Comparative Characterization of Bistrifluron as a Novel Slow-Acting Termiticide

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Rhinotermitid subterranean termites of two genera, *Coptotermes* and *Reticulitermes* are serious damaging pests of structures all over the world. All termite species have their well-organized eusocial caste systems, which discriminate those from other pest insects in terms of management methods. Therefore, methods for controlling entire colonies using bait system had been exploited and various slow-acting insecticides had been tested as bait toxicants for years. Since a benzoylphenylurea (BPU) compound, hexaflumuron was found to be effective for colony elimination of subterranean termites in 1990's, various bait products containing BPUs have been commercialized. Although BPUs are so far only chemicals that can successfully eliminate termite colonies of *Coptotermes* and *Reticulitermes* when they are used as bait toxicants, a new BPU bisrifluron has not yet been studied in details so far.

Termiticidal efficacy of bistrifluron as a bait toxicant against Japanese subterranean termites, *Coptotermes formosanus* and *Reticuliterme speratus*

The insecticidal efficacy of bistrifluron as a bait toxicant against the Japanese subterranean termite species, *Coptotermes formosanus* Shiraki and *Reticulitermes speratus* (Kolbe) was evaluated in the laboratory. The no-choice feeding tests using filter-paper bait and paper-towel bait were conducted with *C. formosanus* and *R. speratus*, respectively. Slow-acting insecticidal efficacy was seen in *C. formosanus* workers upon exposure to 5,000 and 50,000 ppm bistrifluron bait, while there was no significant increase in mortality at 500 ppm in the 8-week test. Faster insecticidal efficacy was observed with *R. speratus* workers upon exposure to 5,000 and 50,000 ppm bistrifluron bait. Unlike *C. formosanus*, the two colonies of *R. speratus* showed different responses at 500 ppm bistrifluron, which might suggest dose-dependent feature of bistrifluron.

Termiticidal efficacies of fenobucarb and permethrin against Japanese subterranean termites, *Coptotermes formosanus* and *Reticulitermes speratus*

The insecticides fenobucarb and permethrin were examined in the laboratory with regard to their termiticidal efficacy and speed of action against *C. formosanus* and *R.speratus*. Test insects were first exposed to filter paper treated with given concentrations of each insecticide for 21 days (continuous exposure) or two .hours (short-term exposure), and changes in termite mortality were compared. The termite species had no significant effect on the termiticidal efficacy or speed of action of the two insecticides. Both fenobucarb and permethrin exhibited very fast actions. The former showed a delayed action only in the 21-day exposure test, whereas the latter did not exhibit any delayed action even in the 21-day exposure test.

Response of *Coptotermes formosanus* to soil sreated with Baktop® MC, microencapsulated fenobucarb

The chemical barrier effect of microencapsulated fenobucarb against *C.formosanus* was examined in the laboratory. Fenobucarb had a significantly faster lethal effect when applied orally than dermally to worker termites. Soil that had been treated with ≥50 ppm (wt/wt) microencapsulated fenobucarb had a barrier effect within a single day, and could stop or retard the penetration of termites for 7 days. Microencapsulated fenobucarb did not act as a repellent agent. The results mean that microencapsulated fenobucarb is a fast-acting contact-poisonous termiticide with a good barrier effect as a soil-treatment agent. These features are favorable for preventive termiticide but not for bait toxicant.

Detailed evaluation of bistrifluron as a bait toxicant against *Coptotermes formosanus*

Bistrifluron was evaluated with regard to its efficacy against workers of *C. formosanus* using three laboratory tests. In the no-choice feeding test, the mortality of bistrifluron-treated worker termites was

significantly higher than that of termites exposed to the same concentrations of hexaflumuron [*e.g.*, 6 week at 500 ppm (wt/wt), 4 week at 5,000 ppm (wt/wt) and 2 week at 50,000 ppm(wt/wt)] and untreated controls. Bistrifluron showed higher dose-dependence and a faster speed of action than hexaflumuron. Both bistrifluron and hexaflumuron had feeding-deterrent effects at 5,000 ppm in the two-choice feeding test, although the mortality of worker termites exposed to bistrifluron or hexaflumuron at 5,000 ppm was not significantly different from untreated controls. In the allogrooming inhibition test, allogrooming behavior of termites and termite movement was affected at one week before termites died when exposed to 5,000 ppm bistrifluron. These results indicate bistrifluron to be effective as a bait toxicant at 5,000 ppm, while bistrifluron may cause some feeding repellency at ≥5,000 ppm.

Lethal dosage and horizontal transfer of bistrifluron among worker termites of *Coptotermes formosanus*

The lethal dose and horizontal transmission of bistrifluron was examined against workers of *C. formosanus* in the no-choice feeding test. When the termite workers were exposed to 5,000 ppm (wt/wt) bistrifluron bait for one week, toxicity appeared slowly with an LT_{50} (50% lethal time) 6.2 weeks. Much faster efficacy was observed after a two-week exposure, which gave an LT_{50} 3.1 weeks. The amount of bistrifluron recovered from moribund termites was 397.7 ± 57.66 ng/termite at 5 weeks in the one-week exposure, while 492.0 ± 50.09 ng/termite was recovered at three weeks in the two-week exposure. Bistrifluron was analyzed quantitatively from the head, legs, alimentary tract and other parts of the termite body, and the amounts were 90.5, 4.5, 60.8 and 559.1 ng/termite, respectively, immediately after the one-week exposure to 5,000 ppm bistrifluron bait. The rate of bistrifluron transferred from 20 donors to 20 recipients for one week was 6% of that taken by the donors during the one-week exposure to 5,000 ppm bistrifluron bait, and much smaller amounts of bistrifluron were transferred afterward from donors to recipients. The amount of bistrifluron that was originally ingested by *C. formosanus* workers, appeared to partly remain in the termite body (approximately 400 ng/termite).

Uptake of b by foraging workers of *Coptotermes formosanus*

Uptake of bistrifluron by foraging workers of *C formosanus* at three sites in the arena; workers on baits were collected and analyzed for bistrifluron content aliquid chromatography. All foragers disappeared from the one site with a bistrifluron bait about two months after the bait placement, while a few foragers were present at the two sites with an untreated bait. Termites contained more bistrifluron if collected from the site with a treated bait than with an untreated bait (~1026 vs. ≤196 ng of bistrifluron/termite). About one month after treated and untreated bait sites were switched, foragers returned to the site with bistrifluron bait, and the colony was shortly eliminated thereafter. Lethal quantities of bistrifluron (483-1380 ng/termite) were present in most of workers before the colony was eliminated.

It can be concluded by the series of experiments: 1) bistrifluron acts on termites extremely slowly in comparison to termiticides used as soil termiticides; however, 2) its efficacy is significantly dose-dependent and appears relatively faster in comparison to hexaflumuron; 3) bistrifluron inhibits colony-maintaining activities of termites like allogrooming behavior before the colony is eliminated; 4) a lethal dose of bistrifluron against *C. formosanus* is ≥400 ng per termite; 5) some portion of bistrifluron once taken up by foraging termites would remain in termite body for weeks, while the rest of bistrifluron is discharged; 6) sufficient amount of bistrifluron can be taken up by foraging termites owing to its slow action and subsequently bistrifluron would be transferred among most of foragers, and 7) Feeding deterrency of bistrifluron as a reflection of its dose-dependence is not always an unfavorable characteristics since the improvement of feeding preference by termites could lead to faster colony elimination. These conclusions clearly support that bistrifluron is a potential candidate as a bait toxicant.