

## DESCRIPTION

METHOD FOR CONTROLLING INSECT PESTS AND ACARINES, AND AEROSOL  
FOR CONTROLLING INSECT PESTS AND ACARINES

5

TECHNICAL FIELD

[0001]

The present invention relates to: a method for  
controlling insect pests and acarines by a spray treatment  
10 using an insect pest and acarine control aerosol obtained by  
filling an aerosol container equipped with a fixed-volume  
spray valve having a sprayed amount of 1.0-5.0 mL per  
operation with an aerosol-forming material containing a  
control component and an organic solvent, and a propellant;  
15 and an aerosol for controlling insect pests and acarines  
(insect pest and acarine control aerosol).

BACKGROUND ART

[0002]

20 Some representative types of insecticides that are for  
creeping insect pests which move around on the floor surface  
and wall such as cockroaches, and house dust acarines, and are  
applied to places and passages which are inhabited by those  
creeping insect pests and acarines, include (1) fumigants, (2)  
25 single-use aerosols, (3) coating-type aerosols, and (4) bait  
agents, which have their own features specific to their

respective dosage forms.

[0003]

In the case of (1) fumigants and (2) single-use aerosols, chemicals are quickly released and diffused throughout an indoor space, which is tightly closed for a predetermined period of time so that the concentration of the chemicals is increased, during which humans are not allowed to enter the space. Therefore, (1) fumigants and (2) single-use aerosols are classified as medicines. Once these formulations are applied, the effect of exterminating creeping insect pests and house dust acarines is sustained for 2-4 weeks. However, it takes time and effort to conduct preparation before use, and it is necessary to take measures to pay particular attention to the safety of chemicals, etc. Therefore, these dosage forms are not considered to be easy or popular.

[0004]

Meanwhile, (3) coating-type aerosols, which are locally applied to the surface, and (4) bait agents, which are applied to the point, are quasi-drugs, which have a mild effect on the human body. It is easier to use these dosage forms than (1) fumigants and (2) single-use aerosols. However, (3) coating-type aerosols and (4) bait agents are not applied to the space, and therefore, have less contact efficiency of chemicals with insect pests and acarines, and do not necessarily lead to an efficient extermination method.

[0005]

Thus, it has conventionally been considered that there are difficulties in developing an agent for controlling creeping insect pests and house dust acarines that is applied to the space and is classified as a quasi-drug.

5 [0006]

Incidentally, Patent Document 1 discloses a method for exterminating creeping insect pests by vaporizing and diffusing an insecticidal liquid containing an insecticidal component and a solvent into a space, such as an indoor space  
10 or storage space, wherein a compound having a specific structure is used as the solvent, and the insecticidal liquid is vaporized and diffused in small portions over time using a piezoelectric atomizer so that fine particles of the insecticidal liquid having a small particle size can continue  
15 to be suspended. In the method proposed in Patent Document 1, a small amount of chemicals continues to be released and diffused in the space over a long period of time to control cockroaches, like liquid electric mosquito killers. That proposed method is for exterminating cockroaches, which are  
20 several tens of times as resistant to chemicals as mosquitoes, and therefore, requires a more potent insecticidal component, inevitably leading to a risk to the safety of the human body.

[0007]

In the development of a spatial treatment agent that is  
25 for controlling creeping insect pests and house dust acarines and that is classified as a quasi-drug, the present inventors

have extensively studied and made attempt to create a formulation that can sustain a control effect for several days under practical conditions after a fixed amount of the formulation is atomized once, i.e., a formulation that is  
5 basically used once per 1-2 days, and is so safe as to be used even in situations that humans are present, instead of formulations that are used once per 2-4 weeks, such as (1) fumigants and (2) single-use aerosols. As a result, the present inventors have arrived at a very useful "insect pest  
10 and acarine control method" that is effective not only in controlling creeping insect pests and house dust acarines, but also in controlling flying insect pests on the day when the formulation is atomized (see Patent Document 2). Note that in that invention, in order to additionally achieve a practical  
15 effect of exterminating flying insect pests, spraying characteristics of an aerosol are designed such that atomized particles after spraying include suspendable particles, and adhesive particles that adhere to the wall surface or the like and settle on the floor surface, preferably such that 30-80%  
20 of all the atomized particles adhere to the wall surface or the like or settle on the floor surface by one hour after a spray treatment. As of the invention disclosed in Patent Document 2, the sprayed amount of the fixed-volume spray valve is typically 0.2-0.4 mL, and a single treatment with the  
25 formulation basically requires a multiple-push operation (the spray button is pushed down multiple times).

[0008]

Meanwhile, Patent Document 3 discloses a creeping insect pest extermination aerosol product employing a fixed-volume spray valve, and a creeping insect pest extermination method.

5 That aerosol product is characterized in that the portion of a propellant blended and contained in an aerosol container is increased and the vapor pressure of a solvent in which an active component is dissolved is decreased so as to reduce the evaporation rate of the solvent that has been sprayed from the  
10 aerosol container and has formed particles, whereby the particles can be diffused deep into gaps and cracks in the indoor space. That is, the method disclosed in Patent Document 3 may be a fixed-volume spray treatment, and indeed, corresponds to a local treatment with (3) a coating-type  
15 aerosol, and therefore, is not a spatial treatment. Therefore, although a high extermination effect may be locally achieved at some of the gaps and cracks, creeping insect pests cannot be efficiently exterminated throughout the indoor space.

20 CITATION LIST

PATENT LITERATURE

[0009]

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2009-143868

25 Patent Document 2: Japanese Patent No. 5517122

Patent Document 3: Japanese Unexamined Patent

SUMMARY

TECHNICAL PROBLEM

5 [0010]

With the above circumstances in mind, the present inventors have recognized that a spatial fixed-volume spray treatment based on Patent Document 2 is a most efficient method for controlling insect pests and acarines, and have  
10 studied and made attempts to improve the convenience thereof, and particularly, the efficacy thereof in controlling creeping insect pests and house dust acarines. Firstly, a recently developed fixed-volume spray valve having a sprayed amount of 1.0-5.0 mL is employed, and a required amount of an active  
15 component is allowed to be sprayed by a single-push operation. The formation of atomized particles after spraying including suspendable particles which are suspended in a treated space and adhesive particles that adhere to exposed portions in the treated space alone is not sufficient to enhance the control  
20 effect of the spatial treatment on creeping insect pests, particularly cockroaches or the like. The present inventors have also concluded that such enhancement is achieved if adhesive particles are made more dominant compared to the spraying characteristics of Patent Document 2, and the  
25 proportion of adhesive particles that settle on the floor surface is increased compared to adhesive particles that

adhere to the wall surface or the like. The present inventors have also found that the specific gravity of the aerosol-forming material and the spray force of the aerosol are an important factor in the determination of the behavior of adhesive particles that settle, and have repeatedly conducted testing through trial and error to identify optimum ranges of the specific gravity of the aerosol-forming material and the spray force of the aerosol and thereby arrive at the present disclosure.

10 [0011]

It is an object to the present disclosure to provide: a method for controlling insect pests and acarines in which a control effect on creeping insect pests and house dust acarines is sustained for several days only by pushing an insect pest and acarine control aerosol equipped with a 1.0-5.0 mL volume fixed-volume spray valve once in an indoor space; and an aerosol for controlling insect pests and acarines.

#### SOLUTION TO PROBLEM

20 [0012]

The object of the present disclosure is achieved by the following configurations.

[1] In an aspect, there is provided a method for controlling insect pests and acarines by a spray treatment using an insect pest and acarine control aerosol obtained by filling an aerosol container equipped with

a fixed-volume spray valve having a sprayed amount of 1.0-5.0 mL per operation with an aerosol-forming material containing a control component and an organic solvent, and a propellant, wherein

5           the control component is a poorly volatile and diffusible compound having a vapor pressure of less than  $1 \times 10^{-4}$  mmHg at 30°C,

          the aerosol-forming material has a specific gravity of 0.85-1.15,

10          the insect pest and acarine control aerosol has a spray force of 10-50 gf at a spray distance of 5 cm, and

          the aerosol-forming material is sprayed into an indoor space in the spray treatment such that the amount of the control component released is 0.1-50 mg/m<sup>3</sup>, and 60% or more of  
15 the control component is diffused and adheres to an entire floor surface of the indoor space by one hour after the spraying.

[2] The method according to [1], wherein

          the insect pest and acarine control aerosol is  
20 configured such that  $\delta$  represented by expression (1) is in the range of 1.0-30:

$$\delta = [a/(a + b)] \times S^2 \times F \quad (1)$$

where a represents the contained amount of the aerosol-forming material, b represents the contained amount of the propellant,  
25 S represents the specific gravity of the aerosol-forming material, and F represents the spray force of the insect pest

and acarine control aerosol.

[3] The method according to [2], wherein  
the insect pest and acarine control aerosol is  
configured to satisfy:

5            $0.1 \leq [a/(a + b)] \leq 0.5 \quad (2).$

[4] The method according to [2] or [3], wherein  
the insect pest and acarine control aerosol is  
configured to satisfy:

10            $3.0 \leq \delta \leq 15 \quad (3).$

[5] The method according to any one of [1]-[4], wherein  
the poorly volatile and diffusible compound is at least  
one creeping insect pest control compound selected from the  
group consisting of phenothrin, cyphenothrin, permethrin,  
15 cypermethrin, cyfluthrin, bifenthrin, fenpropathrin,  
tralomethrin, etofenprox, and dinotefuran.

[6] The method according to any one of [1]-[4], wherein  
the poorly volatile and diffusible compound is at least  
one acarine control compound selected from the group  
20 consisting of amidoflumet, benzyl benzoate, phenyl salicylate,  
benzyl salicylate, dibutyl sebacate, dipropyl sebacate,  
dibutyl adipate, diethyl phthalate, dibutyl phthalate, and p-  
menthane-3,8-diol.

[7] The method according to any one of [1]-[6], wherein  
25 the organic solvent is a lower alcohol having 2 or 3  
carbon atoms.

[8] The method according to any one of [1]-[7], wherein the area of the floor surface of the indoor space is 7.5-26.6 m<sup>2</sup>.

[9] In another aspect, there is provided an insect pest and acarine control aerosol obtained by filling an aerosol container equipped with a fixed-volume spray valve having a sprayed amount of 1.0-5.0 mL per operation with an aerosol-forming material containing a control component and an organic solvent, and a propellant, wherein

the control component is a poorly volatile and diffusible compound having a vapor pressure of less than  $1 \times 10^{-4}$  mmHg at 30°C,

the aerosol-forming material has a specific gravity of 0.85-1.15,

the insect pest and acarine control aerosol has a spray force of 10-50 gf at a spray distance of 5 cm, and

when the aerosol-forming material is sprayed into an indoor space in a single-spray treatment through the fixed-volume spray valve such that the amount of the control component released is 0.1-50 mg/m<sup>3</sup>, 60% or more of the control component is diffused and adheres to an entire floor surface of the indoor space by one hour after the spraying.

#### ADVANTAGEOUS EFFECTS

[0013]

With the insect pest and acarine control method and

insect pest and acarine control aerosol of the present disclosure, only by spraying a specific insect pest and acarine control aerosol containing a poorly volatile and diffusible compound into an indoor space by a single-push operation, a control effect particularly on creeping insect pests and house dust acarines can be sustained in the treated zone for several days. Thus, a convenient and effective insect pests and acarines control method and insect pest and acarine control aerosol are provided, which are significantly practical.

10

#### DESCRIPTION OF EMBODIMENTS

[0014]

In the present invention, a poorly volatile and diffusible compound having a vapor pressure of less than  $1 \times 10^{-4}$  mmHg at 30°C is used as a control component. After a spray treatment is performed in an indoor space by pushing an insect pest and acarine control aerosol of the present invention once (a single-push operation), most of the control component settles as adhesive particles on the floor surface to exhibit an excellent control effect particularly on creeping insect pests and house dust acarines in the indoor space. As used herein, the extermination effect based on the knockdown effect and the lethal effect, and the repellent effect, are collectively referred to as a "control effect." In most situations, control is practically achieved by a sufficient repellent effect even if the extermination effect

is low.

[0015]

Specifically, based on the recognition that a spatial fixed-volume spray treatment based on Patent Document 2 is a most efficient method for controlling insect pests and acarines, the present invention is directed to an improvement in the convenience thereof, and particularly, in the efficacy thereof in controlling creeping insect pests and house dust acarines. Firstly, a recently developed fixed-volume spray valve having a sprayed amount of 1.0-5.0 mL is employed so that a required amount of an active component is allowed to be sprayed by a single-push operation. In order to enhance the control effect of the spatial treatment on creeping insect pests, particularly cockroaches or the like, it is important that adhesive particles are made more dominant in atomized particles after spraying (including suspendable particles and adhesive particles), and the proportion of adhesive particles that settle on the floor surface is increased compared to adhesive particles that adhere to the wall surface. Based on such a concept, the present invention has been achieved. Note that the adhesive particles of the present invention enter gaps and cracks or hiding places during settlement, and therefore, if a pyrethroid compound is used as a control component, the flushing-out effect of causing cockroaches or the like to leave gaps and cracks or hiding places, can be sufficiently expected.

[0016]

As the poorly volatile and diffusible control component used in the present invention, creeping insect pest control compounds for mainly controlling creeping insect pests such as  
5 cockroaches, and/or acarine control compounds for mainly controlling house dust acarines, can be used. Examples of the creeping insect pest control compound include: pyrethroid compounds such as phenothrin, cyphenothrin, permethrin, cypermethrin, cyfluthrin, bifenthrin, fenpropathrin,  
10 tralomethrin, etofenprox, and imiprothrin; silicon-based compounds such as silafluofen; organic phosphorus-based compounds such as dichlorvos and fenitrothion; carbamate compounds such as propoxur; neonicotinoid compounds such as dinotefuran, imidacloprid, and clothianidin; fipronil; and  
15 indoxacarb. Of them, phenothrin, cyphenothrin, permethrin, cypermethrin, cyfluthrin, bifenthrin, fenpropathrin, tralomethrin, etofenprox, and dinotefuran are preferable. Note that if there are optical or geometrical isomers based on asymmetric carbon at an acid moiety or alcohol moiety of a  
20 pyrethroid compound, these individual isomers and any combinations thereof can, of course, be included in the present invention.

[0017]

Examples of the acarine control compound include  
25 amidoflumet, benzyl benzoate, phenyl salicylate, benzyl salicylate, dibutyl sebacate, dipropyl sebacate, dibutyl

adipate, diethyl phthalate, dipropyl phthalate, dibutyl phthalate, p-menthane-3,8-diol, 3-iodo-2-propynyl butylcarbamate, phenothrin, and DEET. Of them, amidoflumet, benzyl benzoate, phenyl salicylate, benzyl salicylate, dibutyl sebacate, dipropyl sebacate, dibutyl adipate, diethyl phthalate, dibutyl phthalate, p-menthane-3,8-diol, phenothrin, and DEET are preferable.

[0018]

In the insect pest and acarine control method of the present invention, a fixed small amount of the aerosol-forming material containing a control component and an organic solvent is sprayed into a space. The control component content of the aerosol-forming material is preferably about 1.0-70 w/v%. If the control component content of the aerosol-forming material is less than 1.0 w/v%, the desired control effect is not obtained. If control component content of the aerosol-forming material is more than 70 w/v%, there are difficulties in stabilizing the liquidity of the aerosol-forming material.

[0019]

In the present invention, in addition to the above poorly volatile and diffusible control component, another control component that has a vapor pressure of not less than  $2 \times 10^{-4}$  mmHg and less than  $1 \times 10^{-2}$  mmHg at 30°C and is volatile and diffusible at room temperature may be added so that after a spatial spray treatment, some of atomized particles remain suspended in the air so that a control effect can be exhibited

on flying insect pests. Examples of the control component that is volatile and diffusible at room temperature include metofluthrin, profluthrin, transfluthrin, empenethrin, terallethrin, and furamethrin. It has been demonstrated that  
5 when the control component that is volatile and diffusible at room temperature, and the poorly volatile and diffusible control component, together partially adhere to the floor surface or the wall surface, these components can exhibit a synergistic control effect on creeping insect pests and/or  
10 house dust acarines. Note that as the control component that is volatile and diffusible at room temperature, metofluthrin, profluthrin, and transfluthrin are preferable in terms of vapor pressure, stability, basic insecticidal efficacy, or the like. If there are optical or geometrical isomers based on  
15 asymmetric carbon at an acid moiety or alcohol moiety of these compounds, these individual isomers and any combinations thereof can, of course, be included in the present invention.

[0020]

In the present invention, an organic solvent for  
20 dissolving the poorly volatile and diffusible control component is added to form the aerosol-forming material. Examples of the organic solvent include: lower alcohols having two or three carbon atoms; hydrocarbon solvents such as normal paraffin and isoparaffin; ester solvents such as isopropyl  
25 myristate (IPM) and hexyl laurate; glycol ether solvents having 3-10 carbon atoms; and ketone solvents. Of them, lower

alcohols having two or three carbon atoms, such as ethanol and isopropanol (IPA), are preferable.

[0021]

In the insect pest and acarine control method of the present invention, the insect pest and acarine control aerosol containing the poorly volatile and diffusible control component is used to perform a spray treatment in an indoor space, where the sprayed amount thereof is 1.0-5.0 mL per operation. As a result, in the space thus treated, the effect of controlling creeping insect pests and/or house dust acarines is sustained for several days. The size of the indoor space is preferably a volume of 18.8-33.3 m<sup>3</sup> (area: 7.5-13.3 m<sup>2</sup>, height: 2.2-3.0 m) corresponding to a room of 4.5-8 Jyo (Jyo is a Japanese unit of area: 1 Jyo is equal to approximately 1.66 m<sup>2</sup>).

[0022]

The atomized particles after spraying are formed as suspendable particles that are suspended in the treated space, or adhesive particles that adhere to an exposed portion in the treated space. The present inventors have made attempts to make adhesive particles more dominant, and to increase the ratio of adhesive particles that settle on the floor surface to adhesive particles that adhere to the wall surface or the like. As a result, the present inventors have found that the specific gravity of the aerosol-forming material and the spray force of the aerosol are important factors that determine the

settling behavior of adhesive particles, and have identify the optimum ranges thereof. Specifically, it has been demonstrated that if the specific gravity of the aerosol-forming material is 0.85-1.15, preferably 0.89-1.10, and the spray force of the spray treatment is 10-50 gf, preferably 15-35 gf, at a spray distance of 5 cm, 60% or more of the control component settles and adheres to the entire floor surface in the indoor space by one hour after spraying, so that an excellent effect of controlling creeping insect pests and acarines can be exhibited. Concerning the "settlement and adhesion of the control component to the entire floor surface," it is not necessary to actually confirm the settlement and adhesion of the control component to the entire floor surface each time spraying is conducted. When the aerosol is sprayed in a space to be treated in a manner as specified in the present invention, then even if the sprayed control component slightly non-uniformly or irregularly settles and adheres to the floor surface, the control component can be assumed to settle and adhere throughout the floor surface, which does not pose a problem with practical use. If the specific gravity of the aerosol-forming material is less than 0.85, the amount of atomized particles adhering to the floor surface tends to be insufficient. Conversely, if the specific gravity of the aerosol-forming material is more than 1.15, atomized particles settle too quickly to spread sufficiently over the entire floor surface. If the spray force of the spray treatment is

less than 10 gf, the spray force tends not to be enough to sufficiently spread over the entire floor surface. If the spray force is more than 50 gf, good ability to spread is not obtained. Note that the spray force of the aerosol can be  
5 suitably adjusted by changing the composition of the aerosol-forming material, the internal pressure of the aerosol, the shape of the outlet, or the like.

[0023]

Furthermore, in the insect pest and acarine control  
10 aerosol,  $\delta$  represented by expression (1) below is preferably in the range of 1.0-30, more preferably 3.0-15:

$$\delta = [a/(a + b)] \times S^2 \times F \quad (1)$$

where a represents the contained amount of the aerosol-forming material, b represents the contained amount of the propellant,  
15 S represents the specific gravity of the aerosol-forming material, and F represents the spray force of the insect pest and acarine control aerosol.

[0024]

If  $\delta$  is in the range of 1.0-30, then when atomized  
20 particles settle, a sufficient amount of the control component uniformly spreads over the entire floor surface, resulting in a preferable control effect. The uniform spread of the control component over the entire floor surface is considered to be attributed to the appropriate initial speed of atomized  
25 particles sprayed from the insect pest and acarine control aerosol, and the quick spread of the atomized particles

throughout the indoor space after spraying. If  $\delta$  is less than 1.0, the amount of the control component adhering to the floor surface may be insufficient. Meanwhile, if  $\delta$  is more than 30, the spread may be insufficient with respect to the entire floor surface. Therefore, if  $\delta$  is not in the range of 1.0-30, a satisfactory control effect is less likely to be exhibited.

[0025]

In the insect pest and acarine control aerosol, the volume ratio  $[a/(a + b)]$  of the contained amount (a) of the aerosol-forming material to the total volume (a + b) of the insect pest and acarine control aerosol preferably satisfies the following expression.

$$0.1 \leq [a/(a + b)] \leq 0.5 \quad (2)$$

If the volume ratio is in the above range, a sufficient amount of the control component uniformly spreads over the entire floor surface. If the volume ratio is less than 0.1 and the propellant is too much, the amount of the control component adhering to the floor surface is insufficient. Meanwhile, if the volume ratio is more than 0.5, atomized particles settle too quickly to spread sufficiently over the entire floor surface.

[0026]

As the insect pest and acarine control aerosol used in the present invention is sprayed in a small amount, it is not necessary to take measures against the risk of catching fire. However, the insect pest and acarine control aerosol may be a

water-based formulation in order to reduce the risk of catching fire to the extent possible. In that case, the amount of water contained in the aerosol-forming material is preferably about 20-70 v/v%, and a slight amount of a non-ionic surfactant may be added as a solubilizing aid in the range that does not affect the spray pattern of atomized particles. Examples of the non-ionic surfactant include: ethers such as polyoxyethylene alkyl ethers, polyoxyethylene alkyl phenyl ethers, polyoxyethylene polyoxypropylene alkyl ethers, and polyoxyethylene alkyl amino ethers; fatty acid ester such as polyethylene glycol fatty acid esters, polyoxyethylene sorbitan fatty acid esters, and polyoxyethylene glycerol fatty acid esters; polyoxyethylene styrenated phenol; and polyalkanolamides of fatty acids. Of them, the above ethers are suitable.

[0027]

The aerosol-forming material can optionally contain, in addition to the above components, antifungal, antimicrobial, and microbicidal agents for molds, fungi, and the like, and fragrances, deodorants, stabilizers, antistatic agents, defoamers, excipients, and the like. Examples of antifungal, antimicrobial, and microbicidal agents include hinokithiol, 2-mercaptobenzothiazole, 2-(4-thiazolyl)benzimidazole, 5-chloro-2-methyl-4-isothiazoline-3-one, triforine, 3-methyl-4-isopropylphenol, and ortho-phenylphenol. Examples of fragrances include, but are not limited to, fragrant

components such as orange oil, lemon oil, lavender oil, peppermint oil, eucalyptus oil, citronella oil, lime oil, yuzu oil, jasmine oil, cypress oil, green tea essential oil, limonene,  $\alpha$ -pinene, linalool, geraniol, phenylethyl alcohol, 5 amylcinnamic aldehyde, cuminaldehyde, and benzyl acetate, and aroma components mixed with leaf alcohol or leaf aldehyde, called "green leaf volatiles."

[0028]

Examples of the propellant used in the present invention 10 include liquefied petroleum gas (LPG), liquefied gases of dimethyl ether, hydrofluorocarbon, and the like, nitrogen gas, carbon dioxide gas, nitrous oxide, and compressed gases such as compressed air. One or more of these gases can be suitably used. The propellant may be suitably selected, taking into 15 account the percentage of adhesion of atomized particles to the floor surface or the wall. It is typically easy to use a gas mainly containing LPG. Note that the gauge pressure of the propellant is preferably adjusted to 0.1-0.7 MPa (20°C) for use.

20 [0029]

The insect pest and acarine control aerosol is equipped with a fixed-volume spray valve having a sprayed amount of 1.0-5.0 mL per operation. The insect pest and acarine control aerosol is used for a fixed-amount spray treatment in an 25 indoor space. While conventional fixed-volume spray valves have a spray amount of 0.2-0.4 mL, the fixed-volume spray

valve used in the present invention can spray a required amount of an active component by a single-push operation because of the increased volume. In addition, the shapes of the outlet, nozzle, container, and the like can be suitably selected according to use, purpose, and the like. For example, the container may be designed as a tabletop container equipped with a spray button which is pushed from above and a diagonally upward nozzle, or as a small-size portable container.

10 [0030]

The insect pest and acarine control method of the present invention is designed such that the insect pest and acarine control aerosol thus obtained is used to perform a spray treatment into the air in an indoor space, where the sprayed amount is 1.0-5.0 mL per operation, preferably 1.0-3.0 mL per operation, whereby the amount of the control component released into the air is 0.1-50 mg/m<sup>3</sup>, preferably 0.5-50 mg/m<sup>3</sup>. When the spray treatment is performed in an indoor space having a volume of 18.8-33.3 m<sup>3</sup> (area: 7.5-13.3 m<sup>2</sup>, height: 2.2-3.0 m) corresponding to a room of 4.5-8 Jyo, the amount of the control component released into the air is typically 0.1-50 mg/m<sup>3</sup> by a single-spray operation of the aerosol-forming material. In the case of an indoor space having a greater volume, the aerosol-forming material may be sprayed by a multiple-spray operation depending on the volume of the indoor space so that the amount of the control component released

into the air is 0.1-50 mg/m<sup>3</sup>, whereby a similar control effect can be obtained irrespective of the size of an indoor space. For example, when a spray treatment is performed in an indoor space having a volume of 37.6-66.6 m<sup>3</sup> (area: 15-26.6 m<sup>2</sup>,  
5 height: 2.2-3.0 m) corresponding to a room of 9-16 Jyo, the amount of the control component released into the air is 0.1-50 mg/m<sup>3</sup> by a double-spray operation of the aerosol-forming material. If the frequency of use of the insect pest and acarine control aerosol is basically once per 1-2 days, and  
10 the amount of the control component released is in the above range in each operation, the control effect on creeping insect pests and/or house dust acarines can be maintained for a number of days. In addition, by using a control component that is volatile and diffusible at room temperature in conjunction  
15 with the above control component, the effect of controlling flying insect pest can be imparted to the insect pest and acarine control method.

[0031]

The insect pest and acarine control method of the  
20 present invention is particularly effective in controlling: cockroaches, such as *Blattella germanica* (German cockroach), *Periplaneta americana* (American cockroach), and *Periplaneta fuliginosa* (smokybrown cockroach); ants; insects of the genus *Cimex* (bed bugs), such as *Cimex lectularius* and *Cimex*  
25 *hemipterus*; creeping insect pests such as *Tribolium castaneum* (red flour beetle), *Sitophilus zeamais* (maize weevil),

Xestobium rufovillosum, Armadillidium vulgare, and Porcellio  
scaber (common rough woodlouse); and house dust acarines, such  
as Tyrophagus putrescentiae (cheese mite), Dermatophagoides  
farinae (American house dust mite), Dermatophagoides  
5 pteronyssinus (European house dust mite), and Cheyletiella.  
However, in addition to these creeping insect pests and  
acarines, the insect pest and acarine control method of the  
present invention is sufficiently applicable to control of  
insect pests that fly in a room and are harmful and annoying  
10 to humans, such as mosquitoes (Culex pipiens pallens, Aedes  
albopictus, etc.), non-biting midges, houseflies, drain flies,  
black flies, horseflies, bees and wasps, and leafhoppers.

#### Examples

[0032]

15 The insect pest and acarine control method and insect  
pest and acarine control aerosol of the present invention will  
be described in greater detail using specific examples and  
example tests. Note that the present invention is not limited  
to these examples.

20 [0033]

#### (Example 1)

An aerosol-forming material was formulated by dissolving  
53 w/v% of phenothrin and 0.7 w/v% of metofluthrin in ethanol.  
An aerosol container (pressure-resistant container) with a  
25 fixed-volume spray valve having a sprayed amount of 1.0 mL was  
filled with 12 mL of the aerosol-forming material (a) and 18

mL of liquefied petroleum gas (b) as a propellant under pressure so that the volume ratio  $[a / (a + b)]$  of the aerosol-forming material is 0.4, to obtain an insect pest and acarine control aerosol of Example 1. The specific gravity of the aerosol-forming material was 0.93, and the spray force of the aerosol was 26 gf at a spray distance of 5 cm. In addition,  $\delta$  was 9.0.

[0034]

A spray treatment was performed by spraying the insect pest and acarine control aerosol slightly diagonally upward once (single-push operation) at the center of a substantially airtightly closed room having a volume of 25 m<sup>3</sup> (6-Jyo room, area: 10 m<sup>2</sup>). The percentage (%) of adhesion of the control component to the floor surface was calculated based on the result of analysis by gas chromatography described below and the amount of the control component released from the aerosol. As a result, it was demonstrated that 72% of all atomized particles sprayed by the spray treatment (i.e., 72% of the amount of the control component released) settled and adhered to the entire floor surface by one hour after the spray treatment. An excellent control effect was exhibited on creeping insect pests such as cockroaches, ants, and *Xestobium rufovillosum* for several days after the spray treatment, and house dust acarines were repelled. Alternatively, a spray treatment was performed by spraying the insect pest and acarine control aerosol slightly diagonally upward twice

(double-push operation) at the center of a substantially airtightly closed room having a volume of 50 m<sup>3</sup> (12-Jyo room, area: 20 m<sup>2</sup>). As a result, as in the case of the room having a volume of 25 m<sup>3</sup>, it was demonstrated that the effect of  
5 controlling creeping insect pests was exhibited.

[0035]

(Examples 2-24 and Comparative Examples 1-4)

Various insect pest and acarine control aerosols shown in Table 1 were prepared in a manner similar to that of  
10 Example 1. Note that an aerosol container with a fixed-volume spray valve having a sprayed amount of 1.0 mL was used for the insect pest and acarine control aerosols of Examples 2-21, 23, and 24 and Comparative Examples 1, 3, and 4, a fixed-volume spray valve having a sprayed amount of 2.2 mL was used for the  
15 insect pest and acarine control aerosol of Example 22, and a fixed-volume spray valve having a sprayed amount of 0.4 mL was used for the insect pest and acarine control aerosol of Comparative Example 2.

20

25

[0036]

Table 1

|                      |                  | Aerosol-forming material (a) (w/v%) |                    |                           | Propellant (b) | Volume ratio | Specific gravity | Spray force (gf/5 cm) | $\delta$ | Amount of control component released (mg/m <sup>3</sup> ) |
|----------------------|------------------|-------------------------------------|--------------------|---------------------------|----------------|--------------|------------------|-----------------------|----------|-----------------------------------------------------------|
|                      |                  | Control component                   | Organic solvent    | Other components          |                |              |                  |                       |          |                                                           |
| Examples             | 1                | Phenothrin 53                       | Ethanol balance    | Metofluthrin 0.7          | LPG            | 0.4          | 0.93             | 26                    | 9        | 8.6                                                       |
|                      | 2                | Phenothrin 53                       | Ethanol balance    | —                         | LPG            | 0.3          | 0.93             | 26                    | 6.7      | 6.4                                                       |
|                      | 3                | Phenothrin 53                       | Ethanol balance    | —                         | LPG            | 0.2          | 0.93             | 26                    | 4.5      | 4.2                                                       |
|                      | 4                | Phenothrin 53                       | Ethanol balance    | —                         | LPG            | 0.5          | 0.93             | 26                    | 11       | 11                                                        |
|                      | 5                | Phenothrin 53                       | Ethanol balance    | —                         | LPG            | 0.5          | 0.93             | 34                    | 15       | 11                                                        |
|                      | 6                | Phenothrin 53                       | Neothiozol balance | —                         | LPG            | 0.15         | 0.91             | 26                    | 3.2      | 3.2                                                       |
|                      | 7                | Permethrin 60                       | Ethanol balance    | —                         | LPG            | 0.2          | 0.99             | 26                    | 5.1      | 4.8                                                       |
|                      | 8                | Permethrin 60                       | Ethanol balance    | —                         | LPG            | 0.5          | 0.99             | 26                    | 13       | 12                                                        |
|                      | 9                | Permethrin 60                       | Neothiozol balance | —                         | LPG            | 0.5          | 0.98             | 26                    | 12       | 12                                                        |
|                      | 10               | Permethrin 60                       | Neothiozol balance | —                         | LPG            | 0.2          | 0.98             | 14                    | 2.7      | 4.8                                                       |
|                      | 11               | Permethrin 70                       | IPM balance        | —                         | LPG            | 0.1          | 1.05             | 28                    | 3.1      | 2.8                                                       |
|                      | 12               | Cyphenothrin 38                     | Neothiozol balance | Lavender oil small amount | LPG, DME       | 0.1          | 0.87             | 26                    | 2        | 1.5                                                       |
|                      | 13               | Tralomethrin 55                     | IPM balance        | —                         | LPG            | 0.5          | 1.12             | 26                    | 16       | 11                                                        |
|                      | 14               | Tralomethrin 55                     | IPM balance        | —                         | LPG            | 0.4          | 1.12             | 28                    | 14       | 8.8                                                       |
|                      | 15               | Tralomethrin 55                     | IPM balance        | —                         | LPG            | 0.2          | 1.12             | 26                    | 6.5      | 4.4                                                       |
|                      | 16               | Tralomethrin 55                     | Ethanol balance    | —                         | LPG            | 0.2          | 1.09             | 15                    | 3.6      | 4.4                                                       |
|                      | 17               | Benzyl benzoate 50                  | Ethanol balance    | —                         | LPG            | 0.3          | 0.93             | 26                    | 6.7      | 6                                                         |
|                      | 18               | Dibutyl sebacate 50                 | IPM balance        | —                         | LPG            | 0.35         | 0.9              | 26                    | 7.4      | 7                                                         |
|                      | 19               | Dibutyl sebacate 50                 | Ethanol balance    | —                         | LPG            | 0.4          | 0.87             | 26                    | 7.9      | 8                                                         |
|                      | 20               | Phenothrin 53                       | Ethanol balance    | Transfluthrin 0.7         | LPG            | 0.4          | 0.93             | 26                    | 9        | 8.6                                                       |
|                      | 21               | Permethrin 70                       | IPM balance        | —                         | LPG            | 0.5          | 1.05             | 39                    | 21       | 14                                                        |
|                      | 22 <sup>※1</sup> | Phenothrin 53                       | IPM balance        | —                         | LPG            | 0.3          | 0.96             | 45                    | 12       | 14                                                        |
|                      | 23               | Phenothrin 53                       | Ethanol balance    | —                         | LPG            | 0.4          | 0.93             | 15                    | 5.2      | 8.5                                                       |
|                      | 24               | Permethrin 60                       | Ethanol balance    | —                         | LPG            | 0.4          | 0.99             | 15                    | 5.9      | 9.6                                                       |
| Comparative Examples | 1                | —                                   | Ethanol balance    | Empenthrin 50             | LPG            | 0.3          | 0.87             | 26                    | 5.9      | 6                                                         |
|                      | 2 <sup>※2</sup>  | Phenothrin 53                       | Ethanol balance    | —                         | LPG            | 0.3          | 0.93             | 6.4                   | 1.7      | 2.6                                                       |
|                      | 3                | Phenothrin 15                       | Ethanol balance    | —                         | LPG            | 0.3          | 0.83             | 26                    | 5.4      | 1.8                                                       |
|                      | 4                | Tralomethrin 70                     | IPM balance        | —                         | LPG            | 0.3          | 1.2              | 26                    | 11       | 8.4                                                       |

※1 A metering spray valve having a sprayed amount of 2.2 mL was used.

※2 A metering spray valve having a sprayed amount of 0.4 mL was used.

[0037]

5 The insect pest and acarine control aerosols of Examples

1-24 and Comparative Examples 1-4 were used to conduct tests below. For house dust acarines, the extermination effect was first assessed, and the repellent effect was then assessed if the extermination effect was poor. The test results are shown in Table 2.

[0038]

#### (1) Extermination Effect on Creeping Insect Pests

A total of 12 glass plates of 20 × 20 cm (4 plates for each of *Blattella germanica* (German cockroach), *Periplaneta americana* (American cockroach), and *Formica japonica*) were placed at four corners of a closed room having a volume of 25 m<sup>3</sup> (area: 10 m<sup>2</sup>). A plastic ring having a diameter of about 20 cm was put on each glass plate, predetermined test insects (*Blattella germanica* (German cockroach): five female adults, *Periplaneta americana* (American cockroach): five larvae, and *Formica japonica*: five insects) were released in each ring and allowed to freely move around. The test aerosol was sprayed slightly diagonally upward at the center of the room once (a single-push operation) (sprayed amounts: 1.0 mL in Examples 1-21, 23, and 24 and Comparative Examples 1, 3, and 4, 2.2 mL in Example 22, and 0.4 mL in Comparative Example 2). After exposure to the chemicals for 24 hours, the glass plate was transferred together with the ring containing the test insects to another room, in which the test insects were fed, and the fatality rate of the test insects was calculated after another 24 hours.

[0039]

(2) Extermination Effect on House Dust Acarines

Eight deep petri dishes having a diameter of 9 cm and a height of 6 cm (four for each of *Dermatophagoides farinae* (American house dust mite) and *Tyrophagus putrescentiae* (cheese mite)) were placed at four corners of a closed room having a volume of 25 m<sup>3</sup>(area: 10 m<sup>2</sup>), and about 200 acarines of each predetermined acarine type were put in the deep petri dish for testing. The test aerosol was sprayed slightly diagonally upward at the center of the room once (a single-push operation). After exposure to the chemicals for 24 hours, the fatality rates of the test acarines were calculated.

[0040]

(3) Repellent Effect on House Dust Acarines

In the above "(2) Extermination Effect on House Dust Acarines" test, a cotton cloth having a diameter of about 4 cm was placed at the four corners of the room instead of the test acarines, and the test aerosol was sprayed once (a single-push operation). The cotton cloth was removed 24 hours after spraying, and fitted into a petri dish having a diameter of 4 cm, and 50 mg of an attraction medium was put at the center of the petri dish. Apart from this, about 10,000 test acarines of *Dermatophagoides farinae* (American house dust mite) and *Tyrophagus putrescentiae* (cheese mite) were released together with a medium into a petri dish having a diameter of 9 cm, and the previously prepared petri dish having a diameter of 4 cm

was put at the center of the petri dish having a diameter of 9 cm. Likewise, a non-treated zone was prepared using a cotton cloth which was not treated with the test aerosol. The number of acarines entering the cotton cloth was counted 24 hours later. The acarine repellent rate was calculated by the following expression.

$$\text{Acarine repellent rate (\%)} = \left[ \frac{\text{(the number of acarines entering the non-treated zone - the number of acarines entering the treated zone)}}{\text{the number of acarines entering the non-treated zone}} \right] \times 100$$

[0041]

#### (4) Adhesion Rate of Control Component to Floor Surface

Six to eight glass plates of 20 × 20 cm were placed and equally spaced throughout the floor surface in a closed room having a volume of 25 m<sup>3</sup>(area: 10 m<sup>2</sup>). The test aerosol was sprayed slightly diagonally upward at the center of the room once (a single-push operation). All of the glass plates were removed one hour after the spray treatment. The adhering control component was removed by washing with acetone and analyzed by gas chromatography. Based on the obtained analysis value, the theoretical ratio of the control component settling and adhering to the floor surface by one hour after the spray treatment to the total amount of the sprayed control component (floor surface adhesion rate) was calculated. In addition, variations in the control component adhering to the glass

plate between each glass plate were analyzed to assess the diffusion uniformity of the atomized particles. The results were rated on a scale of A, B, C, and D in order of diffusion uniformity, where A indicates the highest diffusion uniformity.

[0042]

Table 2

|                      |    | Creeping insect pest fatality rate (%) |                              |                         | Acarine fatality rate (%)       |                                 | Acarine repellent rate (%)      |                                 | Floor surface adhesion rate (%) | Diffusion uniformity |
|----------------------|----|----------------------------------------|------------------------------|-------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------|
|                      |    | <i>Blattella germanica</i>             | <i>Periplaneta americana</i> | <i>Formica japonica</i> | <i>Dermatophagoides farinae</i> | <i>Tyrophagus putrescentiae</i> | <i>Dermatophagoides farinae</i> | <i>Tyrophagus putrescentiae</i> |                                 |                      |
| Examples             | 1  | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 72                              | A                    |
|                      | 2  | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 70                              | A                    |
|                      | 3  | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 71                              | A                    |
|                      | 4  | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 75                              | A                    |
|                      | 5  | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 73                              | A                    |
|                      | 6  | 100                                    | 95                           | 90                      | —                               | —                               | 100                             | 90                              | 67                              | A ~ B                |
|                      | 7  | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 72                              | A                    |
|                      | 8  | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 74                              | A                    |
|                      | 9  | 100                                    | 95                           | 100                     | —                               | —                               | 100                             | 95                              | 68                              | A ~ B                |
|                      | 10 | 95                                     | 90                           | 95                      | —                               | —                               | 95                              | 90                              | 63                              | A ~ B                |
|                      | 11 | 90                                     | 100                          | 95                      | —                               | —                               | 90                              | 100                             | 69                              | A ~ B                |
|                      | 12 | 90                                     | 90                           | 90                      | —                               | —                               | 95                              | 85                              | 61                              | A ~ B                |
|                      | 13 | 95                                     | 85                           | 85                      | —                               | —                               | 90                              | 85                              | 69                              | B                    |
|                      | 14 | 95                                     | 95                           | 90                      | —                               | —                               | 90                              | 90                              | 71                              | A ~ B                |
|                      | 15 | 85                                     | 90                           | 95                      | —                               | —                               | 90                              | 95                              | 74                              | A                    |
|                      | 16 | 90                                     | 100                          | 85                      | —                               | —                               | 85                              | 90                              | 70                              | A ~ B                |
|                      | 17 | 45                                     | 35                           | 90                      | 100                             | 100                             | —                               | —                               | 74                              | A                    |
|                      | 18 | 35                                     | 30                           | 45                      | 70                              | 65                              | 95                              | 95                              | 75                              | A                    |
|                      | 19 | 25                                     | 20                           | 40                      | 55                              | 50                              | 85                              | 85                              | 67                              | A                    |
|                      | 20 | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 73                              | A                    |
|                      | 21 | 95                                     | 90                           | 85                      | —                               | —                               | 90                              | 90                              | 64                              | B                    |
|                      | 22 | 90                                     | 95                           | 95                      | —                               | —                               | 90                              | 100                             | 66                              | B                    |
|                      | 23 | 100                                    | 100                          | 100                     | —                               | —                               | 100                             | 100                             | 85                              | A ~ B                |
|                      | 24 | 95                                     | 100                          | 90                      | —                               | —                               | 90                              | 95                              | 91                              | B                    |
| Comparative Examples | 1  | 20                                     | 15                           | 30                      | —                               | —                               | 30                              | 15                              | 46                              | B ~ C                |
|                      | 2  | 75                                     | 65                           | 80                      | —                               | —                               | 65                              | 55                              | 57                              | C                    |
|                      | 3  | 70                                     | 55                           | 65                      | —                               | —                               | 60                              | 50                              | 53                              | D                    |
|                      | 4  | 75                                     | 65                           | 70                      | —                               | —                               | 65                              | 60                              | 69                              | D                    |

[0043]

The test results demonstrated that in the insect pest and acarine control method of the present invention using the insect pest and acarine control aerosols of Examples 1-24, atomized particles are substantially uniformly diffused throughout the floor surface, and 60% or more of the control component settles and adheres to the floor surface by one hour after spraying. It was also demonstrated that when the insect pest and acarine control aerosols of Examples 1-16 and 20-24, which contain a creeping insect pest control compound as the poorly volatile and diffusible control component, have an excellent control effect on both creeping insect pests and house dust acarines. It was also demonstrated that when the insect pest and acarine control aerosols of Examples 17-19, which contain an acarine control compound as the poorly volatile and diffusible control component, have an excellent control effect on house dust acarines.

[0044]

In contrast to this, in Comparative Examples 1-4, a sufficient control effect was not obtained on any of creeping insect pests and house dust acarines. It is considered that in Comparative Example 1, the aerosol contains, as a control component, only a pyrethroid compound that is volatile and diffusible at room temperature, such as empenethrin, and as a result, the floor surface adhesion rate was reduced, and therefore, the control effect was reduced. It is considered that in Comparative Example 2, in which a fixed-volume spray

valve having a sprayed amount of 0.4 mL was used, a required  
sprayed amount of the control component was not obtained by a  
single-push operation, and therefore, the control effect was  
reduced. It is considered that in the case where the specific  
5 gravity of the aerosol-forming material was not in the range  
of 0.85-1.15 specified in the present invention like  
Comparative Examples 3 and 4, the reduced diffusion uniformity  
of atomized particles is responsible for the reduction of the  
control effect.

10

#### INDUSTRIAL APPLICABILITY

[0045]

The insect pest and acarine control method and insect  
pest and acarine control aerosol of the present invention are  
15 applicable for the purpose of control of insect pests and  
acarines in indoor spaces and wider ranges.

## CLAIMS

1. A method for controlling insect pests and acarines by a spray treatment using an insect pest and acarine control aerosol obtained by filling an aerosol container equipped with a fixed-volume spray valve having a sprayed amount of 1.0-5.0 mL per operation with an aerosol-forming material containing a control component and an organic solvent, and a propellant, wherein

the control component is a poorly volatile and diffusible compound having a vapor pressure of less than  $1 \times 10^{-4}$  mmHg at 30°C,

the aerosol-forming material has a specific gravity of 0.85-1.15,

the insect pest and acarine control aerosol has a spray force of 10-50 gf at a spray distance of 5 cm, and

the aerosol-forming material is sprayed into an indoor space in the spray treatment such that the amount of the control component released is 0.1-50 mg/m<sup>3</sup>, and 60% or more of the control component is diffused and adheres to an entire floor surface of the indoor space by one hour after the spraying.

2. The method according to claim 1, wherein

the insect pest and acarine control aerosol is configured such that  $\delta$  represented by expression (1) is in the

range of 1.0-30:

$$\delta = [a/(a + b)] \times S^2 \times F \quad (1)$$

where a represents the contained amount of the aerosol-forming material, b represents the contained amount of the propellant, S represents the specific gravity of the aerosol-forming material, and F represents the spray force of the insect pest and acarine control aerosol.

3. The method according to claim 2, wherein  
10 the insect pest and acarine control aerosol is configured to satisfy:

$$0.1 \leq [a/(a + b)] \leq 0.5 \quad (2).$$

4. The method according to claim 2 or 3, wherein  
15 the insect pest and acarine control aerosol is configured to satisfy:

$$3.0 \leq \delta \leq 15 \quad (3).$$

5. The method according to any one of claims 1-4,  
20 wherein

the poorly volatile and diffusible compound is at least one creeping insect pest control compound selected from the group consisting of phenothrin, cyphenothrin, permethrin, cypermethrin, cyfluthrin, bifenthrin, fenpropathrin, tralomethrin, etofenprox, and dinotefuran.  
25

6. The method according to any one of claims 1-4,  
wherein

the poorly volatile and diffusible compound is at least  
one acarine control compound selected from the group  
5 consisting of amidoflumet, benzyl benzoate, phenyl salicylate,  
benzyl salicylate, dibutyl sebacate, dipropyl sebacate,  
dibutyl adipate, diethyl phthalate, dibutyl phthalate, and p-  
menthane-3,8-diol.

10 7. The method according to any one of claims 1-6,  
wherein

the organic solvent is a lower alcohol having 2 or 3  
carbon atoms.

15 8. The method according to any one of claims 1-7,  
wherein

the area of the floor surface of the indoor space is  
7.5-26.6 m<sup>2</sup>.

20 9. An insect pest and acarine control aerosol  
obtained by filling an aerosol container equipped with a  
fixed-volume spray valve having a sprayed amount of 1.0-5.0 mL  
per operation with an aerosol-forming material containing a  
control component and an organic solvent, and a propellant,  
25 wherein

the control component is a poorly volatile and

diffusible compound having a vapor pressure of less than  $1 \times 10^{-4}$  mmHg at 30°C,

the aerosol-forming material has a specific gravity of 0.85-1.15,

5 the insect pest and acarine control aerosol has a spray force of 10-50 gf at a spray distance of 5 cm, and

when the aerosol-forming material is sprayed into an indoor space in a single-spray treatment through the fixed-volume spray valve such that the amount of the control  
10 component released is 0.1-50 mg/m<sup>3</sup>, 60% or more of the control component is diffused and adheres to an entire floor surface of the indoor space by one hour after the spraying.