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(54) Title: INSECT REPELLING AND ANTIMICROBIAL COMPOSITION

(57) Abstract: The invention relates to a composition having improved disinfectant, antimicrobial, air-purifying and insect repelling properties. In an aspect of the invention, there is provided a composition comprising a porous inorganic catalyst carrier and a binder, wherein the porous inorganic catalyst carrier comprising one or more of aluminum oxide, silica, zeolite, sepiolite, montmorillonite and diatomite, and the binder comprising a silane based antimicrobial agent, a silicon resin, a cross-linker, a catalyst, a photocatalyst and a thickener.



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DESCRIPTION

INSECT REPELLING AND ANTIMICROBIAL COMPOSITION

FIELD OF THE INVENTION

[0001] The invention relates to a composition having improved disinfectant and insect repelling properties. Additional benefits include sanitizing, removing or preventing microbial build up and purifying air.

BACKGROUND OF THE INVENTION

[0002] There are current methods of removing microbial contaminants in the environment. Common methods include employing air filters such as HEPA filters to trap airborne contaminants, employing ultraviolet light or chemicals such as chlorine or hydrogen peroxide to kill or inactivate microorganisms.

[0003] However, the above-mentioned methods have not always been effective. In addition, using chemicals may be hazardous, if not dangerous, because of the potential for producing harmful byproducts. In addition, for chemicals that are effective, the use of these chemicals requires specialized equipment and trained personnel for safe storage and handling. This can be more complex and expensive compared to other disinfectants.

[0004] Likely, the use of current insect repellents employs chemical repellents that may cause harmful effects to users, such as skin irritation, and the environment. Also, current repellents have varying effectiveness depending on the insect species, concentration of the repellent etc. For those repellents that require application on a user's skin, frequent reapplication is required.

[0005] There is thus a need for an improved and safe product providing enhanced antimicrobial and insect repelling properties, and also affording additional benefits such as sanitizing and purifying air. Furthermore, other desirable features and characteristics will

become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0006] In an aspect of the invention, there is provided a composition comprising a binder, wherein the binder comprises a silane based antimicrobial agent, a silicon resin, a cross-linker, a catalyst, a photocatalyst and a thickener.

[0007] In various embodiments, the composition further comprises a porous inorganic catalyst carrier comprising one or more of aluminum oxide, silica, zeolite, sepiolite, montmorillonite and diatomite.

[0008] In various embodiments, the porous inorganic catalyst carrier is impregnated with the binder, and the binder forms a coating on the surface of the porous inorganic catalyst carrier.

[0009] In various embodiments, at least 95% of the porous inorganic catalyst carrier is impregnated with the binder.

[0010] In various embodiments, the porous inorganic catalyst carrier is a powder and forms a solution with the binder.

[0011] In various embodiments, the binder is present in an amount of about 92% of the composition.

[0012] In various embodiments, the porous inorganic catalyst carrier powder has a hole density of 120 meshes.

[0013] In various embodiments, the silane based antimicrobial agent is a quaternary ammonium silane and is present in an amount of between 5 to 10% of the binder.

[0014] In various embodiments, the photocatalyst is titanium dioxide and present in an amount of between 0.5 to 5% of the binder.

[0015] In various embodiments, the silicone resin is Dow DC 2405 or 2403 and is present in an amount of between 1 to 5% of the binder.

[0016] In various embodiments, the cross-linker is Dow DC 531 or 536 and is present in an amount of between 1 to 5% of the binder.

[0017] In various embodiments, the catalyst is aminosilane and is present in an amount of between 0.5 to 2% of the binder.

[0018] In various embodiments, the thickener is Dow Cellosize hydroxypropyl methyl cellulose and is present in an amount of between 0.3 to 3% of the binder. Rheology control and methyl cellulose may be used.

[0019] In various embodiments, the binder further comprising sulphur.

[0020] Advantageously, this invention comprises of a coating which has been improved to enable the coating to not only be resistant to microorganisms but also have the capacity to repel insects. The invention is able to repel 99.9% of germs and bacteria commonly found around human. This includes Staphylococcus Aureus, Escherichia Coli, Community Associated MRSA, Severe acute respiratory syndrome (SARS), Hepatitis B, Rhinovirus, HIV (Human Immunodeficiency Virus), Poliovirus Type 1, H1N1, Salmonella Choleraesuis, Streptococcus Pyogenes, Rotovirus, Canine Parvovirus and many others. Further the coating is also effective to inhibit the growth of bacteria, mold and fungi on treated surfaces for extended periods.

[0021] Additionally, the coating is also able to provide freshness, combating deterioration and discoloration caused by bacteria, fungi, and algae, hence eliminates the problems caused by odour-causing bacteria on treated surfaces. The coating is environmentally friendly which inflict minimal or no harm on the environment. Further, since the coating will be chemically bounded to the surface molecules (in this case via a paint formulation), there will be no

spraying and/or frequent application required. This will greatly reduce human contact with harmful chemicals and/or potential irritant in the market such as the insecticide, fungicide and other microbial repellent sprays.

[0022] The advantage in the present invention in comparison with the prior art patent applications are the ability to repel insects. The invention has been tested on the mosquitoes (*Aedes aegypti*), houseflies (*Musca domestica*) and cockroaches (*Periplaneta americana* and *Blatella germanica*) and possess positive results of the same. The efficiency of the said coating is supported by the research conducted in one of the reputable Vector Control Research Unit, School of Biological Sciences, Universiti Sains Malaysia in Penang, Malaysia. The details of the experiment along with the results have been reproduced within the detailed description of the patent specification.

[0023] The impregnated / coated porous inorganic catalyst carrier may be used in conjunction with or incorporated into a wet air scrubber. These may be in the form of beads and chlorine dioxide (which disinfects the air passed into the air scrubber and repels insects) is slowly released when these beads come into contact with the water in the wet air scrubber. The effectiveness of the impregnated / coated porous inorganic catalyst carrier beads incorporated wet air scrubber has been tested at the Vector Control Research Unit at the School of Biological Sciences. The trials were conducted in the laboratory with the temperature $26 \pm 20^\circ\text{C}$ and humidity of $70 \pm 10\%$. The AOP insect repellent device was tested with common insects such as mosquitoes (*Aedes aegypti*), houseflies (*Musca domestica*) and cockroaches (*Periplaneta americana* and *Blatella germanica*). The chlorine dioxide gas released by the beads can destroy all types of microorganisms, including bacteria, spores, fungi, viruses, and even protozoans, in indoor environments.

[0024] The binder and porous inorganic catalyst carrier mixture of this invention may also be resistant to heat. This mixture may then be added with other types of additives required to form a stable formulation, like a coating and/or paint, to enable it to be used in the desired areas. Some of the key areas of use identified was air filters, filter inserts for face masks, air scrubbers, packaging protection layers, odour capture, reusable diapers, water purification, water sanitation, air conditioning systems, air sanitizing window curtains, insect repelling

antimicrobial foam tapes for kitchen area, double sided mountable to protect foods during food processing, transportation, storage and many other possible uses.

[0025] The invention not only efficiently repel against Mosquitoes (*Aedes aegypti*) as claimed by the earlier prior arts but also efficiently repels other common insects such as the houseflies (*Musca domestica*) and cockroaches (*Periplaneta americana* and *Blatella germanica*) with repellence percentage of 86.00%, 97.33% and 95.00% respectively at 24 hours interval. This means that the invention had not only solved the problem with the infestation of the above-mentioned common household insects but also provides additional antimicrobial protection to the users and/or the surface in which the coating has been applied. The mixture / impregnated and coated porous inorganic catalyst carrier may have additional potential to repel other insects such as ants, houseflies, termites, lizards and other common insects and pests around humans.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Figure 1 is a photo of an air scrubber incorporating the inorganic catalyst carrier (in bead form) coated and impregnated with the binder according to an embodiment of this invention.

[0027] Figure 2 is a photo showing two connecting chambers with a measurement of 70 cm (length) x 70 cm (height) x 70 cm (width) with a small opening (e.g. door) in middle of the base of each chamber, which serves as a release point for mosquitoes or other insects). The connecting tunnel is for insects to travel between chambers.

[0028] Figure 3 is a photo showing the condition of study arena (Two connecting chambers 70 cm (length) x 70 cm (height) x 70 cm (width) with an opening (e.g. door) in the middle of each chamber) tested against 2 species of Cockroaches (*Periplaneta americana* and *Blatella germanica*) at 24 hours interval. Insects are released in Chamber B (shown on the right) and Air Scrubber is placed in Chamber A (shown on the left).

[0029] Figure 4 is a photo showing hands releasing insects in Chamber B through the insect release window (also known as "insect release point").

[0030] Figure 5 is a photo showing the air scrubber inside Chamber A.

DETAILED DESCRIPTION

[0031] The invention illustratively described herein may suitably be practiced in the absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including", "containing", etc. shall be read expansively and without limitation. Additionally, the terms and expressions employed herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the inventions embodied therein herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention.

[0032] The proportions and amounts of the composition disclosed in this invention may be read in terms of weight percentage.

[0033] The composition of this invention comprises a binder, wherein the binder comprises a silane based antimicrobial agent, a silicon resin, a cross-linker, a catalyst, a photocatalyst and a thickener.

[0034] By "antimicrobial", it is mean to include, but is not limited to, the effect of inhibiting or preventing growth of, or killing, microorganisms. The term "antimicrobial agent" includes chemicals or other substances that either kill or slow the growth of microorganisms. Examples of antimicrobial agents include antibacterial agents (which kill bacteria), antiviral agents (which kill viruses), antifungal agents (which kill fungi), antialgae agents (which kill algae) and antiparasitic agents (which kill parasites).

[0035] By "silane based antimicrobial agent", it is meant to include silicon with a functional group. In an embodiment, the functional group is a quaternary ammonium compound. In an embodiment, the silane based antimicrobial agent is a quaternary ammonium silane. In

various embodiments, the quaternary ammonium silane may be present in an amount of between 5 to 10% of the binder.

[0036] By "silicone resin", it is meant to include any material derived from silicone. The term "silicon resin" includes but is not limited to straight silicon consisting only of organosiloxane bonds, and silicon resins modified with alkyd, polyester, epoxy, acrylic, urethane and the like. The term "silicon resin" is also meant to include a resin formed by hydrolysis and dehydration condensation polymerization of a coating film forming element containing at least one of organoalkoxysilane, a hydrolyzate thereof, and a dehydration condensation polymerization product thereof. In various embodiments, the silicone resin is Dow DC 2405 or 2403 and is present in an amount of between 1 to 5% of the binder. DC3074 may also be used.

[0037] As used herein, the term "crosslinker" is meant to include a bifunctional or multifunctional chemical or biological moiety that can bind two separate components. For example, the term "crosslinker" includes a molecule capable of forming a covalent linkage between polymers or between two different regions of the same polymer or between macromolecular molecules. In various embodiments, the cross-linker is Dow DC 531 or 536 and is present in an amount of between 1 to 5% of the binder. By "cross-linker", it is meant to include any extenders or polymers that allows the silicone resin and silane to form a matrix.

[0038] The term "catalyst" refers to a material that promotes chemical reactions. In various embodiments, the catalyst is aminosilane and is present in an amount of between 0.5 to 2% of the binder. Advantageously, the catalyst speeds up the condensation and cross-linking reactions. Also, this catalyst allows for faster drying of the polymer network with stronger alkalinity.

[0039] As used herein, the term "thickener" refers to a substance which, when added to a liquid, increases the viscosity of the liquid. The term "thickener" may include a thickening agent, gelling agent, polymer, and/or linear gel. In various embodiments, the thickener is Dow Cellosize hydroxypropyl methyl cellulose and is present in an amount of between 0.3 to 3% of the binder. Carboxyl cellulose may also be used but require alkaline.

[0040] In various embodiments, the binder of the composition may further comprise a photocatalyst. In addition, or alternatively, any optical fluorescent agent may be used. The term "photocatalyst" refers to a material having photocatalytic properties, that is, capable of generating a photocatalysis process when exposed to light radiation. In photocatalysis, the photocatalyst changes its energy structure when stimulated with light of a suitable wavelength, creating an electron-hole pair on the surface of the material. An "activated" photocatalyst is able to initiate reactions that lead to the oxidation of contaminant particles. Therefore, photocatalytic processes can eliminate pollutants, such as organic pollutants, by mineralization (i.e., converting them into non-hazardous compounds, such as, for example, CO₂ and H₂O).

[0041] The use of the photocatalyst provides air sanitizing and self- sanitizing in the coating. The photocatalyst may be titanium dioxide and present in an amount of between 0.5 to 5% of the composition. Advantageous, the use of the optical fluorescent agent provides a label that allows for easy identification and authentication of the composition product when said product is exposed to UV light. Also, the use of the photocatalyst provides air sanitizing and self- sanitizing in the coating when the porous inorganic catalyst carrier is coated with the binder of this invention.

[0042] In various embodiments, the binder of the composition may further comprise sulphur. Advantageously, the inclusion of sulphur allows the composition product to be used as a fertiliser in agricultural production.

[0043] In various embodiments, the composition as described herein further comprises a porous inorganic catalyst carrier comprising one or more of aluminum oxide, silica, zeolite, sepiolite, montmorillonite and diatomite.

[0044] By "porous inorganic catalyst carrier", it is meant to include any catalyst capable of generating free radicals in gas phase comprising OH, .ClO₂, .HO₂ and .O, which absorb and oxidize viruses, bacteria, fungi and other microorganisms in the air, and clear formaldehyde and other chemical containments by oxidation. It is also meant to include any chlorine dioxide carrying catalyst carrier. It also includes any kind of inorganic porous materials, such as silica, zeolite, sepiolite, diatomite, montmorillonite, and aluminum oxide (with hole density greater than 100 meshes). The particle sizes of 2-3 mm or 3-5 mm are preferred. It can be one of the

above porous materials or a combination thereof. Dip the compound into stabilized chlorine dioxide solution or stabilized chlorite solution and then dehydrate the compound at a temperature under 85° C., and when the moisture content is lower than 8%, the catalyst carrier is obtained.

[0045] The porous material may be a structured carrier, using cordierite honeycomb or mullite ceramic honeycomb, (hole density 50 meshes to 900 meshes) preferably 400 meshes, with a size of 150×150 mm. The thickness can be adjusted as needed, preferably 25 mm, 50 mm, 100 mm and 150 mm. Dip the porous material into stabilized chlorine dioxide solution or stabilized chlorite solution, dehydrate at a temperature under 85° C., when the moisture content is lower than 8%, the catalyst carrier is obtained.

[0046] The catalyst carrier can be used in two ways: the first way, after ultraviolet irradiation, active radical particles such as .OH, .ClO₂, .HO₂ and .O can be generated, chain reaction will be initiated, these active particles can quickly eliminate virus, bacteria and mildew and degrade chemical contaminant. The final products are carbon dioxide, water and trace of mineral salt; the second way, based on the differences of environments and objectives, the process of Ultraviolet irradiation can be omitted. Directly as a catalytic oxidation material, elimination of virus, bacteria, and mildew as well as other chemical contaminants can also be achieved, only the purification efficiency is slightly lower than the first way. To achieve the same effect, 30% more catalyst is needed when Ultraviolet irradiation is not used.

[0047] As used herein, the term "impregnation" refers to a process where a substance is placed into the voids of a porous substrate. The term "impregnation" is intended to include the penetration of a liquid into pores of a porous material. For example, the impregnation of a catalyst carrier refers to the penetration of a liquid into a porous catalyst carrier to facilitate the partial or complete saturation of the pores with the liquid.

[0048] There are two schemes for the impregnation solution which is used to impregnate the porous material to form the porous inorganic catalyst carrier which comprises the catalyst.

[0049] Scheme 1: Prepare stabilized chlorine dioxide solution, using high-purity chlorine dioxide generator to obtain chlorine dioxide gas with purity higher than 98%. Use sodium carbonate peroxyhydrate (chemical formula: Na₂CO₃.mH₂O₂.nH₂O) as stabilizer agent,

prepare a specific ratio of absorption solution, and a solution with chlorine dioxide content of 2% to 5% is obtained.

[0050] Scheme 2: Prepare stabilized sodium chlorite solution, the solution comprises the following compound: Chlorite 0.1-10%; Stabilizer agent 0.1-5%; Buffer agent 0.05%-15%; Absorbers 0.1-75%.

[0051] Chlorite refers to chemical salt with chlorite ion ClO_2^- , such as sodium chlorite, potassium chlorite, and lithium chlorite.

[0052] Stabilizer solution is also a strong oxidant, for example: potassium permanganate, hydrogen peroxide, perchlorate, nitrate etc.

[0053] Buffer solution refers to the chemical which can maintain the basic balance of the pH value in a solution within a certain range, and generally is a salt. Here, salts formed by strong base and weak acid, for example: sodium carbonate, borate or citrate can be used.

[0054] Absorber refers to a type of chemical absorbent. It reacts with the solute. The solubility of the solute relates not only to the vapor-liquid equilibrium, but also to the chemical equilibrium. Most chemical absorbent is a solution with certain type of active ingredient, such as potassium carbonate, sodium carbonate, sodium hydroxide, and potassium hydroxide solutions in water.

[0055] Using either of the two impregnation solutions as described above, impregnating the porous material, performing dehydration at a temperature under 85°C . till moisture content $\leq 8\%$, the porous inorganic catalyst carrier which comprises the catalyst can be obtained.

[0056] All of the three wave band A, B and C (wavelength 180 nm-400 nm) in UV lamp could activate the porous inorganic catalyst carrier (which comprises the catalyst) to produce mass free radicals in gas phase, such as $\cdot\text{OH}$, $\cdot\text{ClO}_2$, $\cdot\text{HO}_2$ and $\cdot\text{O}$. So long as the power density is the same, the result is about the same using either LED UV lamp or mercury UV lamp. For central air supply filter system, the catalyst produced with honeycomb ceramics as

carrier (low air resistance) in combination with C wavelength UV irradiation (185 nm), where ozone would be generated, could achieve the best disinfection and purification results.

[0057] When the air humidity is high, (e.g. >80%), the pollutant removal efficiency of conventional photocatalytic oxidation technology or room temperature heterogeneous catalytic oxidation technology is significantly declined. Yet the porous inorganic catalyst carrier would not be impacted by high air humidity, especially in daily life, where the air humidity over 80% is quite often. When the air is very dry, with a concentration of water below 4%, the pollutant removal efficiency of the invention will be greatly impacted, however, this extreme dryness in the air rarely occurs.

[0058] In an embodiment, the porous inorganic catalyst carrier may be in a solid form that may have any suitable shape. For example, the porous inorganic catalyst carrier may be shaped in the form of spherical beads. In an example, the spherical beads may be between 3 to 5mm in diameter. Alternatively, they may be shaped in tablet form.

[0059] The term “coating” refers to a substance applied to a surface to form a layer. The term “coating” is meant to include a complete or partial coating of the surface. In various embodiments, the porous inorganic catalyst carrier is impregnated with the binder, and the binder forms a coating on the surface of the porous inorganic catalyst carrier. The coating may be a few microns thick. This composition may be used in an air scrubber, particularly a wet air scrubber which uses water or another liquid solution to trap contaminants as the air passes through it. Advantageously, the coating hinders or slows down the beads from being degraded by the water in the scrubber in rotation and allows for the slow release of chlorine dioxide.

[0060] In another embodiment, the porous inorganic catalyst carrier is in a powder form having a hole density of about 120 meshes. The powdered porous inorganic catalyst carrier forms a solution with the binder. Here, the binder is present in an amount of about 92% while the remaining 8% constitutes the powdered porous inorganic catalyst carrier. By “solution”, it is intended to include any mixture, slurry, concentrate or syrup-like consistency of the porous inorganic catalyst carrier and binder mixture.

[0061] The invention has been described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part

of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

[0062] Other embodiments are within the following claims and non-limiting examples. In addition, where features or aspects of the invention are described in terms of Markush groups, those skilled in the art will recognize that the invention is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0063] **EXAMPLES**

[0064] Non-limiting examples of the invention and comparative examples will be further described in greater detail by reference to specific Examples, which should not be construed as in any way limiting the scope of the invention.

[0065] Preparing the binder

[0066] Table 1 below shows the proportions of each component in the binder of the composition. The remaining component is water to make up to 100% of the binder. The method of preparing the binder is set out in Method Steps A.

Component	Proportion (out of 100%)
Quaternary ammonium silane	5-10%, preferably 8%
Photocatalyst e.g. TiO ₂ <20nm	0.5-5%, preferably 3%
Silicone resin e.g. Dow DC 2405 or 2403	1-5%, preferably 3%
Crosslinker e.g. Dow DC 531 or 536	1-5%, preferably 2%
Catalyst e.g. aminosilane	0.5-2%, preferably 1%
Thickener e.g. Dow Cellosize hydroxypropyl methyl cellulose	0.3-3%, preferably 1%

Table 1

[0067] The following Method Steps A are associated with the preparation of the binder:

- a) Mix the Silicone Resin and Crosslinker for 10 minutes with slow 60 RPM.
- b) Add in Quaternary Ammonium Silane and mix for 10 minutes 60 RPM.
- c) Add the above blend into the total amount of water needed and let them dissolve and hydrolyse well 20 to 30 minutes at room temperature (about 25°C to 32°C).
- d) Add in Catalyst and disperse over 10 minutes 60 RPM.
- e) Add in photocatalyst over 10 minutes 60 RPM.
- f) Disperse with mixing 60 RPM the thickener in 15 minutes in 3 portions and let it sit for 30 minutes to thicken well. By "3 portions", it is meant to refer to dividing the thickener used in 3 portions and adding each portions sequentially. Adding all the thickener in one go may end up in the mixture clumping.

[0068] Preparing the porous inorganic catalyst carrier

[0069] US10,183,187, its entirety incorporated by reference, teaches the manufacture of the porous inorganic catalyst carrier.

[0070] Preparing the impregnated and coated porous inorganic catalyst carrier (e.g. in bead form)

[0071] The binder prepared in Method Steps A is diluted 10 times with water to form a soaking solution. In an embodiment, 5% binder is diluted with 45% water. The porous inorganic catalyst carrier, preferably in the granules, beads, spheres, are then allowed to soak in this soaking solution until all the soaking solution is absorbed in the porous inorganic catalyst carrier.

[0072] In one embodiment, 45ml of water is added to 5ml of binder to provide 50ml of diluted binder. The porous inorganic catalyst carrier (in bead form, for example) is then soaked in this diluted binder. In an example, 100g of the porous inorganic catalyst carrier beads may be soaked with 50ml of the diluted binder. These proportions may be increased to scale production. The effect of this method produces porous inorganic catalyst carrier beads/spheres that may be 95% hydrated or impregnated with the diluted binder. This method allows for each bead/sphere to be uniformly hydrated / impregnated at 95%. This means

closing up the porosity of the porous inorganic catalyst carrier and results in an increased ability of the beads/spheres to release chloride dioxide slowly. In addition, it also allows for the integrity of beads/spheres to remain longer in the water of the wet air scrubber.

[0073] The porous inorganic catalyst carrier is then allowed to dry at room temperature and the dried beads are then stored in air-tight containers.

[0074] Preparing the porous inorganic catalyst carrier and binder mixture

[0075] The following steps are associated with the preparation of the porous inorganic catalyst carrier and binder mixture:

- a) In this method, the porous inorganic catalyst carrier is in powder form. In this embodiment, the porous inorganic catalyst carrier powder is prepared by grounding the porous inorganic catalyst carrier beads of size 3-5mm (such as those manufactured in accordance with US10,183,187). Put porous inorganic catalyst carrier powder (120 meshes) into a container HDPE plastic pail such that the porous inorganic catalyst carrier powder would be present at an amount of 8% or less of the total mixture.
- b) Pour binder (prepared with method steps set out above) on top of the powder such that the binder is present at an amount of 92% or more of the total mixture, with slow mixing 60 RPM, approx. 5 minutes.
- c) Then increase to 150 RPM (higher speed) to disperse the powder well 10 minutes.
- d) Do not reverse pouring the binder onto powder to become adding powder onto binder, as the powder will float on top of the binder creating spillages in stirring.
- e) Take retained sample needed for analysis, and close the lid of the pail tightly with seal.

[0076] Applications of the invention

[0077] As described above, the binder of this invention may be used to impregnate and coat the porous inorganic catalyst carrier to form impregnated and coated beads or granules. These beads or granules may be used in a wet air scrubber. In an embodiment, each bead

may be 3 to 5 mm in diameter. Advantageously, the beads or granules provides a slow release of chloride dioxide in the air scrubber by retaining its structure in the water for as long as possible, for example 90 to 180 days – which is typically longer than what it would have lasted if not for the impregnation and coating. The slow release of the chloride dioxide may be below 0.1 ppm (or 50 ppb) when used in the wet air scrubber over a period of time such as 3 to 6 months. For example, the concentration of chlorine dioxide released may be between 0.0001ppm to 0.1ppm.

[0078] Alternatively, the binder of this invention may also be used to form a mixture with powdered porous inorganic catalyst carrier. This mixture may be used to coat surfaces such as walls, face masks, food packaging etc. and it lends its anti-microbial, air-sanitizing and insect repellent properties to these coated surfaces.

[0079] EXAMPLE 1

[0080] The impregnated and coated porous inorganic catalyst carrier beads may be used in a wet air scrubber. An example of such an air scrubber is shown in Figure 1. With reference to Figures 2 and 3, we describe below the various insect repellence efficiency tests carried out with the air scrubber.

[0081] Mosquitoes – *Aedes aegypti*

[0082] This test was conducted in a connecting glass chamber with a measurement of 70 cm (length) x 70 cm (height) x 70 cm (width) each, with a tunnel connected to both chambers (Chamber A and Chamber B). Chamber A is shown on the left side of Figures 2 and 3, and Chamber B is shown on the right side of Figures 2 and 3. A total of 2500 laboratory-cultured sucrose-fed adult female mosquitoes (aged 5 - 7 days) were released into the chamber through an opening in the middle of Chamber B (e.g. a window in the centre at the base of Chamber B) (“insect release point”). The number of mosquitoes in Chamber A, tunnel and Chamber B was recorded. After that all the mosquitoes are removed, the impregnated / coated porous inorganic catalyst carrier-incorporated air scrubber was set in Chamber A. Then, a total of 2500 laboratory-cultured sucrose-fed adult female mosquitoes (aged 5 - 7 days) are released into the connecting tunnel. The numbers of mosquitoes in Chambers A and B were recorded at the intervals of 30 minutes, 1 hour and 24 hours after introduction.

[0083] Houseflies – *Musca domestica*

[0084] This test was conducted in a connecting glass chamber with a measurement of 70 cm (length) x 70 cm (height) x 70 cm (width) each with a tunnel connected to both chambers. A total of 1500 laboratory-cultured adult houseflies (mix male and female aged 5 – 7 days) were released into the chamber through an opening in the middle of the connecting tunnel. The number of houseflies attracted to Chamber A, tunnel and Chamber B was recorded. Then, all the houseflies are removed from the chambers and the impregnated / coated porous inorganic catalyst carrier-incorporated air scrubber was set in Chamber A. A total of 1500 laboratory-cultured sucrose-fed adult houseflies (aged 5 - 7 days) are released in the base window of Chamber B. The numbers of houseflies in Chambers A and B were recorded at the intervals of 30 minutes, 1 hour and 24 hours after introduction.

[0085] Cockroaches – *Periplaneta americana* and *Blatella germanica*

[0086] This test was conducted in a connecting glass chamber with a measurement of 70 cm (length) x 70 cm (height) x 70 cm (width) each with a tunnel connecting to both chambers. A total of 500 each of laboratory-cultured American and German cockroaches (nymph, male and female) were released into the chamber through an opening in the middle of connecting tunnel. The number of both species of cockroaches was recorded (in Chamber A) and in the other chamber (in Chamber B). Then, all the cockroaches are removed from both chambers and the impregnated / coated porous inorganic catalyst carrier-incorporated air scrubber was set in Chamber A., A total of 500 of each species of cockroaches are released through the connecting tunnel. The numbers of cockroaches in both the Chamber A and B were recorded at the intervals of 30 minutes, 1 hour and 24 hours after introduction.

[0087] The effectiveness of the insect repellence strength of the mixture was calculated from the formula below:

$$\bullet \quad \text{Bite reduction (\%)} = 100 - [\text{no. of test insect in chamber A} / \text{Total no of test insect used}] \times 100$$

[0088] The results shows that the mixture gave excellent repellence against Mosquitoes (*Aedes aegypti*), Houseflies (*Musca domestica*) and Cockroaches (*Periplaneta americana* and *Blatella germanica*) with repellence percentage of 86.00%, 97.33% and 95.00% respectively at 24 hours interval (see Tables 2, 3 and 4).

Interval	Section of Test Arena		
	Chamber A	Tunnel	Chamber B
PRETREATMENT			
30 minutes	430	1770	300
1 hour	900	920	680
24 hours	1100	50	1350
TREATMENT			
30 minutes	0 (100%)	0	2500
1 hour	0(100%)	0	2500
24 hours	350 (86%)	0	2150

Table 2: Number of Mosquitoes recorded at different time interval of impregnated / coated porous inorganic catalyst carrier incorporated air scrubber samples against *Aedes aegypti* (n=2500).

- number of mosquitoes released was 2500.
- Pretreatment – no impregnated / coated porous inorganic catalyst carrier incorporated air scrubber was set in the chamber A
- Treatment – impregnated / coated porous inorganic catalyst carrier incorporated air scrubber was set in chamber A
- Number in bracket is percentage of repellence.

Interval	Section of Test Arena		
	Chamber A	Tunnel	Chamber B
PRETREATMENT			
30 minutes	501	576	423
1 hour	610	350	540
24 hours	720	98	682
TREATMENT			
30 minutes	0 (100%)	0	1500
1 hour	0 (100%)	2	1498
24 hours	40 (97.33%)	3	1457

Table 3: Number of Houseflies recorded at different time intervals of the impregnated / coated porous inorganic catalyst carrier incorporated air scrubber repellent samples against *Musca domestica* (n-1500).

- number of houseflies release was 1500

- Pretreatment – no impregnated / coated porous inorganic catalyst carrier incorporated air scrubber was set in the chamber A
- Treatment – impregnated / coated porous inorganic catalyst carrier incorporated air scrubber was set in chamber A
- Number in bracket is percentage of repellence

Interval	Section of Test Arena		
	Chamber A	Tunnel	Chamber B
PRETREATMENT			
30 minutes	400	220	380
1 hour	510	50	440
24 hours	520	8	472
TREATMENT			
30 minutes	0 (100%)	0	1000
1 hour	0 (100%)	0	1000
24 hours	50 (95%)	5	945

Table 4: Number of Cockroaches recorded at different time interval of impregnated / coated porous inorganic catalyst carrier incorporated air scrubber samples against *Periplaneta americana* (n=500) and *Blatella germanica* (n=500).

- *number of cockroaches release was 500 Periplaneta americana and 500 Blatella germanica (nymph, male and female)*
- Pretreatment – no impregnated / coated porous inorganic catalyst carrier incorporated air scrubber was set in the chamber A
- Treatment – impregnated / coated porous inorganic catalyst carrier incorporated air scrubber was set in chamber A
- Number in bracket is percentage of repellency

[0089] Overall, the impregnated / coated porous inorganic catalyst carrier incorporated air scrubber gave excellent repellency against Mosquitoes (*Aedes aegypti*), Houseflies (*Musca domestica*) and Cockroaches (*Periplaneta americana* and *Blatella germanica*). At 30 minutes and 1-hour intervals it gave 100% repellency against all 3 insects tested. While at 24 hours interval, the percentage repellency against Mosquitoes (*Aedes aegypti*),

Houseflies (*Musca domestica*) and Cockroaches (*Periplaneta americana* and *Blatella germanica*) were 86.00%, 97.33% and 95.00% respectively at 24 hours interval.

[0090] EXAMPLE 2

[0091] In an embodiment, the binder and porous inorganic catalyst carrier mixture provides a solution to repel insects for the users in addition to repellence towards common microbes. It is able to repel insects and prevent microbial attack on the surface in the coating.

[0092] The porous inorganic catalyst carrier powder is made by grounding the porous inorganic catalyst carrier (in bead form) to a particle size between 60 to 120 meshes powder. Upon contact with water or water vapor, the said fine particles which has been integrated with chlorine dioxide gas will then release hydroxyl radical slowly. Chlorine dioxide is soluble in water and will react rapidly with other compounds, thus able to kill bacteria and microorganisms. Besides that, chlorine dioxide can be used as an insect repellent, a biting repellent, and a preventive for arthropod-borne diseases. Chlorine dioxide can be applied to the skin to repel mosquitoes that carry diseases, e.g., malaria parasites. However, in the present invention, the said chlorine dioxide beads will be integrated with the binder to provide protection against both microorganisms and insects.

[0093] When the impregnated and coated beads (the porous inorganic catalyst carrier powder) are activated by water particles, the chlorine dioxide gas may be released at 0.01 ppm which is below the permissible level of exposure limit of 0.1 ppm set by the Occupational Safety and Health Administration (OSHA). The effectiveness of the mixture toward insects had been tested at the Vector Control Research Unit at the School of Biological Sciences, University of Science Malaysia, in particular, tested solely on common insects such as mosquitoes (*Aedes aegypti*), houseflies (*Musca domestica*) and cockroaches (*Periplaneta americana* and *Blatella germanica*). The trials were conducted in the laboratory with the temperature of $26 \pm 20^\circ\text{C}$ and humidity of $70 \pm 10\%$ using a device of this invention (i.e. the air scrubber) as shown in Figure 1.

[0094] The synergistic use of both the binder and nano titanium dioxide has an antimicrobial and air sanitizing properties.

[0095] As described earlier, the binder comprises a photocatalyst, for example titanium dioxide with a size of less than 20 nm. The quaternary ammonium silane in the binder is 3-trimethoxysilylpropyldimethyloctadecyl ammonium chloride, that will provide additional antimicrobial properties to the mixture when used as a coating for application on relevant or desired surfaces.

[0096] The binder further incorporates additional additives such as silicone resins (such as the Dow Silicone resins), extenders (in a form of silicone fluids), thickening agents Hydroxy ethyl cellulose) and cross-linkers (mainly amino silane and fluids) to form a stable coating formulation. This formulation which will have a dual property, will be used in a form of coating and/or paint. The said coating formulation will not only be effective to repel insects but also in preventing the growth of harmful microorganisms. Further, the effectiveness of the paint formulation in repelling insects and preventing growth of microorganisms can last up to 12 months, with occasional reapplication to maintain the same.

[0097] Due to the versatile functions (insect repellent repellence, anti-microbial property, heat resistance and air purification) possessed by the coating, it can be utilized as air filters in air conditioners, filter inserts in face masks, air scrubbers, packaging materials, reusable baby cloth diapers, diaper covers, water purification systems, window curtains, foams and in other suitable areas.

[0098] The following are tests carried out to analyse the effectiveness of the mixture. The test method is with reference to United States Pharmacopeis (USP) 41.

[0099] 0.1 ml of initial bacteria load and fungal load were added to 10 ml of sample (i.e. the binder / porous inorganic catalyst mixture) and tested for 5 minutes contact time. After contact time, 1 ml of samples from both contact time were immediately transferred into Tryptone Soy Agar and Malt Extract Agar using pour plate method. The agar plates were incubated at 35 degree C for 48 hours & 25 degree C for 72 hours respectively. The number of colony forming units were recorded.

[00100] The results below show a reduction rate at 6 logs for two bacteria (E Coli, S. Aureas) and fungus C. Albicans at 5 logs for fungus A. Niger.

Initial Count:

Culture Name ATCC No.	10 ⁻⁵	10 ⁻⁶	10 ⁻⁷	Concentration of Bacteria Stock, cfu/ml (Count x Dilution Factor)	Log ₁₀
<i>Candida albicans</i> ATCC 10231	TNTC – Too Numerous To Count	184	17	184 x 10 ⁶ = 1.8 x 10 ⁸	6.25
<i>Aspergillus niger</i> ATCC 6275	TNTC	26	2	26 x 10 ⁶ = 2.6 x 10 ⁷	5.41

Table 5. Initial count of *C. Albicans* and *A. Niger*.

Initial Bacteria Load:

Add 0.1 ml (1.8 x 10⁸) into 10ml of sample to achieve 1.8 x 10⁶ cfu/ml = Log₁₀ 1.8 x 10⁶ = 6.25

Initial Fungus Load:

Add 0.1 ml (2.6 x 10⁷) into 10ml of sample to achieve 2.6 x 10⁵ cfu/ml = Log₁₀ 2.6 x 10⁵ = 5.41

Test Microorganism	Contact Time	Count of Surviving Test Microorganism, cfu/ml	Log ₁₀	Log Reduction	Percentage Kill of the Microorganism, %
<i>Candida albicans</i> ATCC 10231	5 min	< 1	-	6.25	99.9999
<i>Aspergillus niger</i> ATCC 6275	5 min	< 1	-	5.41	99.999

Table 6. Log reduction of *C. Albicans* and *A. Niger*.

Initial Count:

Culture Name ATCC No.	10 ⁻⁶	10 ⁻⁷	10 ⁻⁸	Concentration of Bacteria Stock, cfu/ml (Count x Dilution Factor)	Log ₁₀
<i>Escherichia coli</i> ATCC 25922	146	18	2	146 x 10 ⁶ = 1.5 x 10 ⁸	6.18
<i>Staphylococcus aureus</i> ATCC 6538	230	30	4	230 x 10 ⁶ = 2.3 x 10 ⁸	6.36

Table 7. Initial count of *E. coli* and *S. aureus*.

Initial Bacteria Load:

Add 0.1 ml (1.5 x 10⁸) into 10ml of sample to achieve 1.5 x 10⁶ cfu/ml = Log₁₀ 1.5 x 10⁶ = 6.18

Initial Fungus Load:

Add 0.1 ml (2.3 x 10⁸) into 10ml of sample to achieve 2.3 x 10⁶ cfu/ml = Log₁₀ 2.3 x 10⁶ = 6.36

Test Microorganism	Contact Time	Count of Surviving Test Microorganism, cfu/ml	Log ₁₀	Log Reduction	Percentage Kill of the Microorganism, %
<i>Escherichia coli</i> ATCC 25922	5 min	< 1	-	6.18	99.9999
<i>Staphylococcus aureus</i> ATCC 6538	5 min	< 1	-	6.36	99.9999

Table 8. Log reduction of *E. coli* and *S. aureus*.

[00101] Based on the results above, the binder and porous inorganic catalyst carrier mixture provides an effective solution to repel mosquitoes and other insects, and is also highly effective in reducing germs.

[00102] While embodiments of the invention have been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

CLAIMS

1. A composition comprising a binder, wherein the binder comprises a silane based antimicrobial agent, a silicon resin, a cross-linker, a catalyst, a photocatalyst and a thickener.
2. The composition according to claim 1, further comprising a porous inorganic catalyst carrier comprising one or more of aluminum oxide, silica, zeolite, sepiolite, montmorillonite and diatomite.
3. The composition according to claim 2, wherein the porous inorganic catalyst carrier is impregnated with the binder, and the binder forms a coating on the surface of the porous inorganic catalyst carrier.
4. The composition according to claim 3, wherein at least 95% of the porous inorganic catalyst carrier is impregnated with the binder.
5. The composition according to claim 2, wherein the porous inorganic catalyst carrier is a powder and forms a mixture with the binder.
6. The composition according to claim 5, wherein the binder is present in an amount of about 92% of the composition.
7. The composition according to claim 5, wherein the porous inorganic catalyst carrier powder has a hole density of 120 meshes.
8. The composition according to any one of the preceding claims, wherein the silane based antimicrobial agent is a quaternary ammonium silane and is present in an amount of between 5 to 10% of the binder.
9. The composition according to any one of the preceding claims, wherein the photocatalyst is titanium dioxide and present in an amount of between 0.5 to 5% of the binder.

10. The composition according to any one of the preceding claims, wherein the silicone resin is Dow DC 2405 or 2403 and is present in an amount of between 1 to 5% of the binder.
11. The composition according to any one of the preceding claims, wherein the cross-linker is Dow DC 531 or 536 and is present in an amount of between 1 to 5% of the binder.
12. The composition according to any one of the preceding claims, wherein the catalyst is aminosilane and is present in an amount of between 0.5 to 2% of the binder.
13. The composition according to any one of the preceding claims, wherein the thickener is Dow Cellosize hydroxypropyl methyl cellulose and is present in an amount of between 0.3 to 3% of the binder.
14. The composition according to any one of the preceding claims, wherein the binder further comprising sulphur.

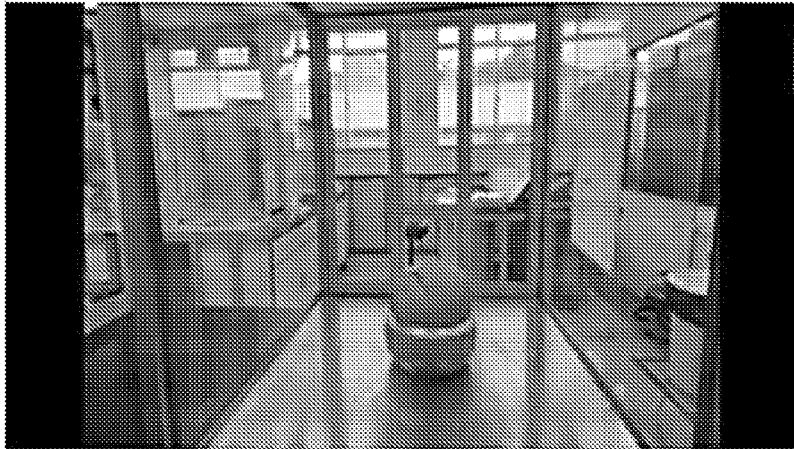


Figure 1

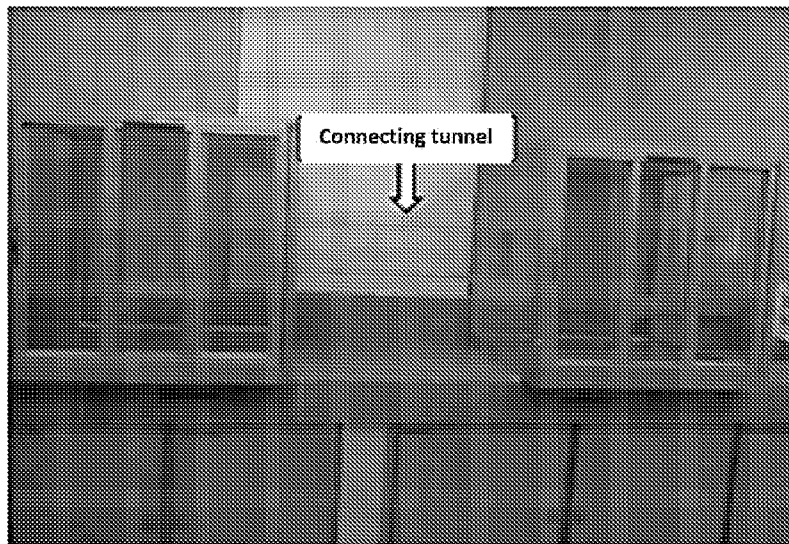


Figure 2

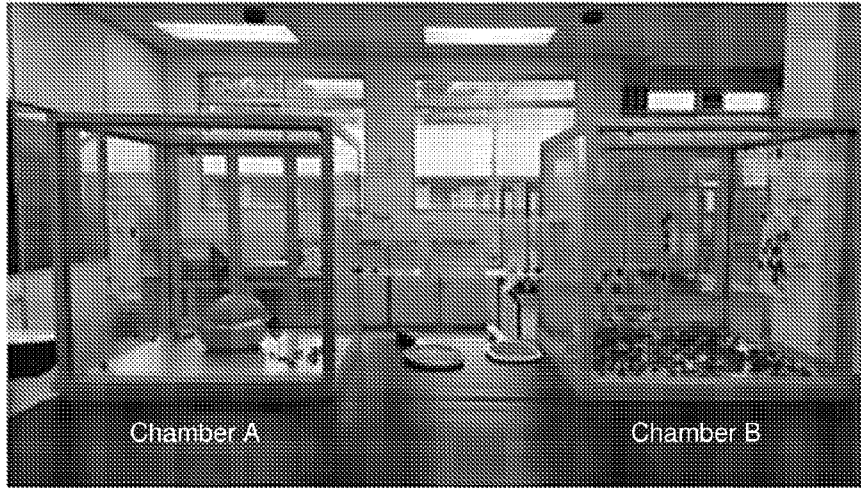


Figure 3

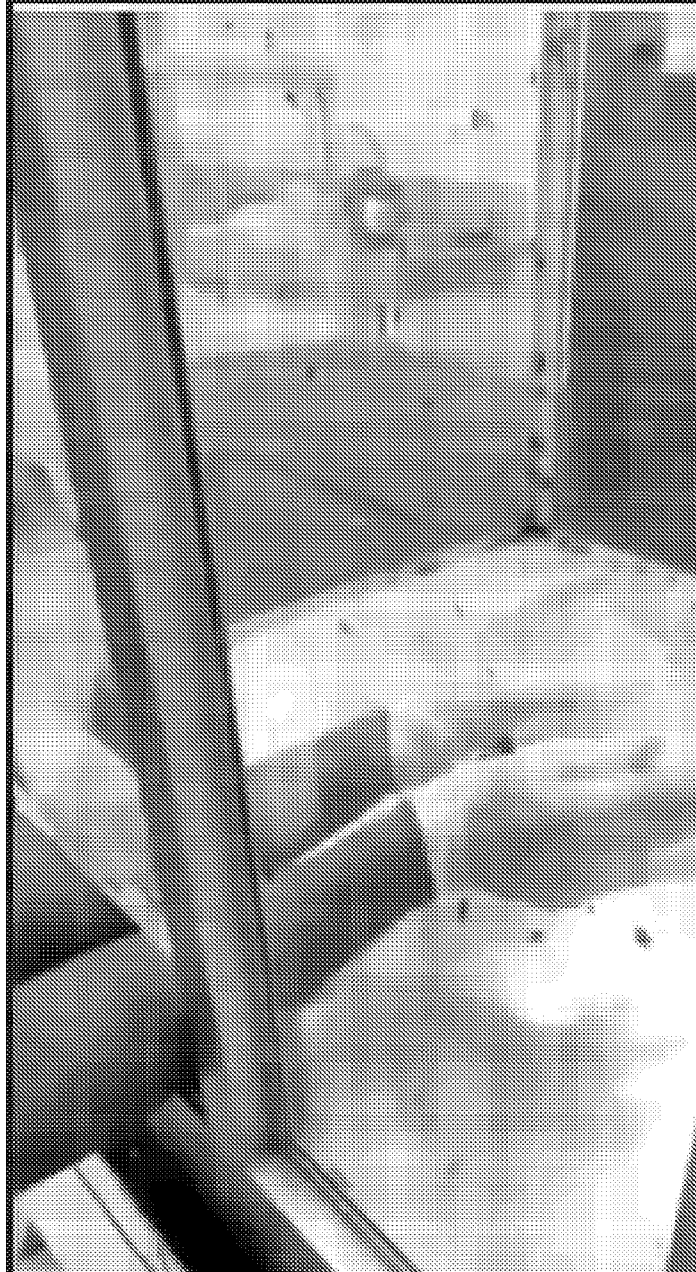


Figure 4

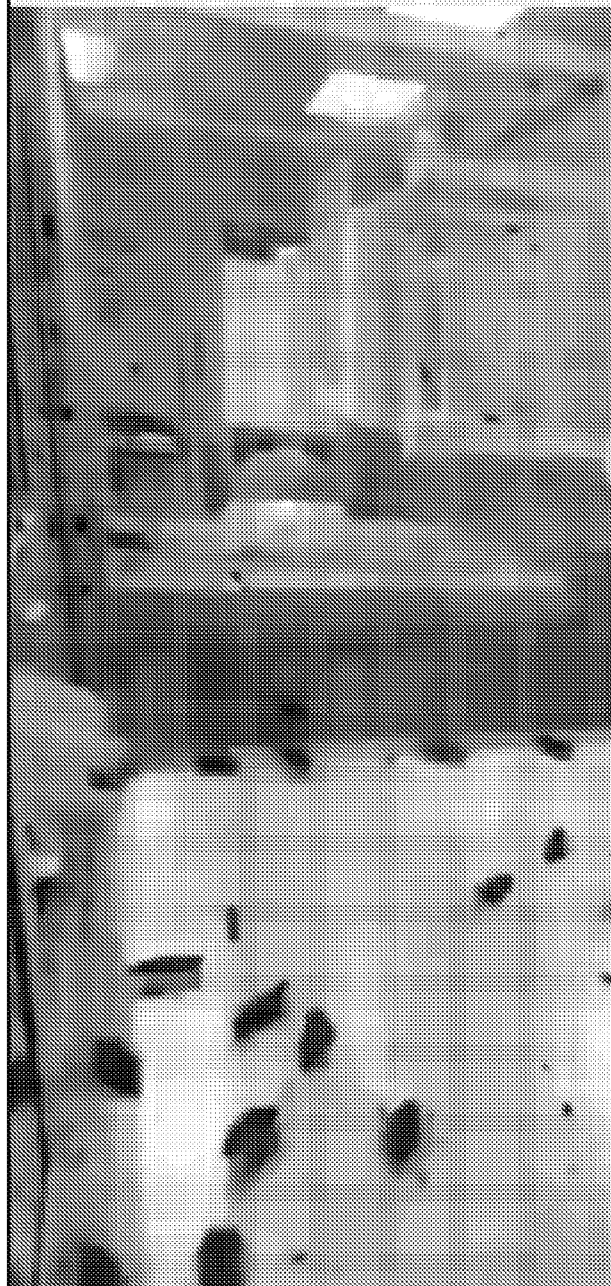


Figure 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2024/050379

A. CLASSIFICATION OF SUBJECT MATTER

A01N 55/10 (2006.01) A01N 25/08 (2006.01) A01P 7/04 (2006.01) A01P 1/00 (2006.01)

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

FAMPAT: silane, antimicrobial, silicone resin, cross-linker, catalyst, photocatalyst, thickener, 2405, 2403, 531, 536, aminosilane, titanium dioxide, hydroxypropyl methylcellulose and related terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/077805 A1 (COMMERCIAL SUPPLIES (FAR EAST) PTE. LTD.) 30 May 2013 pp. 1-4	1-14
D,A	US 10183187 B2 (LI G.) 22 January 2019 p. 2	1-14
A	WO 2019/145352 A1 (WORLEE-CHEMIE GMBH ET AL.) 1 August 2019 claims	-

Further documents are listed in the continuation of Box C.

See patent family annex.

*Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

01/09/2024

(day/month/year)

Date of mailing of the international search report

03/09/2024

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2024/050379

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013/077805 A1	30/05/2013	CN 103249788 A	14/08/2013
US 10183187 B2	22/01/2019	US 2018/0021613 A1 WO 2017/117861 A1	25/01/2018 13/07/2017
WO 2019/145352 A1	01/08/2019	ES 2907041 T3 JP 2021514406 A CN 111918913 A ES 2907082 T3 US 2021/0032499 A1 US 2023/0416567 A1 WO 2019/145349 A1 KR 20200108443 A RU 2020125210 A KR 20200108444 A RU 2020125202 A US 2021/0040323 A1 EP 3743466 A1 CN 111936568 A JP 2021512181 A EP 3743467 A1	21/04/2022 10/06/2021 10/11/2020 21/04/2022 04/02/2021 28/12/2023 01/08/2019 18/09/2020 31/01/2022 18/09/2020 31/01/2022 11/02/2021 02/12/2020 13/11/2020 13/05/2021 02/12/2020