# Efficacy of the Novel Termiticide Guntoner®SC against Termites

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Guntoner®SC is a novel termiticide for use by termite control operators and contains clothianidin as the active ingredient. Although Guntoner®SC was developed and registered as a soil-applied termiticide, it would be practically more useful if it could give excellent efficacy when applied as concrete surface and elimination treatments against *Coptotermes formosanus* and/or *Reticulitermes speratus*, and when used as direct spray as well as wood surface treatments against *Incisitermes minor* alates. The present report describes the methodology and biological performance of the novel termiticide Guntoner®SC against termites.

This paper is translated from R&D Report, "SUMITOMO KAGAKU", vol. 2016.

## Introduction

Guntoner®SC is a novel termiticide for professional termite control operators. It contains the neonicotinoid insecticide clothianidin[1], which demonstrates high activity against termites, as an active ingredient. The product outline is shown in **Table 1**.

Based on the results of indoor and field tests conducted by official facilities, the preventive effect of Guntoner®SC has fulfilled the performance requirements; therefore, Guntoner®SC was registered by the Japan Termite Control Association (JTCA) and the Japan Wood Protection Association (JWPA) in March, 2014 as a soil-applied termiticide for soil treatment under floors. Because mat foundation structures using reinforced concrete have recently become popular, it is required that Guntoner®SC demonstrates preventive effects when used as concrete surface treatment[2] to

**Table 1** General description of Guntoner®SC

| | |
|---|---|
| Active Ingredient | Clothianidin (15%) |
| Formulation | Suspension concentrate |
| Appearance | White, non-transparent viscous liquid |
| Category of Termiticide | Soil-applied termiticide |
| Registration No. | 3523 (JTCA) |
| | A-4262 (JWPA) |
| Direction for use | |
| (1) Dilution rate | Soil surface 200 times with water |
| | Concrete surface 67 times with water |
| (2) Application method | To apply in accordance with "the standard specifications for termite control" stipulated by JTCA[7] |
| Toxicity | |
| (1) Acute oral | Rat $LD_{50}$ ♀>2000 mg/kg |
| (2) Acute dermal | Rat $LD_{50}$ ♀>2000 mg/kg |
| (3) Acute inhalation | Rat $LC_{50}$ ♂♀>4.47 mg/L |
| (4) Eye irritation | Rabbit minimally irritating |
| (5) Skin irritation | Rabbit minimally irritating |
| (6) Skin sensitization | Mouse negative |
| (7) Fish | Carp $LC_{50}$ (96 h) >100 mg/L |
| Poisonous and Deleterious Substances Control Act | Not classified |

prevent the invasion of houses by termites through concrete surfaces.

Furthermore, to eliminate termite infestations in existing houses, it is required that Guntoner®SC demonstrates an elimination effect when sprayed directly onto damaged areas[3].

We have therefore evaluated not only the preventive effects as soil treatment but also those as concrete surface treatment and elimination effects against the target termites *Coptotermes formosanus* and/or *Reticulitermes speratus*.

Besides the aforementioned termite species, there has been an increasing number of reports of infestation by *Incisitermes minor,* a termite which damages dry wood in existing houses and is considered difficult to control[4]. Because these alates swarm from infested houses to other nearby houses, resulting in a steady spread of the infested areas[5], the demand for rapid effects of direct spray treatment and the prevention of infestation by these alates through wood surface treatment has increased. Therefore, we have also evaluated those effects, and we introduce the results in the present report.

## Preventive Effects of Soil Treatment

To evaluate the effects of soil treatment to prevent termites from penetrating treated soil, we performed indoor and field tests as described in the JWPA standard test methods.[6]

### 1. Indoor Test (Soil Penetration Test)

(1) Test facilities:

Research Institute of Sustainable Humanosphere, Kyoto University; and the Faculty of Agriculture, Kindai University

(2) Test chemical:

Guntoner®SC diluted 200 times

(3) Test termites:

*C. formosanus* (100 workers and 10 soldiers)

(4) Test method:

The test was conducted in accordance with the JWPA standard test method JWPAS-TS-(1) (2011), "Test methods for determining the effectiveness of termiticides for soil treatment and their performance requirements – 4. Indoor Test" (**Fig. 1**).

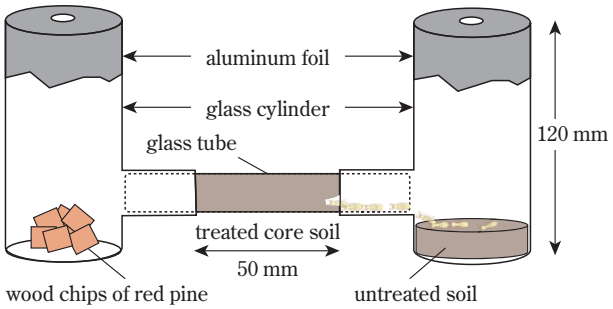


**Fig. 1** Soil penetration test method

(5) Performance requirements:

**Table 2** shows the relationship between the penetration degree and distance. All the penetration degrees ≤1 indicate that the termiticide for soil treatment shall have preventive performance. However, although a penetration degree of 2 exists, it shall be still considered to have preventive performance as long as all test termites are dead within one week. Control tests must reach a penetration degree of 5 within one day after the start of the test. (**Fig. 2**).

**Table 2** Relationship between the penetration degree and penetrated distance

| Penetration degree | | Penetrated distance |
|---|---|---|
| 0 | : | 0 mm |
| 1 | : | 1 ~ 9 mm |
| 2 | : | 10 ~ 19 mm |
| 3 | : | 20 ~ 29 mm |
| 4 | : | 30 ~ 39 mm |
| 5 | : | 40 ~ 50 mm |

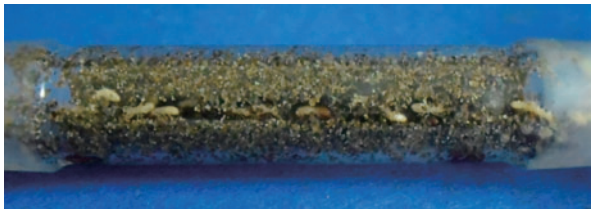

**Fig. 2** Untreated 5-cm core soil penetrated by termites within one day of exposure

(6) Test results:

**Table 3** shows the results of the tests conducted at Kyoto University's Research Institute of Sustainable Humanosphere and Kindai University's Faculty

**Table 3** Horizontal distance of soil penetrated by *Coptotermes formosanus* and the associated penetration degree and mortality after one or two days by the soil penetration test method

| Test termiticide | Test no. | Kyoto University Research Institute for sustainable humanosphere | | | Kindai University Faculty of Agriculture | | |
|---|---|---|---|---|---|---|---|
| | | Penetrated distance (mm) | Penatation degree | Mortality (%) after 1 day | Penetrated distance (mm) | Penatation degree | Mortality (%) after 2 days |
| Guntoner®SC | 1 | 8 | 1 | 100 | 0 | 0 | 100 |
| | 2 | 6 | 1 | 100 | 1 | 1 | 100 |
| | 3 | 12 | 2 | 100 | 1 | 1 | 100 |
| | 4 | 7 | 1 | 100 | 2 | 1 | 100 |
| | 5 | 3 | 1 | 100 | 2 | 1 | 100 |
| Control | 1 | 50 | 5 | 3 | 50 | 5 | — |
| | 2 | 50 | 5 | 4 | 50 | 5 | — |
| | 3 | 50 | 5 | 6 | 50 | 5 | — |
| | 4 | 50 | 5 | 4 | 50 | 5 | — |
| | 5 | 50 | 5 | 5 | 50 | 5 | — |

of Agriculture. Guntoner®SC fulfilled the performance requirements of the above test facilities.

## 2. Field Test

(1) Test site:

Fukiagehama, Fukiage-cho, Hioki, Kagoshima Prefecture (Kindai University, Field Test Site for Termites)

(2) Test chemical:

Guntoner®SC diluted 200 times

(3) Test method:

The test was conducted in accordance with the JWPA standard test method JWPAS-TS-(1) (2011) "Test methods for determining the effectiveness of termiticides for soil treatment and their performance requirements – 5. Field Test" (**Fig. 3**).

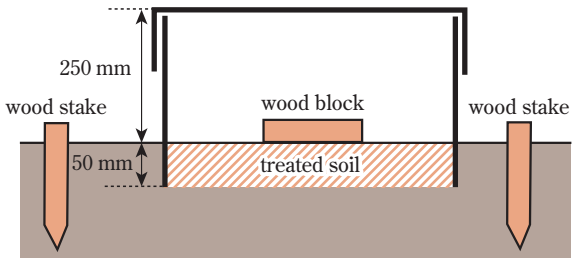


**Fig. 3** Field test method

(4) Test period:

A two-year test period shall be implemented. The presence or absence of feeding damage in wood blocks shall be observed once per year (**Fig. 4**); however, if no feeding damage has been found on the untreated soil within one year after installation, the test shall be restarted after relocating the test site.

**Fig. 4** Wood block damaged by termites on untreated soil

(5) Performance requirements:

If no feeding damage in the wood blocks on the treated soil has been observed in any of the five repeated tests for the period of two years after the start of the test, it shall be determined that the test chemical for soil treatment has preventive performance.

(6) Test results:

**Table 4** shows the test results. The result of the evaluation conducted two years after the installation shows that Guntoner®SC fulfilled performance requirements. The field test was continued, with the results showing no damage to the wood blocks on the treated soil by the third year. Therefore, the residual efficacy period is now being renewed (**Fig. 5**).

Given the aforementioned favorable test results, Guntoner®SC was registered as a soil-applied termiticide in

**Table 4** Field evaluation of soil treated with Guntoner®SC by the field test method

| Test no. | The presence/absence of wood damage on the treated soil | | |
|---|---|---|---|
| | 1st year | 2nd year | 3rd year |
| 1 | A | A | A |
| 2 | A | A | A |
| 3 | A | A | A |
| 4 | A | A | A |
| 5 | A | A | A |

A: Absence

**Fig. 5** View of field test

Japan. For successful registration, other data such as physical properties, toxicity, and clothianidin concentration in indoor air would also be required.

## Preventive Effects of Concrete Surface Treatment

If the ground surface under a floor is constructed of concrete, termites may invade houses through the grooves of spreader clips for continuous-footing molding flasks or cracks in the concrete.[2] We have therefore conducted a contact test and a mud-tube building test to evaluate the preventive effect of Guntoner®SC when applied to concrete surfaces.

### 1. Contact Test

(1) Test chemical:

Guntoner®SC diluted 67 times

(2) Test termites:

*C. formosanus* (10 workers)

(3) Test method:

Concrete was poured over a dish ($\phi$9 cm) and allowed to dry completely. The test chemical was then sprayed onto the surface of the concrete at a rate of 1 L/m$^2$ and maintained at 40 °C in a darkroom for the periods of 1, 3, 6, and 12 months. The test termites were then released onto the concrete (**Fig. 6**). After 1, 3, and 24 h of the test termite release, at each time the numbers of moribund and dead termites were observed, and the sum of moribund and mortality rates was calculated by the formula shown below. The test was replicated three times.

The sum of moribund and mortality rates (%) = (number of moribund and dead termites) / number of test termites × 100

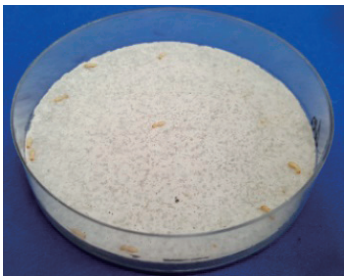

**Fig. 6** Concrete plate contact test method

(4) Test results:

**Table 5** shows the results of termite moribund and mortality rates. The sum of moribund and mortality rates was 100% (**Fig. 7**) for exposure time > 3 h for any storage period.

**Table 5** Sum of moribund and mortality rates of *Coptotermes formosanus* at each time after three 1, 3, and 24 h exposure periods to a concrete plate applied with Guntoner®SC by the concrete plate contact test method

| Months after treatment | Guntoner®SC | | | Control | | |
|---|---|---|---|---|---|---|
| | 1 h | 3 h | 24 h | 1 h | 3 h | 24 h |
| 0 | 90 | 100 | 100 | 0 | 0 | 0 |
| 1 | 100 | 100 | 100 | 0 | 0 | 0 |
| 3 | 80 | 100 | 100 | 0 | 0 | 0 |
| 6 | 97 | 100 | 100 | 0 | 0 | 0 |
| 12 | 100 | 100 | 100 | 0 | 0 | 0 |

**Fig. 7** Moribund workers of *Coptotermes formosanus* after a 3 h exposure period

### 2. Mud-Tube Building Test

(1) Test Block:

A concrete block (10 × 20 × 6 cm) was treated with 67 times-diluted Guntoner®SC at a rate of 1 L/m$^2$ , and then maintained in a darkroom at 40 °C for 3 months.

(2) Test method:

A new feeding arena was prepared adjacent to a nest of *C. formosanus*, following which this feeding arena and the nest were connected using a bridge constructed of a cardboard strip (**Fig. 8**). An untreated concrete block (10 × 20 × 6 cm) (hereinafter referred to as the "untreated block") was then installed in the feeding arena. After one week, it was confirmed that mud tubes had been built on the surface of the untreated block (**Fig. 9**). The untreated block was then removed from the feeding arena and a test block was installed at the exact same spot. After one week, the block was assessed for the presence of mud tubes on the surface.

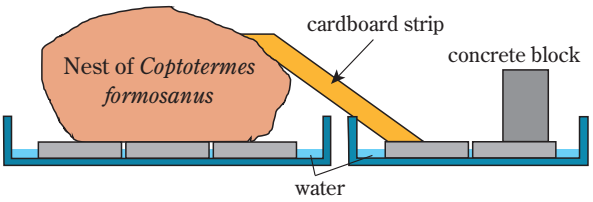


**Fig. 8** Mud tube building test method

**Fig. 9** Mud tubes built on an untreated concrete block one week after installation

(3) Test result:

It was found that no mud tubes had been built on the surface of the test block one week after the installation of the test block (**Fig. 10**).

**Fig. 10** The treated concrete block one week after installation showing the absence of mud tubes

Based on these test results, it can be considered that concrete surface treatment with Guntoner®SC prevents termites from invading houses for an extended period of time.

We conducted tests using our own test method as introduced in this study due to there being as yet no authorized test method based on concrete surface treatment. However, over recent years, mat foundation structures using reinforced concrete have been applied in > 90% of housing construction[8], indicating increasing popularity of these structures. Thus, the establishment of authorized test methods for the concrete surface treatment is desirable.

## Elimination Effects

To evaluate the effect of Guntoner®SC in the elimination of termite infestations in existing houses, we conducted a direct-spray test for the evaluation of the rapid effects and a horizontal transmission test for the evaluation of chemical-transmission effects, which is the effect whereby termites exposed to the chemical transmit the effect to other termites. We used a pyrethroid termiticide S as a contrast termiticide.

### 1. Direct Spray Test

Termite species responsible for invasion of houses from the ground under the floor in Japan are typically *C. formosanus* and *R. speratus* (**Fig. 11**). As soldier as

*Coptotermes formosanus* *Reticulitermes speratus*

**Fig. 11** Workers (top image) and soldiers (bottom image) of *Coptotermes formosanus* and *Reticulitermes speratus*

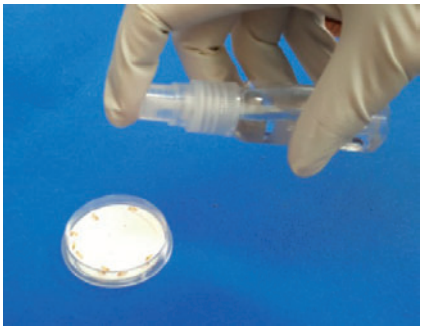

**Fig. 12** Direct spray test method

well as worker termites are often observed at the damaged areas, the test was conducted against both casts of the above termite species.

(1) Test chemicals:

Guntoner®SC diluted 200 times

A pyrethroid termiticide S (permethrin 10%) diluted 50 times

(2) Test termites:

*C. formosanus* (10 workers or 10 soldiers)

*R. speratus* (10 workers or 10 soldiers)

(3) Test method:

Ten test termites were released into a dish with filter paper ($\phi$5 cm) and were then sprayed with the test chemical two to three times (approximately 0.2 mL) using a spray bottle (**Fig. 12**). The number of moribund termites was calculated at intervals of 5, 10, 20, 30, and 40 min after spraying. After one day after spraying, the number of dead termites was recorded, and the moribund and mortality rates for each chemical were calculated. The test was replicated three times.

(4) Test result:

**Table 6** shows the results of the direct spray test. Guntoner®SC showed a moribund rate of 100% within 30 to 45 min after spraying, whereas pyrethroid termiticide S showed a 100% moribund rate within 20 min of spraying. However, there was no significant difference in the efficacy of each test chemical between termite species or casts.

After termite control operators have explained their process of termite control to their clients, the clients may notice that some termites exposed to the chemicals are still alive and vigorously walking around. This situation may prompt the clients to file complaints. Therefore, a rapid action of termite control application is desirable. It is expected that Guntoner®SC will show sufficiently rapid effects.

## 2. Horizontal Transmission Test

(1) Test chemicals:

Guntoner®SC diluted 200 times

A pyrethroid termiticide S (permethrin 10%) diluted 50 times

**Table 6** Efficacy of Guntoner®SC against workers and soldiers of *Coptotermes formosanus* and *Reticulitermes speratus* by the direct spray method

| Test termiticides | Test insects | Moribund rate (%) at each time after spray | | | | | Mortality (%) |
|---|---|---|---|---|---|---|---|
| | | 5 min | 10 min | 20 min | 30 min | 45 min | |
| Guntoner®SC | Workers of C.F. | 0 | 33 | 63 | 97 | 100 | 100 |
| | Soldiers of C.F. | 0 | 7 | 50 | 90 | 100 | 100 |
| | Workers of R.S. | 17 | 43 | 83 | 100 | 100 | 100 |
| | Soldiers of R.S. | 7 | 47 | 80 | 87 | 100 | 100 |
| Termiticide S with pyrethroid | Workers of C.F. | 43 | 90 | 100 | 100 | 100 | 100 |
| | Soldiers of C.F. | 30 | 57 | 100 | 100 | 100 | 100 |
| | Workers of R.S. | 14 | 85 | 100 | 100 | 100 | 100 |
| | Soldiers of R.S. | 20 | 87 | 100 | 100 | 100 | 100 |

C.F. : *Coptotermes formosanus*
R.S. : *Reticulitermes speratus*

(2) Test method:

A volume of 1 μL of the test chemical was applied to the abdomens of three *C. formosanus* workers by a topical applicator (**Fig. 13**). Those termites were then released into a dish containing 500 *C. formosanus* workers. The numbers of moribund and dead termites were observed three days later, and the sum of moribund and mortality rates (%) was calculated by the following formula:

The sum of moribund and mortality rates (%) =
(number of moribund and dead termites) / 500 × 100

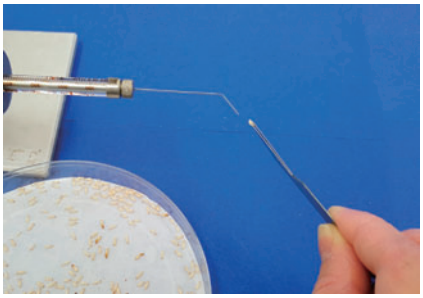

**Fig. 13** Horizontal transmission test method

(3) Test results:

**Table 7** shows the results of the horizontal transmission test. Guntoner®SC showed a sum of moribund and mortality rates of 84%, indicating an outstanding chemical-transmission effect. Therefore, it can be expected that application to the damaged areas will demonstrate a weakening of activity in the nest.

**Table 7** Sum of moribund and mortality rates of Guntoner®SC against workers of *Coptotermes formosanus* by the horizontal transmission test method

| Test termiticides | The sum of moribund and mortal rates (%) |
|---|---|
| Guntoner®SC | 84 |
| Termiticide S with pyrethroid | 2 |

Although the chemical-transmission effect of pyrethroid termiticide S was lower than that of Guntoner®SC, as according to Hirose's report[9], when a wood block treated with the pyrethroid termiticide S was installed directly adjacent to the *C. formosanus* nest, an excellent repellent effect was evident due to no acoustic emission (AE) accounts, as shown in **Table 8**. Therefore, it can be considered that pyrethroid termiticide S is suitable for treatment on wood surfaces to prevent termite damage.

**Table 8** Acoustic emission (AE) counts emanated from wood blocks treated with borate or pyrethroid termiticide for a 10-min period at each exposure day (Data from Hirose[9])

| Exposure day | AE counts/10 min | |
|---|---|---|
| | Borate | Pyrethroid |
| 1 | 12 | 0 |
| 2 | 83 | 0 |
| 3 | 403 | 0 |
| 4 | 2,714 | 0 |
| 5 | 4,445 | 0 |
| 6 | 4,313 | 0 |
| 7 | 4,411 | 0 |

## Rapid and Preventive Effects against Alates of *Incisitermes minor*

To evaluate the rapid effects of direct spray treatment as well as the effects of wood surface treatment on the prevention of infestation by alates of *I. minor*, we conducted a direct-spray test by spraying the tested chemical directly onto alates, as well as a contact test using treated plywood.

### 1. Direct Spray Test

(1) Test chemical:

Guntoner®SC diluted 200 times

(2) Test termites:

Alates of *I. minor* (**Fig. 14**)

**Fig. 14** Alates of *Incisitermes minor*

(3) Test method:

One test termite was released into a dish with filter paper ($\phi$5 cm), which was sprayed with the test chemical two to three times (approximately 1 mL) using a trigger sprayer. The response degrees (e.g., immobile, moribund or dead) were observed at intervals of 30, 60,

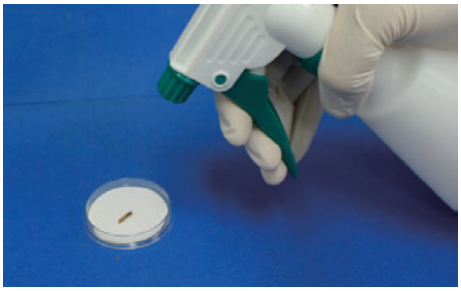

**Fig. 15** Direct spray test method

90, and 120 min after spraying, and survival was recorded 24 h after spraying (**Fig. 15**). The test was replicated three times.

(4) Response degrees:

The response degrees were categorized as follows:

Immobile: the alate is immobile, but it can walk when probed with forceps.

Moribund: the alate no longer walks or stands when probed with forceps.

Dead: the alate is dead.

(5) Test results:

**Table 9** shows the results of the direct spray test. Following the spraying of the chemical onto the test alates, the alates entered immobile and moribund states 30 and 90 min after spraying, respectively, and eventually died 24 h after spraying. As described above, a rapid action of termite control application is desirable; therefore, it can be concluded that Guntoner®SC demonstrates sufficiently rapid effects against alates of *I. minor*.

**Table 9** Efficacy of Guntoner®SC against alates of *Incisitermes minor* by the direct spray test method

| Test no. | 30 min | 60 min | 90 min | 120 min | 24 h |
|---|---|---|---|---|---|
| 1 | I | I | M | M | D |
| 2 | I | M | M | M | D |
| 3 | I | I | M | M | D |

I : immobile
M : moribund
D : dead

## 2. Contact Test

(1) Test chemical:

Guntoner®SC diluted 200 times

(2) Test termites:

Alates of *I. minor*

(3) Test method:

The test chemical was applied evenly onto the plywood test sample at an application rate of 100 mL/m$^2$, whereupon the sample was air-dried and then maintained in a darkroom at room temperature. A glass ring with an internal diameter of 4 cm was placed onto the plywood. Due to a limited supply of test termites, three alates were released into the glass ring during the first replicate, and two alates were released into the glass ring during the second replicate (**Fig. 16**), and were exposed to the test chemical for periods of 0.5, 1, and 2 h. These alates were removed from the glass ring and placed into a plastic dish ($\phi$5 cm) with filter paper, following which the numbers of alates in the immobile, moribund, and dead states were observed at 0.5, 1, 2, 3, 4, and 24 h after the start of the test.

**Fig. 16** Plywood contact test method

(4) Test result:

**Table 10** shows the test results. After contact with the three year- old stored plywood treated with the test chemical for ≥0.5 h, all five test termites entered a moribund state and died 24 h after exposure. Some moribund alates showed abnormal behaviors such as shedding their wings and evacuating (**Fig. 17**) or raising up their abdomens (**Fig. 18**). From these observations, it can be surmised that Guntoner®SC demonstrates protection of wood construction materials from alate infestation for an extended period of time.

A report on treatment for elimination of dry-wood termite infestations in existing houses using Everwood® mousse aerosol (manufactured by SC Environmental Science Co., Ltd., **Fig. 19**) has been introduced due to its workability and effectiveness[10].

**Table 10** Number of immobile, moribund or dead alates of *Incisitermes minor* after three 0.5 h, 1 h and 2 h exposure periods by the plywood contact test method

| exposure periods | No. of immoble - moribund - dead (Total 5) at each time after exposure | | | | | |
|---|---|---|---|---|---|---|
| | 0.5 h | 1 h | 2 h | 3 h | 4 h | 24 h |
| 0.5 h | 0 – 0 – 0 | 0 – 0 – 0 | 0 – 0 – 0 | 2 – 0 – 0 | 5 – 0 – 0 | 0 – 2 – 3 |
| 1 h | 0 – 0 – 0 | 0 – 0 – 0 | 1 – 0 – 0 | 5 – 0 – 0 | 5 – 0 – 0 | 0 – 1 – 4 |
| 2 h | 2 – 0 – 0 | 5 – 0 – 0 | 2 – 3 – 0 | 1 – 4 – 0 | 0 – 3 – 2 | 0 – 0 – 5 |
| control | 0 – 0 – 0 | 0 – 0 – 0 | 0 – 0 – 0 | 0 – 0 – 0 | 0 – 0 – 0 | 0 – 0 – 0 |

**Fig. 17** Alate shedding its wings and evacuating

**Fig. 18** Alate raising its abdomen in a moribund state

**Fig. 19** Everwood® mousse aerosol manufactured by SC Environmental Science Co., Ltd.

Thus it can be expected that treatment for both prevention and elimination of termite infestation can be effectively applied through the use of Guntoner®SC and Everwood® mousse aerosol, respectively, in houses infested by *I. minor*. We plan to verify this assertion at actual sites in the future.

The JTCA has established a registration system for termiticides[11] developed to eliminate dry-wood termites. We consider that a similar registration system for termiticides developed for prevention of infestation by dry-wood termites will also be required in the future because from this point forward, more effective termiticides for prevention and treatment will be developed.

## Conclusion

Following the diversification of housing structures, termiticides should demonstrate a variety of effects. In addition to the effects introduced in this study, the effects listed directly below can be listed as examples of such a trend: the effect of eliminating termite infestations by wood injection treatment[12]; the effect of controlling termites by soil spot treatment, and; the effect of controlling termite infestations in heat-insulation materials (**Fig. 20**). Further verification of the effects of Guntoner®SC that may be required for various sites is planned to establish the position of Guntoner®SC as a superior termiticide.

We have launched on to the market not only Guntoner®SC, but also other termiticides containing clothianidin, including the soil-applied termiticide “Guntoner®MC” in the form of a microcapsule formulation

**Fig. 20** Heat-insulting material damaged by termites

developed by Sumitomo Chemical; the wood preservative "Guntoner®MC for wood surface treatment"; and the wood preservative "Guntoner®20EC" containing a fungicide[13], all of which are highly regarded by our customers. Apart from liquid termiticides or wood preservatives, we are also developing a termite and moisture- proof sheet, the "Guntoner® Sheet" to be installed prior to the construction of mat foundations. We will continue to contribute to the wood preservation industry by developing products with termiticides or wood preservatives containing clothianidin as the active ingredient.

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