof or waterproof function in the prior art, the additional health and air purification effects provided by the negative ion releaser enhance the comprehensive function of the membrane. **Titanium alloy** has high strength, corrosion resistance and good electronic conductivity, and is suitable for **negative ion release**. The **titanium**

S. No.	Key Features	Relevant Text for CN119910973A
		surface can generate negative ions under the action of air humidity and ultraviolet rays, and release them into the air through a certain carrier structure. **Zinc oxide** is a common semiconductor material that can generate electron-hole pairs under ultraviolet light, thereby releasing negative ions. It is widely **used in air purification** and antibacterial materials. **Iron oxide can be used as a catalyst for the release of negative ions, and its surface can adsorb and release negative ions to improve air quality.** [Excerpt 3] In the formula, the organic **pollutant benzyl methane is decomposed into carbon dioxide and water under the catalytic action of titanium dioxide, purifying the air; ultraviolet light UV is the driving factor in the reaction and is used to enhance the efficiency of photocatalysis.** [Excerpt 4] To further optimize the technical solution, the photocatalytic nanoparticles are titanium dioxide. **Under ultraviolet irradiation, titanium dioxide decomposes organic pollutants in the air;**

S. No.	Key Features	Relevant Text for CN119910973A
2a	The mechanism of action for degradation is by gas phase degradation	[Excerpt 1] In the formula, the organic **pollutant benzyl methane is decomposed into carbon dioxide and water under the catalytic action of titanium dioxide, purifying the air**; ultraviolet light UV is the driving factor in the reaction and is used to enhance the efficiency of photocatalysis.
2b	The photocatalytic layer includes a photocatalyst selected from titanium dioxide (anatase), graphene oxide, zinc oxide, tungsten trioxide, or ferric oxide.	[Excerpt 1] Furthermore, the **negative ion releaser provides a continuous air purification function in the outer layer of the membrane, which is particularly suitable for environments with poor air quality.** Compared with the single moisture-proof or waterproof function in the prior art, the additional health and air purification effects provided by the negative ion releaser enhance the comprehensive function of the membrane. Titanium alloy has high strength, corrosion resistance and good electronic conductivity, and is suitable for negative ion release. The **titanium surface can generate negative ions under the action of air humidity and ultraviolet rays, and release them into the air through a certain carrier structure**. **Zinc oxide** is a common semiconductor material that can generate electron-hole pairs **under ultraviolet light, thereby releasing negative ions**. It is

S. No.	Key Features	Relevant Text for CN119910973A
		widely used in **air purification** and antibacterial materials. **Iron oxide can be used as a catalyst for the release of negative ions**, and its surface can adsorb and **release negative ions to improve air quality**. [Excerpt 2] To further optimize the technical solution, the **negative ion releaser includes titanium alloy, zinc oxide and iron oxide**;
2b1	The layer is a sticky hydrophilic layer	NA
3	The surface coating system includes a self-healing/regenerative intermediate layer, which facilitates the generation/repair/healing of the top layer upon degradation.	[Excerpt 1] **1 and 2 are the first embodiment of the present invention, which provides a moisture-absorbing and moisture-proof composite film, including** an inner layer, **a middle layer** and an outer layer, wherein the inner layer is a moisture-absorbing layer, the middle layer is a moisture-proof layer, and the outer layer is a protective layer [Excerpt 2]

S. No.	Key Features	Relevant Text for CN119910973A
		the **photocatalytic nanoparticles and self-repairing polymer are added in the middle layer** [Excerpt 3] the **self-healing polymer can automatically repair cracks when the membrane surface is damaged, extending the service life**; [Excerpt 4] **Middle layer** (moisture-proof layer): **Photocatalytic nanoparticles and self-healing polymers** enable the membrane to have **self-cleaning and self-repairing** capabilities, improving the durability and intelligence of the membrane. **Analyst comment:** The reference discloses a composite film with a middle layer with photocatalytic nanoparticles and self-repairing polymers which repair cracks when the surface is damaged.
3a	The layer includes nano-encapsulated photocatalytic agents.	[Excerpt 1] the **photocatalytic nanoparticles and self-repairing polymer are added in the middle layer**

S. No.	Key Features	Relevant Text for CN119910973A
		[Excerpt 2] To further optimize the technical solution, the **photocatalytic nanoparticles are titanium dioxide. Under ultraviolet irradiation, titanium dioxide decomposes organic pollutants in the air;** **Analyst comment:** The reference discloses that the middle layer includes photocatalytic nano-particles. However, the reference does not explicitly disclose use of nano-encapsulated photocatalytic nanoparticles.
3a1	The nano-capsules include silica-encapsulated or similar photocatalytic agents, such as TiO_2 and graphene composites, ensuring sustained performance.	NA
3a2	Fresh TiO_2 + graphene released stays anchored near the surface so it stays UV-accessible	NA

S. No.	Key Features	Relevant Text for CN119910973A
3b	The layer includes a polyurethane-based matrix with healing agents.	[Excerpt 1] The components of the **middle layer include polyurethane**, fluorinated polymer, graphene and waterproof coating; for moisture-proofing, polyurethane provides strength and elasticity, fluorinated polymer enhances the waterproof performance of the membrane, graphene improves the overall stability and thermal conductivity of the membrane, and the waterproof coating effectively prevents moisture penetration. [Excerpt 2] the **photocatalytic nanoparticles and self-repairing polymer are added in the middle layer** **Analyst comment:** The reference discloses that the middle layer includes polyurethane. Further, there reference discloses that the middle layer includes photocatalytic nanoparticles and self-repairing polymer. Therefore, it is inferred that the middle layer includes polyurethane-based matrix with healing agents.
3b1	The healing agents include isocyanate-terminated	[Excerpt 1]

S. No.	Key Features	Relevant Text for CN119910973A
	prepolymers, epoxy-amine dual-reactants, dynamic covalent networks such as Diels–Alder systems, and supramolecular hydrogen bonding networks.	To further optimize the technical solution, the self-repairing polymer contains **microcapsules, and the microcapsules contain a repair agent** of a **carboxyl monomer**; when the composite film is damaged, the repair agent is released from the microcapsules and undergoes a polymerization reaction to repair the cracks; **Analyst comment:** The reference discloses that microcapsules contain a repair agent of a carboxyl monomer which can be part of supramolecular hydrogen bonding networks.
3b2	The healing agents are microencapsulated agents that rupture upon abrasion.	[Excerpt 1] To further optimize the technical solution, the **self-repairing polymer contains microcapsules**, and the microcapsules contain a repair agent of a carboxyl monomer; **when the composite film is damaged, the repair agent is released from the microcapsules and undergoes a polymerization reaction to repair the cracks;**
3b3	The healing agents can include in-matrix healing chemistries.	NA

S. No.	Key Features	Relevant Text for CN119910973A
3c	The self-healing regenerative layer includes optional acoustic-damping fillers such as cork powder, rubber crumb, or polymer microspheres, for acoustic damping.	NA
4	The surface coating system includes a primer layer, which is applied to prepared substrates.	NA
4a	The primer layer is composed of polyurethane-epoxy resin or similar to provide appropriate adhesion to broad range of substrates	NA
4b	The primer layer is compatible with substrates including	[Excerpt 1]

S. No.	Key Features	Relevant Text for CN119910973A
	concrete, metal, asphalt, composites, and glass.	Self-healing polymers can effectively extend the service life of the membrane and reduce maintenance costs. They have obvious advantages in environments where long-term use is required (such as **building exterior walls, car sunshade films**, etc.). **Analyst comment:** The reference discloses use of the composite film on building exterior walls which can be of concrete or other mentioned substrates. However, the reference does not explicitly disclose use of primer layer.
5	The surface coating system can also be in a single-layer-based structure with a self-healing layer and a photocatalytic (pollutant degradation) layer incorporated into one.	NA
6	The surface coating(s) can be applied by spray-on or roll-on	NA

S. No.	Key Features	Relevant Text for CN119910973A
7	The surface coating operates under passive, ambient triggers like humidity or moisture with no external heat or power requirement.	[Excerpt 1] Furthermore, the **negative ion releaser** provides a continuous air purification function in the **outer layer of the membrane**, which is particularly suitable for environments with poor air quality. Compared with the single moisture-proof or waterproof function in the prior art, the additional health and air purification effects provided by the negative ion releaser enhance the comprehensive function of the membrane. Titanium alloy has high strength, corrosion resistance and good electronic conductivity, and is suitable for negative ion release. The **titanium surface can generate negative ions under the action of air humidity and ultraviolet rays**, and release them into the air through a certain carrier structure. Zinc oxide is a common semiconductor material that can generate electron-hole pairs under ultraviolet light, thereby releasing negative ions. It is widely used in air purification and antibacterial materials. Iron oxide can be used as a catalyst for the release of negative ions, and its surface can adsorb and release negative ions to improve air quality.

RESULT 2: KR102040964B1

Title	A coating composition manufacturing method of silica aerogel for radon mitigation		
Publication No.	KR102040964B1	**Publication Date**	Nov 06, 2019
Application No.	KR20190066230A	**Application Date**	June 04, 2019
Assignee	SEONG HWA FINE CERAM CO LTD	**Priority Date**	June 04, 2019
Abstract	The present invention relates to a silica aerogel coating composition, which is used as interior finishing material for buildings, penetrates deeply into interior pores of building materials and hardens the surface, thereby not deteriorating over time, maintains aesthetic and texture of the materials by forming a transparent interior finishing material, has an effect of improving indoor air quality by suppressing the emission of radon gas and alpha waves of the buildings, and has excellent weather resistance such as water resistance, scratch resistance and the like, thereby being usefully used in the fields.		

S. No.	Key Features	Relevant Text for KR102040964B1
1	A multifunctional self-healing surface coating system for combating air pollution.	[Excerpt 1] The present invention relates to a **silica aerogel coating composition**, **which is used as interior finishing material for buildings**, penetrates deeply into interior

S. No.	Key Features	Relevant Text for KR102040964B1
		pores of building materials and hardens the surface, thereby not deteriorating over time, maintains aesthetic and texture of the materials by forming a transparent interior finishing material, has **an effect of improving indoor air quality by suppressing the emission of radon gas and alpha waves of the buildings**, and has excellent weather resistance such as water resistance, scratch resistance and the like, thereby being usefully used in the fields. [Excerpt 2] In the present invention, the composition may further include a known **additive in addition to the material**. Examples of the additives include fillers (pigments) such as artificial graphite, talc, mica, glass flakes, barium sulfate **and titanium dioxide;** Adhesion enhancers such as epoxy silane, amino silane, vinyl silane and acrylic silane; It may further contain an acrylic or silicone leveling agent. [Excerpt 3] In the present invention, the self-healing composition may be cured at room temperature in order to satisfy the above characteristics, and in particular, it is preferable to use a material that is cured according to moisture in the air. In addition, since the **self-healing composition should be cured only when necessary**, the

S. No.	Key Features	Relevant Text for KR102040964B1
		microcapsules block contact with the surroundings. **When a scratch occurs, the microcapsules are automatically broken to induce the internal self-healing composition to harden by filling the scratch periphery.** It is desirable to. **Analyst comment:** The reference discloses a coating composition which helps in improving indoor air quality by suppressing the emission of radon gas and alpha waves of the buildings. Further, the reference discloses use of titanium oxide as an additive. Here, the reference does not explicitly disclose combating of air pollution. Further, the reference discloses use of additive in the coating to facilitate self-healing of the coating.
2	The coating system includes a photocatalytic top layer that uses UV light or visible light to decompose pollutants such as nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs), PM2.5, PM10.	NA

S. No.	Key Features	Relevant Text for KR102040964B1
2a	The mechanism of action for degradation is by gas phase degradation	NA
2b	The photocatalytic layer includes a photocatalyst selected from titanium dioxide (anatase), graphene oxide, zinc oxide, tungsten trioxide, or ferric oxide.	[Excerpt 1] In the present invention, the composition may further include a known **additive in addition to the material**. Examples of the additives include fillers (pigments) such as artificial graphite, talc, mica, glass flakes, barium sulfate **and titanium dioxide;** Adhesion enhancers such as epoxy silane, amino silane, vinyl silane and acrylic silane; It may further contain an acrylic or silicone leveling agent. **Analyst comment:** The reference discloses a coating composition in which additives such as titanium dioxide is added to the composition. However, reference does not disclose use of titanium dioxide as the photocatalyst.
2b1	The layer is a sticky hydrophilic layer	NA
3	The surface coating system includes a self-	[Excerpt 1]

S. No.	Key Features	Relevant Text for KR102040964B1
	healing/regenerative intermediate layer, which facilitates the generation/repair/healing of the top layer upon degradation.	**The self-healing composition is to compensate for the low scratchability of the composition** and to keep the thickness of the coating film formed on the subject as constant as possible**. When a scratch occurs, the self-healing composition contained in the composition fills the recessed area where the scratch occurred**. It takes advantage of the property of rapidly converting into a solid polymer. That is, due to the above characteristics, the coating film can maintain a constant thickness at all times even if scratch occurs, and thus the radon shielding performance of the coating film can be maintained constantly. [Excerpt 2] In the present invention, the self-healing composition may be cured at room temperature in order to satisfy the above characteristics, and in particular, it is preferable to use a material that is cured according to moisture in the air. In addition, **since the self-healing composition should be cured only when necessary, the microcapsules block contact with the surroundings. When a scratch occurs, the microcapsules are automatically broken to induce the internal self-healing composition to harden by filling the scratch periphery**. It is desirable to.

S. No.	Key Features	Relevant Text for KR102040964B1
		Analyst comment: The reference discloses a coating composition which includes an additive to facilitate self-healing of the coating. However, the reference does not explicitly disclose use of multi-layered structure.
3a	The layer includes nano-encapsulated photocatalytic agents.	[Excerpt 1] In addition, any one selected from among melamine-formalin resin, urea-formalin resin, **polyurethane resin** and inorganic materials including **silica, titania, zirconia, alumina, zinc oxide nanoparticles**, etc. may be **used as a shell for the self-healing composition**. Melamine-formalin resin, urea-formalin resin may be preferable, including two or more materials, and in consideration of heat resistance and ease of encapsulation at the same time. [Excerpt 2] **Encapsulated self-healing composition comprising as an internal material, any one or a plurality of metals selected from TiO2,** Fe2O3, CuO, ZnO, Y2O3, ZrO2, Nb2O5, MoO3, In2O3, SnO2, Sb2O5, Ta2O5, WO3, PbO, Bi2O3 Preparing a composition by mixing a metal colloidal component comprising an oxide and a solvent.

S. No.	Key Features	Relevant Text for KR102040964B1
		Analyst comment: The reference discloses encapsulation of agents including TiO2. However, the reference does not explicitly disclose that TiO2 can be used as a photocatalytic agent and whether the encapsulation is a nano-encapsulation. Therefore, no mapping is considered.
3a1	The nano-capsules include silica-encapsulated or similar photocatalytic agents, such as TiO_2 and graphene composites, ensuring sustained performance.	[Excerpt 1] In addition, any one selected from among melamine-formalin resin, urea-formalin resin, **polyurethane resin** and inorganic materials including **silica, titania, zirconia, alumina, zinc oxide nanoparticles**, etc. may be **used as a shell for the self-healing composition**. Melamine-formalin resin, urea-formalin resin may be preferable, including two or more materials, and in consideration of heat resistance and ease of encapsulation at the same time. [Excerpt 2] **Encapsulated self-healing composition comprising as an internal material, any one or a plurality of metals selected from TiO2,** Fe2O3, CuO, ZnO, Y2O3, ZrO2, Nb2O5, MoO3, In2O3, SnO2, Sb2O5, Ta2O5, WO3, PbO, Bi2O3 Preparing

S. No.	Key Features	Relevant Text for KR102040964B1
		a composition by mixing a metal colloidal component comprising an oxide and a solvent **Analyst comment:** The reference discloses encapsulation of agents including TiO2. However, the reference does not explicitly disclose that TiO2 can be used as a photocatalytic agent and whether the encapsulation is a nano-encapsulation. Therefore, no mapping is considered.
3a2	Fresh TiO_2 + graphene released stays anchored near the surface so it stays UV-accessible	NA
3b	The layer includes a polyurethane-based matrix with healing agents.	NA
3b1	The healing agents include isocyanate-terminated prepolymers, epoxy-amine dual-reactants, dynamic covalent networks such as Diels–Alder	[Excerpt 1] In the present invention, the self-healing composition has properties similar to those of the binder, and it is preferable to use a material that is easily cured at room temperature or moisture while maintaining adhesive properties. Specifically, **the self-healing composition is vinyltrimethoxysilane, vinyltriethoxysilane, N- (2-**

S. No.	Key Features	Relevant Text for KR102040964B1
	systems, and supramolecular hydrogen bonding networks.	**aminoethyl) -3-aminopropylmethyldimethoxysilane) (N- (2-Aminoehtyl) -3-aminopropylmethyldimethoxy silane), N- (2-aminoethyl) -3-aminopropyltrimethyldimethoxysilane (N- (2-Aminoehtyl) -3-aminopropyltrimethoxysilane), 3-aminopropyltreethoxysilane (3-Aminopropyltriethoxy silane), N- [2- (vinylbenzylamino) ethyl] -3-aminopropyl-trimethoxysilanemonohydrochloride (N- [2- (Vinylbezylamino) ethyl] -3-aminopropyl-trimethoxysilane monohydrochloride) 3-Glycidoxypropyltrimethoxy silane, 3-Glycidoxypropylmethyldimethoxy silane, 2- (3,4-epoxycyclohexyl) ethylcrimethoxysilane (2- (3,4-Epoxycyclohexy silanes such as ethyltrimethoxy silane) and alkyl tin such as dibutyltin oxide. Or, preferably containing silicon compounds such as perhydrothiazine polysilazane**. **Analyst comment:** The reference discloses different types of compositions that can be used as healing agents. Therefore, the feature is considered to be inferentially mapped.
3b2	The healing agents are microencapsulated agents that rupture upon abrasion.	[Excerpt 1]

S. No.	Key Features	Relevant Text for KR102040964B1
		In the present invention, the self-healing composition may be cured at room temperature in order to satisfy the above characteristics, and in particular, it is preferable to use a material that is cured according to moisture in the air. In addition, since the **self-healing composition should be cured only when necessary**, the **microcapsules** block contact with the surroundings. **When a scratch occurs, the microcapsules are automatically broken to induce the internal self-healing composition to harden by filling the scratch periphery.** It is desirable to.
3b3	The healing agents can include in-matrix healing chemistries.	NA
3c	The self-healing regenerative layer includes optional acoustic-damping fillers such as cork powder, rubber crumb, or polymer microspheres, for acoustic damping.	NA

S. No.	Key Features	Relevant Text for KR102040964B1
4	The surface coating system includes a primer layer, which is applied to prepared substrates.	NA
4a	The primer layer is composed of polyurethane-epoxy resin or similar to provide appropriate adhesion to broad range of substrates	NA
4b	The primer layer is compatible with substrates including concrete, metal, asphalt, composites, and glass.	[Excerpt 1] The present invention relates to a silica aerogel **coating composition, which is used as interior finishing material for buildings,** penetrates deeply into interior pores of building materials and hardens the surface, thereby not deteriorating over time, maintains aesthetic and texture of the materials by forming a transparent interior finishing material, has an effect of improving indoor air quality by suppressing the emission of radon gas and alpha waves of the buildings, and has excellent weather resistance such as water resistance, scratch resistance and the like, thereby being usefully used in the fields.

S. No.	Key Features	Relevant Text for KR102040964B1
		[Excerpt 2] In the present invention, **the urethane resin collectively refers to a material** produced by polymerization of polyol and isocyanate, **and may provide** excellent water resistance, chemical resistance, scratch resistance, and **adhesiveness to a coating film.** **Analyst comment:** The reference discloses use of coating composition as interior finishing material for buildings. Further, the reference discloses use of additives including material which enhances adhesiveness of the coating. Thus, the feature is considered inferentially mapped.
5	The surface coating system can also be in a single-layer-based structure with a self-healing layer and a photocatalytic (pollutant degradation) layer incorporated into one.	[Excerpt 1] **The silica airgel coating composition prepared according to the present invention is used as an interior finishing material of a building**, penetrates deeply into the internal pores of the building material and hardens the surface, thereby preventing deterioration with time and forming transparently. By maintaining the aesthetics and texture of the material**, it is effective to improve indoor air quality by suppressing the emission of radon gas and alpha waves**

S. No.	Key Features	Relevant Text for KR102040964B1
		of the building, and excellent weather resistance such as water resistance, scratch resistance, etc. can be useful in the field. [Excerpt 2] In addition**, the composition may further include a self-healing composition** to further increase scratch resistance in addition to the additive. **Analyst comment:** The reference discloses a coating composition which helps in improving indoor air quality by suppressing the emission of radon gas and alpha waves of the buildings. Further, the reference discloses use of additive in the coating to facilitate self-healing of the coating. Thus, it can be inferred that the coating is a single layer coating which facilitates suppression of gas emission and self-healing.
6	The surface coating(s) can be applied by spray-on or roll-on	NA
7	The surface coating operates under passive, ambient triggers like humidity or moisture with no	NA

S. No.	Key Features	Relevant Text for KR102040964B1
	external heat or power requirement.	

3. ADDITIONAL REFERENCES

PATENT REFERENCES

S. No.	Patent No.	Title	Publication Date
1.	EP1642643B1	Coating composition for sound-absorbing and pollution-abating facings	Nov 24, 2010
	Abstract Coating composition (A) for sound-proofing (sound-absorbing) and antipollution facings (B) comprises a photocatalyst (I), comprising titanium dioxide particles; at least one hydraulic binder (II), i.e. cement or siliconized compounds; at least one sound-absorbing material (III) and water. Independent claims are also included for the following: (1) sound-proofing and antipollution facing (B) preparing by applying (A) to a solid support; and (2) method for preparing (B).		
2.	WO2011118857A1	Photocatalytic paint	Sep 29, 2011
	Abstract: Disclosed is a photocatalyst that has excellent elasticity. In particular, the disclosed photocatalytic paint ensures the adhesiveness of a base and a photocatalytic layer, even when cracks form in the photocatalyst coating due to seasonal variations in the temperature of the coating surface, and considerably suppress the propagation and development of these		

	cracks in both the surface and the base. The disclosed photocatalytic paint is provided with a base, a photocatalytic layer that includes the photocatalyst, and an intermediate layer that is provided so as to be interposed between the base and the photocatalytic layer and in contact with the underside of the photocatalytic layer. The intermediate layer includes a resin component, which has a silicone component and a flexible non-silicone component. The loss tangent of the intermediate layer at 25 °C, measured by a solid-matter viscoelasticity measuring device, is between 0.2 and 1.5. At least one spectral peak of the temperature change curve of the loss elasticity ratio, which is measured by a solid-matter viscoelasticity measuring device that is based on JIS K7244-4 for the intermediate layer, is greater than -80 °C and up to 30 °C.		
3.	CN103788815B	The preparation method of the quick selfreparing protective system of a kind of room temperature	Apr 20, 2016
	Abstract: A method for preparing a rapid self-repairing anti-corrosion coating at room temperature, relating to a preparation method for an anti-corrosion coating. The method uses urea-formaldehyde resin as a wall material. As the outer core material, the mercaptan curing agent can achieve the effect of quickly repairing cracks at room temperature; due to the special photocatalytic properties, super hydrophilicity, and UV shielding properties of nano-titanium dioxide, it is applied to the coating and made in the coating Maintaining the nanoscale state can improve the shortcomings of existing coatings such as weather resistance and poor staining, and will improve the siphon effect of micro-cracks due to its porous properties. Due to the addition of mesoporous molecular sieves and self-healing microcapsules with a double-wall sandwich structure, the self-healing performance of the coating is significantly improved, the self-healing time is shorter, and it has excellent anti-corrosion properties.		

4.	US20190270075A1	Photocatalytic composite material for the decomposition of air pollutants	Sept 05, 2019
	Abstract: The present disclosure relates to a UV- and visible-light photocatalytic titanium dioxide composite material. In particular, the disclosure relates to a 5 photocatalytic titanium oxide composite material for the decomposition of airborne pollutants.		
5.	US10508204B2	Self-healing coating	Dec 17, 2019
	Abstract Photo-protected microcapsules containing a photopolymer composition are dispersed in an epoxy coating to form an autonomic self-healing material. The capsule shell wall is formulated to protect the photopolymer composition from electromagnetic radiation exposure prior to rupture of the capsule shell, so that the photopolymer composition (e.g., a UV curable epoxy resin) remains active until triggered by damage to the capsule shell. Carbon black pigment is a suitable UV protector for the capsules. Upon sufficient damage to a region of the coating, the capsules will rupture and the photopolymer composition will fill and cure in and/or around the damaged region in the presence of electromagnetic radiation, achieving autonomic healing of the damaged coating.		
6.	US7192993B1	Self-healing coating and microcapsules to make same	March 20, 2007

	Abstract A liquid self-healing coating, incorporating microcapsules filled with tailored repair formulations, repairs itself upon physical compromise after curing. In one embodiment, a commercially available paint primer is mixed with a pre-specified amount of these microcapsules. After the coating has cured on the substrate to which it is applied, any physical compromise of the cured coating results in the microcapsules bursting to release a liquid that fills and seals the compromised volume of the coating. In applications where paint is used to provide corrosion protection, the liquid contains anti-corrosion material as well as suitable diluents and film-forming compounds. In another embodiment, the microcapsules may be provided separately to enhance commercially available products. For example, if a paint formulation is known a priori, specifically configured microcapsules packaged separately from the paint and designed for use with the paint formulation, may be added to the commercially available product just prior to application.		
7.	US2012189681A1	Photocatalytic Coating For The Controlled Release Of Volatile Agents	July 26, 2012
	Abstract A layered heterostructured coating has functional characteristics that enable the controlled release of volatile agents. The coating has photocatalytic properties, since it uses titanium dioxide, its derivatives or materials with similar photocatalytic properties (2), which upon solar irradiation open and/or degrade nano or microcapsules (3) and subsequently releases in a controlled form the volatile agents contained in them.		

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NON-PATENT REFERENCES

S. No.	Title	Publication Date
1.	Preparation and Self-Healing Application of Isocyanate Prepolymer Microcapsules	Jan 28, 2022

Abstract

In this study, we successfully manufactured polyurethane microcapsules containing isocyanate prepolymer as a core material for self-healing protection coatings via interfacial polymerization of a commercial polyurethane curing agent (Bayer L-75) and 1,4-butanediol (BDO) as a chain extender in an emulsion solution. With an optical microscope (OM) and a scanning electron microscope (SEM), the resulting microcapsules showed a spherical shape and an ideal structure with a smooth surface. Fourier transform infrared spectra (FTIR) showed that the core material was successfully encapsulated. Thermal gravimetric analysis (TGA) showed that the initial evaporation temperature of the microcapsules was 270 °C. In addition, we examined the influence of the concentration of the emulsifier and chain extender on the structure and morphology of the microcapsules. The results indicate that the optimal parameters of the microcapsule are an emulsifier concentration of 7.5% and a chain extender concentration of 15.38%. Microcapsules were added to the epoxy resin coating to verify the coating's self-healing performance by a surface scratch test, and the results showed that the cracks could heal in 24 h. Furthermore, the self-healing coating had excellent corrosion resistance.

2.	Synthesis of UV-Responsive Self-Healing Microcapsules and Their Potential Application in Aerospace Coatings	Aug 14, 2019
	Abstract Advanced polymer composite coatings in the spacecraft are threatened by harsh space environment factors, such as strong UV radiation, atomic oxygen, thermal cycles, space debris, etc. Their service life can be drastically shortened by the unavoidable formation of cracks caused by these factors (especially strong and abundant UV radiation) during long-term flight. Herein, a UV-responsive microcapsule-based coating is developed for in-orbit damage repairing. UV-responsive microcapsules of which the inner polymeric shell can be degraded rapidly by the outer pure TiO2 shell under UV radiation are produced by UV-initiated polymerization of Pickering emulsions and subsequently embedded into silicon resin matrices. When damaged, some microcapsules will be ruptured under the stimulus of external force, afterward the unbroken ones around the scratched areas will be degraded by UV radiation, as a result, encapsulated healing agents can be released and finally repair cracks. In this system, UV-responsive microcapsules can release more agents more effectively due to the dual release mode, compared with the traditional crack-repairing system. Moreover, the damage of UV radiation in space can be transferred into the favorable ones, which makes it have a potential application in aerospace coatings.	
3.	Dynamic Polymer/Metal–Organic Framework Hybrid Microcapsules for Self-Healing Anticorrosion Coatings	Dec 02, 2024

	Abstract An ideal microcapsule effectively preserves an active substance and can rapidly release it to elicit a self-healing anticorrosion effect. However, the development of highly efficient microcapsules remains a challenge. In this study, polymer/metal–organic framework hybrid microcapsules with dynamic properties were constructed as self-healing anticorrosion coatings. The shell of the microcapsule consisted of flexible polydopamine and a hard crystalline zeolitic imidazolate framework-8 (ZIF-8) layer. The corrosion inhibitor 8-hydroxyquinoline (8-HQ) was trapped in the microcapsules and remained unreleased because the ZIF-8 layer acted as a molecular sieve. When the coating was surrounded by an acidic environment, the ZIF-8 nanocrystals in the shell dissociated, followed by the release of 8-HQ. A dense protective layer was formed on the steel surface to suppress extensive corrosion propagation. The $\|Z\|_{0.01Hz}$ value of the self-healing coating increased from 1.9×10^4 Ω cm^2 to 2.2×10^6 Ω cm^2 within 48 h and remained at this level until 120 h post application. This value is 3 orders of magnitude higher than that of a pure epoxy coating under the same conditions. Compared with conventional coatings, the novel dynamic microcapsules enable the application of self-healing coatings that can withstand harsh acidic environments without human intervention.	
4.	Dual-Shell Microcapsules for High-Response Efficiency Self-Healing of Multi-Scale Damage in Waterborne Polymer–Cement Coatings	Dec 29, 2023
	Abstract Waterborne polymer–cement coatings have been widely applied in building materials due to their organic solvent-free nature, low cost, and eco-friendliness. However, these coatings can easily crack during the drying process as a result of	

	construction environment factors, compromising the barrier performance of the coating and limiting its large-scale application. In this study, a dual-shell self-healing microcapsule was developed, which can effectively heal damage on a macro scale in waterborne polymer–cement coatings. Specifically, this dual-shell self-healing microcapsule was designed with a silica gel shell and a tannic acid–cuprum (TA–Cu) double-shell structure embedded with an epoxy resin (EP) healing agent, which was successfully fabricated via a two-step in situ polymerization. This silica gel shell self-healing microcapsules can effectively load into waterborne polymer–cement coatings. As the coating dries and solidifies, the silica gel shell of the microcapsule also becomes loose and brittle due to dehydration. This improves the mechanical initiation efficiency of the microcapsules in the coating. This study provides a novel approach for the application of self-healing microcapsules in waterborne coating systems, which can significantly reduce cracking during the drying process of waterborne polymer–cement coatings and improve the service life of the coating under complex conditions.	
5.	Fabrication of Dual Self-Healing Multifunctional Coating Based on Multicompartment Microcapsules	Dec 06, 2021
	Abstract By designing and preparing multifunctional materials exhibiting self-healing ability, problems related to their durability outdoors can be solved. This study, inspired by the self-healing mechanism of natural creatures, successfully prepared a dual self-healing multifunctional coating using temperature stimuli-responsive multicompartment microcapsules. Phase change materials (PCMs) were employed to load multicompartment microcapsules that were produced through Pickering emulsion polymerization by applying hydrophobic materials encapsulated by titanium dioxide (TiO_2) nano-capsules as Pickering emulsifiers. The multifunctional coating produced using microcapsules and self-healing waterborne polyurethane	

	(WPU) exhibited thermal insulation and antireflection properties, which was attributed to the application of PCMs and TiO_2, and it also achieved remarkable superhydrophobicity. Moreover, this coating exhibited the intrinsic and superficial dual self-healing ability, which was attributed to the release of hydrophobic materials from microcapsules and the self-healing ability of WPU. This study can be referenced to guide the fabrication of high-performance self-healing materials, and it can contribute to the long-term use of multifunctional coatings.

4. APPENDIX

PATENT SEARCH STRINGS

S. No.	Search Strings
	Google Patents
1	Coating system
2	Multisurface coatings
3	TiO2 photocatalyst coating
4	Self healing layer in coating
5	Silicon based nano encapsulated coating
6	Microencapsulated healing/regenerative layer
7	Photocatalytic coating
8	Microencapsulated paint
9	Microencapsulated coating structure

S. No.	Search Strings
10	Self healing layer
11	Adhesive coating for pollution
12	Surface coating for air pollution
13	Surface coating for pollution
14	Functionalized coating systems
18	Smart coatings for environmental applications
19	Responsive coating materials
20	Multifunctional surface coatings
21	Protective barrier coatings
22	Antifouling coating technology
23	UV-curable coating systems
24	Thermally responsive coatings

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S. No.	Search Strings
25	Corrosion-resistant surface coatings
26	Moisture-triggered coating layer
27	Photocatalytic nanocoatings
28	Air-purifying photocatalyst surfaces
29	Pollution-degrading surface coatings
30	NOx-reducing photocatalytic films
31	TiO2-based pollution control coatings
32	Light-activated pollutant degradation coatings
33	VOC-removing surface layers
34	Solar-active environmental coatings
35	Autonomous self-healing films
36	Mechanically triggered healing coatings

S. No.	Search Strings
37	Thermal-responsive self-repair coatings
38	Nano-enabled healing layers
39	Capsule-based healing mechanisms
40	Reversible damage repair coatings
41	Stimuli-responsive self-healing layers
42	Embedded microcapsule healing system
43	Sound proof coatings
44	Noise cancellation coating with photocatalysis
45	Silica nanocoatings
46	Silicon-doped protective layers
47	Acoustic surface coatings
48	("photocatalytic") ("self healing") (coat*)

S. No.	Search Strings
49	("photocatalytic" OR photocataly*) (heal* OR “cure”) (coat* OR paint* OR film*)
50	("photocatalytic") ("self healing") (coat*) ("pollution" OR "pollutant")
51	("photocatalytic") ("self healing") (coat*) ("two layer")
52	("photocatalytic") ("self healing") ("surface coating")
53	("photocatalytic") OR "photocatalyst" AND (heal*) AND (coat*)AND ("air pollution" OR "air pollutant") AND (encapsul*) AND ("isocyanate") OR "epoxy amine"
54	("photocatalytic") ("self healing") (coat*)
55	("photocatalytic") ("sound" OR “acoustic”) (coat* OR paint*)
56	("photocatalytic" OR "photocatalyst" AND (heal* OR repair* OR “cure” OR regenerat*) AND (coat*)AND ("air pollution" OR "air pollutant") AND (encapsul*) AND ("isocyanate") OR "epoxy amine"
57	("photocatalytic" OR "photocatalyst" AND (heal* OR repair* OR “cure” OR regenerat*) AND (coat*)AND ("air pollution" OR "air pollutant") AND (encapsul*)

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S. No.	Search Strings
58	("photocatalytic" OR "photocatalyst" AND (heal* OR repair* OR “cure” OR regenerat*) AND (coat*)AND ("pollutant" OR “pm2.5” OR “pm10” OR “volatile matter” OR “organic compound”) AND (encapsul*) AND ("isocyanate" OR "epoxy amine" OR “hydrogen bond” OR “diel alder”)
59	("photocatalytic" OR "photocatalyst" AND (heal* OR repair* OR “cure” OR regenerat*) AND (coat*)AND ("air pollution" OR "air pollutant") AND (micro* OR nano*)
60	("photocatalytic" OR "photocatalyst" OR “photocatalysis”) AND (heal* OR repair* OR “cure” OR regenerat*) AND (coat*)
61	("photocatalytic" OR "photocatalyst" AND (heal* OR repair* OR “cure” OR regenerat*) AND (coat*)AND (adhesi* OR stick*) AND (damp*)

S. No.	Search Strings
	Relecura
1	(heal OR "healing" OR repair* OR regen*) AND ((micro OR nano) NEAR2 encapsulat*) AND (coat* OR paint* NEAR9 (concrete OR metal OR asphalt OR composite* OR "glass")) AND ("photocatalytic" OR "photocatalysis")

S. No.	Search Strings
2	(heal* OR "self-healing" OR "self repair" OR regen*) AND ((micro* OR nano*) NEAR3 encapsulat*) AND ((coat* OR paint*) NEAR7 (asphalt OR concrete OR glass OR composite* OR metal)) AND ("photocatalytic" OR "photocatalysis") AND ("air pollution" OR "VOC" OR "NOx" OR "particulate matter")
3	(heal OR "healing" OR repair* OR regen*) AND ((micro OR nano) NEAR2 encapsulat*) AND (coat* OR paint* NEAR9 (concrete OR metal OR asphalt OR composite* OR "glass")) AND ("photocatalytic" OR "photocatalysis") AND ("isocyanate" OR "epoxy amine" OR "epoxy-amine" OR (covalent NEAR3 network*) OR "Diels–Alder" OR "Diels Alder" OR (hydrogen NEAR3 bond*) AND ("air" NEAR3 pollut*)
4	("self-healing" OR autonomous* OR repair* OR regen*) AND ((micro OR nano) NEAR5 encapsulat*) AND (coating* OR film* OR layer*) AND ((TiO2 OR titanium*) AND (photocatalytic OR photocatalysis)) AND ((civil OR infrastructure OR building OR road* OR bridge*) OR (concrete OR asphalt OR metal OR composite*))
5	("heal" OR "healing" OR repair* OR regen*) AND ((micro OR nano) NEAR7 encapsulat*) AND ((concrete OR metal OR asphalt OR composite* OR "glass") OR "civil" OR "building") AND ("photocatalytic" OR "photocatalysis") AND ("air" NEAR3 pollut*)
6	("self-healing" OR repair*) AND ((microcapsule* OR nanocapsule*) NEAR3 (dispers* OR embed* OR encapsulat*)) AND ("smart coating*" OR "protective coating*" OR "pollution-responsive coating*") AND ("photocatalytic" OR "photocatalysis") AND (TiO2 OR "titanium dioxide") AND ("urban air" OR "NOx" OR "PM2.5" OR "air pollutant*")

S. No.	Search Strings
7	("heal" OR "healing" OR repair* OR regen*) AND ((micro OR nano) NEAR7 encapsulat*) AND ((concrete OR metal OR asphalt OR composite* OR "glass") OR "civil" OR "building") AND ("photocatalytic" OR "photocatalysis") AND ((air* OR organic*) NEAR3 pollut*)
8	((fto:"repair" OR fto:"self-healing" OR fto:regen*) AND fto:((micro OR nano) NEAR3 encapsulat*) AND (fto:coat* OR fto:paint* OR fto:film*) AND (fto:asphalt OR fto:glass OR fto:metal OR fto:concrete OR fto:composite*) AND (fto:"photocatalytic" OR fto:"photocatalysis") AND (fto:"air pollution" OR fto:VOC OR fto:NOx OR fto:"PM2.5"))
9	(((((fto:"heal" OR fto:"healing" OR fto:repair* OR fto:regen*) AND fto:((micro OR nano) NEAR7 encapsulat*)) AND ((fto:concrete OR fto:metal OR fto:asphalt OR fto:composite* OR fto:"glass") OR fto:"civil" OR fto:"building")) AND (fto:"photocatalytic" OR fto:"photocatalysis")) AND fto:pollut*)
10	((((taco:"photocatalyst" OR taco:"photocatalytic") AND taco:("coating" OR "layer" OR "film")) AND fto:((self-healing OR repair OR regen*) NEAR4 (microcapsule OR nanocapsule OR encapsulat*))) AND (fto:"TiO2" OR fto:"titanium oxide") AND (fto:"civil infrastructure" OR fto:"urban material*" OR fto:(concrete OR glass OR composite OR metal OR asphalt)) AND (fto:"covalent network*" OR fto:"epoxy-amine" OR fto:"isocyanate" OR fto:"hydrogen bonding" OR fto:"Diels–Alder"))
11	((((taco:"photocatalytic" OR taco:"photocatalysis") AND (taco:heal OR taco:"healing" OR taco:repair* OR taco:regen*)) AND fto:((micro OR nano) NEAR2 encapsulat*)) AND (fto:concrete OR fto:metal OR fto:asphalt OR fto:composite* OR fto:"glass" OR fto:building* OR fto:"civil"))

S. No.	Search Strings
12	((taco:"photocatalytic" OR taco:"photocatalysis") AND (fto:"encapsulation" OR fto:"microcapsule" OR fto:"nanocapsule") AND fto:(heal* OR repair* OR "self-healing") AND (fto:"titanium dioxide" OR fto:"TiO2") AND (fto:"isocyanate" OR fto:"epoxy-amine" OR fto:(covalent NEAR3 network*) OR fto:"diels–alder") AND allclc:C08K0003200000)
13	((((((taco:"photocatalytic" OR taco:"photocatalyst") AND taco:(("middle" OR "center" OR "second") NEAR3 layer*)) AND (fto:"air pollution" OR fto:"particulate matter" OR fto:"volatile matter")) AND (fto:building* OR fto:"civil" OR fto:"concrete" OR fto:"composite" OR fto:"glass" OR fto:"asphalt" OR fto:"concrete" OR fto:"metal")) AND fto:titanium*) AND (fto:"isocyanate" OR fto:"epoxy amine" OR fto:"epoxy-amine" OR fto:(("covalent" OR hydrogen) NEAR3 network*) OR fto:"diels-alder" OR fto:"diels alder"))
14	(((fto:"coating" OR fto:"film" OR fto:"encapsulation") AND (fto:"self-healing" OR fto:repair OR fto:regen*) AND (taco:"photocatalysis" OR taco:"photocatalyst")) AND (fto:"air pollut*" OR fto:"VOC" OR fto:"particulate matter") AND (allclc:C09D175/00 OR allclc:C08K0003200000 OR allclc:B32B37/00))
15	((((((taco:"photocatalytic" OR taco:"photocatalyst") AND taco:(("middle" OR "center" OR "second") NEAR3 layer*)) AND (fto:"air pollution" OR fto:"particulate matter" OR fto:"volatile matter")) AND (fto:building* OR fto:"civil" OR fto:"concrete" OR fto:"composite" OR fto:"glass" OR fto:"asphalt" OR fto:"concrete" OR fto:"metal")) AND (fto:"isocyanate" OR fto:"epoxy amine" OR fto:"epoxy-amine" OR fto:(("covalent" OR hydrogen) NEAR3 network*) OR fto:"diels-alder" OR fto:"diels alder")) AND allclc:C08K0003200000)

S. No.	Search Strings
16	("noise reduction" OR "sound insulation" OR "acoustic damping" OR "sound absorption" OR "noise barrier") AND ((coat* OR paint* OR layer* OR film*) NEAR5 (building OR concrete OR composite OR asphalt OR metal OR glass)) AND ((micro OR nano) NEAR3 encapsulat*) AND ("self-healing" OR regen* OR repair*) AND ("photocatalytic" OR "photocatalysis")
17	(acoustic* NEAR3 (damp* OR insulat* OR absorb*)) AND ((nano* OR micro*) NEAR3 encapsulat*) AND (coating* OR film* OR surface* OR paint*) AND (self-healing OR repair* OR regen*) AND (titanium OR TiO2 OR "photocatalytic") AND (building* OR "civil structure" OR asphalt OR concrete OR composite*)
18	((fto:"noise reduction" OR fto:"acoustic damping" OR fto:"sound insulation") AND fto:((micro OR nano) NEAR3 encapsulat*) AND (fto:coating* OR fto:paint* OR fto:film*) AND (fto:concrete OR fto:metal OR fto:composite OR fto:glass OR fto:asphalt) AND (fto:"photocatalytic" OR fto:"self-healing" OR fto:regen*))
19	((fto:"sound damping" OR fto:"acoustic absorb*" OR fto:"vibration reduction") AND (fto:"isocyanate" OR fto:"epoxy amine" OR fto:"Diels-Alder" OR fto:"covalent network" OR fto:"hydrogen bonding")) AND ((fto:coating OR fto:film OR fto:encapsulation) AND fto:(self-healing OR repair*)) AND fto:(composite* OR asphalt OR metal OR building*) AND (taco:"photocatalytic" OR taco:"photocatalysis"))
20	(((fto:"sound insulation" OR fto:"acoustic damping") AND fto:(encapsulation OR coating)) AND allclc:E04B0001000000)

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S. No.	Search Strings
21	(((taco:"photocatalytic" OR taco:"photocatalysis") AND taco:("noise reduction" OR "sound control")) AND fto:("microencapsulation" OR "self-healing") AND allclc:C09D0001330000 OR allclc:C08K0003200000)

S. No.	Search Strings
Google	
1	Self-healing/regenerative materials based coats/paints
2	Micro/nano encapsulation surface/substrate coating
3	Photocatalytic coatings
4	Acoustic damping / sound insulation / noise control
5	Civil engineering / infrastructure materials for paints/coats/films
6	Advanced functional coatings
7	self-healing coating
8	regenerative layer

S. No.	Search Strings
9	healing material
10	repair mechanism
11	healing film
12	microcapsule system for paints
13	nanocapsule coating
14	microencapsulation photocatalytic coating
15	encapsulated agent in coating
16	capsule-based layers for surface coat
17	healing interface coatings
18	smart capsule infused coat
19	damage repair paint
20	crack healing coat layer

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S. No.	Search Strings
21	healing polymer
22	Piston with drill hole
23	Dual chamber injector
24	Noise reduction photocatalytic coating
25	Sound insulation paint/coat/film
26	Acoustic damping coat/paint/film with photocatalytic layer

ASSIGNEE BASED SEARCH

Some of the leading assignees came up from the search are listed below

- YUNNAN MINGBO IND CO LTD
- SEONG HWA FINE CERAM CO LTD
- TOTO LTD
- LIAONING SHUNFENG NEW MATERIAL TECHNOLOGY CO LTD
- EUROVIA SA
- PPG BV
- UNIVERSIDADE DO MINHO

PROLIFIC INVENTORS

Some of the prolific inventors identified from the search are listed below.

- GE YINGCANG
- KIM DAE SIK
- TERASAKI HIROSHI
- IKEDA TAKESHI
- MACEDO TAVARES CARLOS JOSE
- FEMANDO DA SILVA PINA
- EMMANUEL TOULAN

- MICHEL MAZE
- MASAYUKI NAKAJIMA
- GERARD GEELS

IMPORTANT CLASSIFICATION

Some of the important classes identified from the search are listed below.

- C08K2003/2241 - Titanium dioxide
- C08L63/00 - Compositions of epoxy resins; Compositions of derivatives of epoxy resins
- C09D175/04 - Polyurethanes
- B01J35/39 - Photocatalytic properties
- A01N25/28 - Microcapsules or nano-capsules
- A01N25/34 - Shaped forms, e.g. sheets, not provided for in any other sub-group of this main group
- B01J21/063 - Titanium; Oxides or hydroxides thereof
- Y10T428/249997 - Encapsulated liquid
- B32B27/00 - Layered products
- C08K9/10 - Encapsulated ingredients
- C04B2111/2061 - Materials containing photocatalysts, e.g. TiO2, for avoiding staining by air pollutants or the like
- C04B2111/52 - Sound-insulating materials

5. DISCLAIMER

The report contains no legal opinion and only seeks to provide a technical analysis. However, the report may include personal, non-legal judgment of technical researcher(s) involved in the search, analysis, and preparation of this report. Therefore, no content of this report should be construed as having any legal weight or being legally dispositive in any manner.

Thank you for trusting us with this opportunity.

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