DURABLE INSECTS REPELLENT COATING WITH ANTIMICROBIAL AIR SANITIZING PROPERTIES

TECHNICAL FIELD

This invention relates to an insect repellent coating, the preparation of the same, and the use to inhibit and/or prevent both microbial growth and repelling insects on the surface and adjacent ambience in which the coating has been applied.

The said insect repellent coating is also capable of air sanitizing and purifying the surrounding area under visible light with high resistance to heat. This helps to reduce the usage of harmful insecticides that pose health risk and pollution to the environment.

BACKGROUND ART

The basic principle of sustainable development is the development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. The increase in an unsustainable pattern of consumption as well as production are core causes of the triple planetary crises of climate change, biodiversity loss and pollution.

Pollution in the cities caused by transportations, chemical products used in the household, productions of chemicals from the industries upset the balance of sustainability, where the environment had to suffer the consequences. A polluted environment will then in turn affect the human beings, where their health is at risk. People who are exposed to toxic air pollutants at sufficient concentrations, for sufficient durations, may increase their risk of getting cancer or other adverse health effects such as reproductive problems, birth defects and aggravated asthma. The quality of human lives can be improved by reducing or preventing the exposure to pollutants from home, office, or the outdoor environment.

Buildings comprised of four walls, which can be as simple as a shop, flats, condominium, apartments to a large macro scale shopping complexes in urban city areas are increasing in large amounts. More developments as well as the purposes of maintaining the building walls in an environment friendly matter is rising rapidly. In order to keep the walls clean and appealing for a long time, paints are often associated with the additional property of antimicrobial efficiency. The paints incorporated with antimicrobial property is designed to resist microbes, including viruses, bacteria, and other germs. It can help keep your home safer, better protected against damage from molds, makes the interior walls be easier to clean, and aesthetically pleasing for a longer time without the need to repaint the walls. This will not only help to reduce the uses of paints in our daily lives, but also can help to cut down the use and emission of chemicals in our daily lives. The reduced usage of chemicals can be considered as one step close to save our environment, at least by cutting down pollution from the source.

Insect repellent is an example of chemicals used to control or prevent insect in households as well as commercially i.e., homes, food manufacturing companies, offices, shops or in any closed environment. Pests are also commonly found where food is handled, such as restaurants, barns, and food stores, insecticides, repellents, attractants, attachments, supplements, etc. are used in areas exposed to pests. These pesticides are used in various forms rather than using the original insecticide as it is for the purpose of use, user convenience, increase of insecticidal effect, etc.

The common insect species that humans encounter in their daily lives are houseflies (*Musca domestica*), cockroaches (*Periplaneta americana* and *Blatella germanica*) and mosquitoes (*Aedes aegypti*). These common insects are known for their potential to inflict many types of diseases. Table 1 below shows the example of diseases associated with list of common insects and the associated health risks.

Insect	Common diseases
Mosquitoes (*Aedes aegypti*)	Zika virus, West Nile virus, Chikungunya virus, dengue, and malaria etc
Houseflies *(Musca domestica)*	Anthrax, Salmonella, typhoid, Tuberculosis, cholera and dysentery etc
Cockroaches (*Periplaneta americana* and *Blatella germanica*)	Campylobacteriosis, Cholera, Dysentery, Giardia, Leprosy, Listeriosis, Salmonellosis, Thyphoid fever, staphylococcus, streptococcus, triggers asthma, allergies etc

Table 1: The list of common insects and the potential diseases caused.

Due to the potential health risk carried by the insects, human could not escape from using an insect repellent in their surrounding environment. Insect repellent represent an effective way to control pest insects but are harmful to both humans and the environment. In general, all chemicals including an insect repellent have some degree of toxicity varies by the product and the route of exposure (i.e., eating, breathing, touching). Most of us are familiar with insect repellent's that can be either sprayed or applied to the skin for prevention from mosquitoes, lice, bedbugs, bees, or other insects. The insect repellent which we rely on are actually a type of pesticide where a common type of chemicals formulated with the product are DEET (chemical name N,N-diethyl-meta-toluamide), permethrin, picaridin and IR3535. Table 2 below shows the type of health risk posed by the common ingredient found in an insect repellent.

Chemical	Risk to health
DEET	Causes irritation to skin and eyes
Permethrin	A neurotoxin that kills brain cells and toxic to cats, bees and aquatic life
Picaridin	acute oral, dermal and inhalation toxicity
IR3535	Causes irritation to skin and eyes

Table 2: Shows the chemical ingredients and their potential health effects.

The uses of environmentally friendly essential oils and plant extracts in paint coatings are an effective alternative way to repel insects from buildings. However, the efficacy of such coatings, needs to be improved since essential oils can only repel insects for only up to a few hours and can be increased to up to one year once incorporated into coating.

The WO/2013/007805, discloses on the process for making an antimicrobial coating having air sanitization, self-cleansing, and heat resistant properties. The invention further described the steps of stabilizing a silane base antimicrobial agent in water with a wetting agent, a surfactant and polyol to create a sol-gel solution, added with a photocatalyst and at least one metallic oxide to the sol-gel solution. Despite the invention having an antimicrobial property, the said invention does not provide a solution for repelling insects or pests upon application.

The KR1020210090864 discloses an insect repellent paint that can repel pests such as mosquitoes, flies, moths, and ants that is harmless to human body. Though the invention claims that the insect repellent is an all-natural formulation from ingredients such as *Cinnamomum verum*, *Syzygium aromaticum*, and *Glycyrrhiza uralensis*, the patent does not disclose about the effectiveness towards preventing microorganisms.

In IN201941031970, discloses an aromatic herbal-based mosquito repellent paint formulated with the herbal plants which includes Citronella, Peppermint, Lavender, Lemongrass and Eucalyptus. This aromatic herbal mosquito repellent paint can prevent mosquito bites, non-toxic, no side effects and promises long term protection. Despite being natural product with less harm to human, the invention is only able to prevent mosquitoes but unable to prevent other common insects such cockroaches and houseflies. The invention also lacks anti-microbial properties.

Similarly in another invention, CN105950015 the invention discloses about a mosquito proof environment friendly paint prepared from ingredients such as tea seed oil along with other less harmful chemicals. The invention claims that the mosquito-proof environment friendly paint can solve the problem of pollution as well as safe to living beings. However, the prior arts cited above does not provide protection towards other common insects (like cockroaches and houseflies) and harmful microorganisms.

In order to overcome the above-mentioned problems in the prior art, the present invention provides a coating that does not only provide protection from common disease-causing insects such as mosquitoes, houseflies and cockroaches but also an added protection towards harmful microbial organisms, protection towards high heat without the use of any harmful toxic substances in the formulation. The use of this coating will reduce pollution as well as reduce health risks.

SUMMARY OF THE INVENTION

Embodiments of the present invention relates to a product in a form of coating which not only prevents microorganisms on the surface applied, but simultaneously able to serve as an insect repellent. This makes the product produced from the said process to possess properties such as anti-microbial, anti-fungal, repels common insects, along with heat resistant properties.

The 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.

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.

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.

The said AOP insect repellent device is integrated with the chlorine dioxide in a form of slow-release powder, an air scrubber with the size between 60 to 120 mesh. The said insect repellent device is padded an air scrubber in a form of mixable powder which later converted into paint (covered by this invention) and coating onto the foam medium. This was done when water or vapours go into contact with the said air scrubber, the moisture generated will activate the chlorine dioxide, which is the key insect repellent chemistry. This is due to the ability of the chlorine dioxide gas which can destroy all types of microorganisms, including bacteria, spores, fungi, viruses, and even protozoans, in indoor environments.

The effectiveness of the said AOP insect repellent device 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 ± 20°C and humidity of 70 ± 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*).

In this invention, the above-mentioned formulation which is present within the AOP insect repellent device (efficient to repel insects) will be integrated with Quaternary Ammonium Silane which has been produced and marketed by the AEGIS Microbe Shield (efficient to repel microbes) and a photocatalyst, comprising of titanium dioxide. With more than 40 years of testing, AEGIS Microbe Shield technology has defined its history of safe use. It has proven to be reliable and an effective way of controlling a range of microbes, including mold, mildew, bacteria, algae and fungi on surfaces.

This will further upgrade the current formulation used within the AOP insect repellent device with additional antimicrobial properties provided by AEGIS Microbe Shield as well as increased resistance to heat. The formulation is then 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 and many other possible uses.

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%, 93.33% 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 AOP insect repellent device 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

Figure 1: Test sample of the AOP insect repellent device.
Figure 2: Two connecting chambers with a measurement of 70 cm (length) x 70 cm (height) x 70 cm (width) with opening door in middle of connecting tunnel (release point of mosquitoes).
Figure 3: The condition of study arena (Two connecting chambers 70 cm (length) x 70 cm (height) x 70 cm (width) with opening door in the middle of connecting tunnel - release point of cockroaches) tested against 2 species of Cockroaches (*Periplaneta americana* and *Blatella germanica* at 24 hours interval.

DETAILED DESCRIPTION

The present invention aims to provide a solution to repel insects for the users in addition to repellence towards common microbes. Most of the prior arts have disclosed on the efficiency of preventing only microorganisms or preventing only insects. However, the invention has come up with a new solution wherein the said coating (an integration of two main products namely the AOP insect repellent device and the AEGIS Microbe Shield technology) is able repel insects and prevent microbial attack on the surface in the coating will be used. The use of the said coating can be by way of application, spraying, lining, inserts, dissolving in a solution and other methods that will not halt the efficiency of the said coating, when the same is in use.

An AOP insect repellent device is comprised of fine powders in a particle size between 60 to 120 mesh. 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 will be integrated with another anti-microbial product from AEGIS Microbe Shield to provide protection against both microorganisms and insects.

When the fine powders are activated by water particles, the chlorine dioxide gas will 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 AOP insect repellent device toward insects has been tested at the Vector Control Research Unit at the School of Biological Sciences, University of Science Malaysia.

The AOP insect repellent device has been 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 ± 20°C and humidity of 70 ± 10% as shown by the Figure 1.

The synergistic use of both the Quaternary Ammonium Silane (AEGIS Microbe Shield) and nano titanium dioxide has an antimicrobial and air sanitizing properties. This has been disclosed within the same applicants earlier patent application No. WO/2013/007805 and ZL201180004829.3.

As described earlier, the said AOP insect repellent device will be further formulated with Quaternary Ammonium Silane which has been produced and marketed by the AEGIS Microbe Shield and a photocatalyst, comprising of titanium dioxide with a size of less than 20 nm. The Quaternary Ammonium Silane is 3-trimethoxsilylpropyldimethyloctadecyl ammonium chloride, that will provide additional antimicrobial properties to the coating referring to the patent application number PCTSG2011/00048 (Filing Date: 21 November 2011 WO/2013/007805) and application number ZL201180004829.3/103249788 (Filing Date: 7 September 2016).

The formulation will be further incorporated with 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.

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 and in other suitable areas.

Detailed procedures on how the insect repellence efficiency test has been carried out is explained as below. Further details on the experiment are illustrated within the Figure 2 and Figure 3.

A. *Mosquitoes – Aedes aegypti*

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 2500 laboratory-cultured sucrose-fed adult female mosquitoes (aged 5 - 7 days) were released into the chamber through an opening in the middle of connecting tunnel. The number of mosquitoes in Chamber A, tunnel and Chamber B was recorded. After that all the mosquitoes are removed and an AOP insect repellent device is 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 chamber A and B were recorded at the intervals of 30 minutes, 1 hour and 24 hours after introduction.

B. *Houseflies – Musca domestica*

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 an AOP repellent device is set into Chamber A. A total of 1500 laboratory-cultured sucrose-fed adult houseflies (aged 5 - 7 days) are released in the connecting tunnel. The numbers of houseflies in chamber A and B were recorded at the intervals of 30 minutes, 1 hour and 24 hours after introduction.

C. *Cockroaches – Periplaneta americana and Blatella germanica*

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 AOP repellent device is set in the 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.

The effectiveness of the insect repellence strength of the AOP repellent device was calculated from the formula below:

Bite reduction (%) *= 100 – [no. of test insect in chamber A/Total no of test insect used] x100*

The results shows that AOP repellent device gave excellent repellence against Mosquitoes (*Aedes aegypti*), Houseflies (*Musca domestica*) and Cockroaches (*Periplaneta americana and Blatella germanica*) with repellence percentage of 86.00%, 93.33% and 95.00% respectively at 24 hours interval.

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

- number of mosquitoes released was 2500.
- Pretreatment – no AOP repellent device was set in the chamber A
- Treatment – AOP repellent device was set in chamber A
- Number in bracket is percentage of repellence.

***Table 1**: Number of Mosquitoes recorded at different time interval of AOP repellent device samples against Aedes aegypti (n=2500).*

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

- number of houseflies release was 1500
- Pretreatment – no AOP repellent device was set in the chamber A
- Treatment – AOP repellent device was set in chamber A
- Number in bracket is percentage of repellence

***Table 2**: Number of Houseflies recorded at different time intervals of AOP repellent device repellent samples against Musca domestica (n-1500).*

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

- *number of cockroaches release was 500 Periplaneta americana and 500 Blatella germanica (nymph, male and female)*
- *Pretreatment – no AOP repellent device was set in the chamber A*
- *Treatment – AOP repellent device was set in chamber A*
- *Number in bracket is percentage of repellency*

***Table 3**: Number of Cockroaches recorded at different time interval of AOP repellent device samples against Periplaneta americana (n=500) and Blatella germanica (n=500).*

CLAIMS

1. A process for making an insect repellent coating comprising the steps of:
   (a) AOP insect repellent device comprised of fine powders integrated with chlorine dioxide gas;
   (b) said device will be further formulated with Quaternary Ammonium Silane;
   (c) additives such as silicone resins, extenders, thickening agents, and cross-linkers will be added for a stable formulation;
   (d) adding a photocatalyst with a size of less than 20 nm to the coating obtained from the steps (a), (b) and (c).

2. A process according to Claim 1, wherein the AOP insect repellent device contains fine powders in a particle size between 60 to 120 mesh will release chlorine dioxide gas upon contact with water or vapours in the surrounding.

3. A process according to Claim 1, wherein the Quaternary Ammonium Silane is 3-trimethoxsilylpropyldimethyloctadecyl ammonium chloride, provides antimicrobial properties to the said coating.

4. A process according to Claim 1, wherein the silane is from the AEGIS Microbe Shield.

5. A process according to Claim 1, wherein the photocatalyst has a particle size between 10 - 15 nm.

6. A process according to Claim 1, wherein the photocatalyst used is titanium dioxide.

7. A process according to Claim 1, wherein the chlorine dioxide gas will be slowly released into the said coating upon contact with water or vapour.

8. A process according to Claim 1, wherein the chlorine dioxide is released at 0.01 ppm that is way below the OSHA permissible level of exposure limit of 0.1 ppm.

9. The coating made in accordance with Claim 1, wherein the coating further possessing the properties of antimicrobial which effectively kill or prevent microbe growth and resistance to high temperatures.

10. The coating made in accordance with Claim 1, wherein the coating will have the insect repellent properties for over 12 months upon usage.

11. The coating made in accordance with Claim 1, wherein the coating will have properties such as antimicrobial, insect repellent and air sanitization under visible light.

12. The coating made in accordance with Claim 1, wherein the coating 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, insect repelling antimicrobial foam tapes for kitchen area, double sided mountable to protect foods during food processing and many other possible uses in other suitable areas.

13. An environment friendly insect repellent coating wherein the coating comprised of:
    AOP insect repellent device with small particles integrated with chlorine dioxide;
    A silane based antimicrobial agent;
    A photocatalyst with a particle size of less than 20 nm; and additives
    wherein the insect repellent coating has air sanitization, antimicrobial and heat resistant properties.

14. The insect repellent coating according to Claim 13, wherein the AOP insect repellent device comprised of particles in the range of 60 to 120 mesh and integrated with chlorine dioxide that activates when there is contact with water or vapor.

15. The insect repellent coating according to Claim 13, wherein the silane based antimicrobial agent is the 3-trimethoxsilylpropyldimethyloctadecyl or the Quaternary Ammonium Silane from AEGIS Microbe Shield.

16. The insect repellent coating according to Claim 13, wherein the photocatalyst has a particle size between 10 to 15 nm.

17. The insect repellent coating according to Claim 13, wherein the photocatalyst used is titanium dioxide.

18. The insect repellent coating according to Claim 13, wherein the chlorine dioxide gas will be slowly released into the said coating.

19. The insect repellent coating according to Claim 13, wherein the chlorine dioxide will be released at 0.01 ppm, below the OSHA permissible level of exposure limit of 0.1 ppm.

20. The insect repellent coating according to Claim 13, wherein the coating has antimicrobial properties which effectively kill or prevent microbe growth and resistance to high temperatures.

21. The insect repellent coating according to Claim 13, wherein the insect repellent properties will last at least about 12 months upon usage.

22. The insect repellent coating according to Claim 13, wherein the coating will have additional properties such as antimicrobial and air sanitization under the visible light.

23. The insect repellent coating according to Claim 13, wherein the coating can be utilized in air conditioners, filter inserts in face masks, air scrubbers, packaging materials, reusable baby cloth diapers, diaper covers, water purification systems, window curtains, insect repelling antimicrobial foam tapes for kitchen area, double sided mountable to protect foods during food processing and many other possible uses in other suitable areas.