# Termite Resistance of TAP Insulation in a No-Choice Test

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**A Report to:**

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# INTRODUCTION

Construction materials used in Hawaii and other tropical and subtropical regions are exposed to severe risk of attack by subterranean termites. The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, in particular is a severe pest in many parts of the world. In Hawaii, this termite is responsible for over $100 million in costs for control and damage repairs each year. In these regions, inhibiting termite penetration of the structure, and the ability of building materials to resist termite attack are critical factors in architectural design and construction decisions.

In the present study, we tested the ability of TAP insulation to deter penetration by Formosan subterranean termites under conditions in which they must either tunnel through the insulation in search of food or starve - a "no-choice" test. TAP is a cellulose-based insulation containing 11.1% (w/w) boric acid, manufactured by Cellulose Technologies Group, Inc. (CTG) and registered by the US Environmental Protection Agency (EPA Reg. 72787-1).

This test represents severe termite exposure, since the termites are freshly collected from field locations immediately before the test, and then kept under warm and humid conditions ideal for survival and feeding. The "no-choice" test is a rigorous test of the ability of the material to resist termite penetration, since no food (wood) is available to them in their nest container, and they must either tunnel through the insulation in search of food or feed upon the insulation directly. This is based upon a standard experimental design in our laboratory that has been published in the technical literature and was originally developed to evaluate termite tunneling into sand treated with borates and other insecticides (Grace (1990, 1991; Grace et al. 1992; Grace & Yates 1992; Tamashiro et al. 1996). We have also previously evaluated TAP insulation in a "choice" test version of this bioassay, in which food was also available to the termites in their nest container (Grace & Mankowski 2002).

## MATERIALS AND METHODS

TAP cellulose-based insulation, containing 11.1% (w/w) boric acid, and equivalent untreated cellulose insulation were provided by Cellulose Technologies Group, Inc. The tunneling assay followed the design described by Grace (1990, 1991), and also used by Grace et al. (1992), Grace & Yates (1992) and Tamashiro et al. (1996) to evaluate termite penetration of insecticide-treated sand. In this assay, standard glass microscope slides (2.5 x 7.5 cm) are spaced 3-4 mm apart and secured in a horizontal upright position along one edge by silicone sealant to a base consisting of a third flat microscope slide. The ends of the tunneling arena are sealed with plastic spacers and silicone caulking, with a 1.5 cm long Tygon tube at the base of each end of the arena leading into the base of one of two 55 ml polystyrene vials, each containing ca. 20 g silica sand and 4 ml water.

The center tunneling area between the two vials was filled with ca. 1 g of either dry TAP insulation, or untreated insulation, and the top of the arena sealed with aluminum foil. A 1 x 1 x 1/4-inch Douglas-fir wood wafer was oven-dried (90 C for 24 hours), weighed, and placed in one of the two vials. Formosan subterranean termites were collected from an active field colony on the Manoa campus of the University of Hawaii (Oahu, Hawaii) immediately before the laboratory test using a trapping technique (Tamashiro et al. 1973). 200 termites (180 workers and 20 soldiers, to mimic natural caste proportions) were placed in the vial without wood, as shown in Figure 1.

Five replicates were constructed with TAP insulation in the center arena, and 5 with untreated insulation. All replicates are held in an unlighted incubator at 27 C for 4 weeks (28 days). At the end of that period, we measured the distance the termites had tunneled through the arena, termite mortality, and the amount of feeding on the wood wafer in the vial at the opposite end of the arena from the initial “nest” vial. Wood wafers were oven-dried and weighed to determine the mass loss from termite feeding. This no-choice test setup represents a rigorous exposure, in which have no choice but to explore the insulation in order to find food.

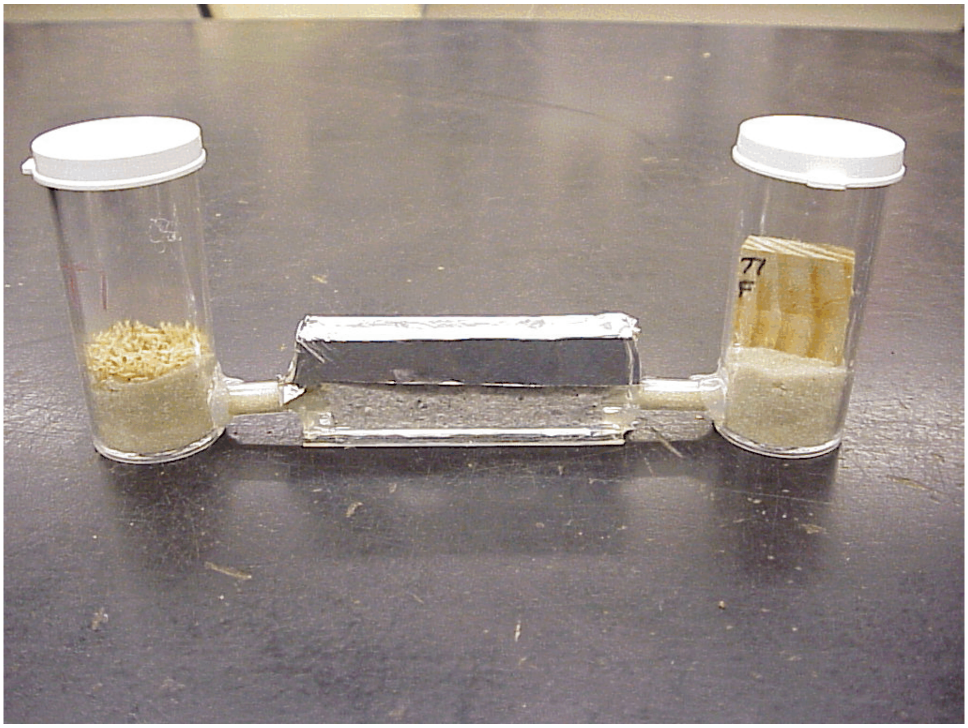


FIGURE 1: No-choice test apparatus for measuring termite tunneling through insulation.

## RESULTS AND CONCLUSIONS

The extent of termite tunneling through both the treated TAP insulation and the untreated insulation, resulting termite mortality, and termite feeding on the wood wafer in the end vial (Vial #2) are presented in Table 1. Termites fully penetrated all of the 7.5 cm long tunneling arenas containing the untreated cellulose insulation. In four of the five control (untreated) replicates, the termites proceeded to feed on the wood wafer. However, in one of these untreated replicates (C5), termites tunneled the length of the arena, but failed to locate the tube leading into the end vial containing wood. Although termite mortality was fairly low in the other 4 control replicates, in this particular replicate, all termites died during the 4 week exposure, apparently as a result of starvation when the wood wafer was not located. These results indicate that the untreated cellulose insulation does not prevent termite tunneling, but is also not an acceptable food source to termites.

In contrast to the situation observed with untreated cellulose insulation, termites were unable to fully penetrate any of the tunneling arenas containing TAP insulation (with 11.1% boric acid). An identical result was observed in an earlier tunneling test in which food was available in the termite nest container (Vial #1), and the termites were given the option of tunneling into the insulation, but were not forced to do so in order to feed (Grace & Mankowski 2002). In both tests, termites tunneled small distances into the treated insulation, but did not fully penetrate it in any case. In the current no-choice test, all termites exposed to the treated insulation died (100% mortality), probably as the combined result of toxicity of the TAP insulation and starvation. Mortality was also very high in the earlier choice test (mean of 78%) (Grace & Mankowski 2002). As in that earlier test, since none of the tunneling arenas were fully penetrated, no feeding at all occurred on the wood wafers on the opposite end of the tunneling arenas. In the absence of termite feeding, three wafers exhibited a very slight mass loss (0.4%), most likely due to slight fluctuations in moisture content.

As observed in our earlier choice test with TAP insulation (Grace & Mankowski 2002), and as is the case with borate wood treatments (Grace 1997), the boric acid content of the TAP insulation did not deter termites from initially exploring and tunneling into the material. However, the 7.5 cm tunneling arena was never fully penetrated. It is noteworthy that, although termites were able to tunnel fully through the untreated cellulose-based insulation, they were apparently unable to feed and survive upon an exclusive diet of it (see replicate C5, Table 1).

These results indicate that installation of TAP insulation will aid in the protection of structures from destruction by Formosan subterranean termites by killing those termites that attempt to tunnel through it. This is not a stand-alone termite protection treatment, but it will help to inhibit termite activity in wall voids, including tunnel (shelter tube) construction on the surface of wood within such voids that is in direct contact with the TAP insulation. Moreover, although termites will tunnel through the untreated cellulose-based insulation, even that untreated material is not an adequate food source for them, and they will die if forced to feed upon it in the absence of wood.

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# TABLE 1
## NO-CHOICE TEST - TAP INSULATION

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**TABLE 1: RESULTS OF NO-CHOICE TEST.** 200 Formosan subterranean termites were placed in Vial #1, with no food present.
Vial #1 was connected to Vial #2, containing a wood wafer for food, by a 7.5-cm tunneling arena containing cellulose insulation.
Termites were forced to tunnel through the arena to reach the wood wafer. Distance tunneled, feeding, and termite mortality were recorded after 4 weeks (28 days).

| **TREATMENT** | | **VIAL #1 (nest) - No wood present** | **TUNNELING ARENA** | | | **VIAL #2** | | | | | **TERMITE MORTALITY** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rep | | Distance tunneled (cm) | **Mean Distance (cm)** | **SD** | Initial Wood Mass (g) | Final Wood Mass (g) | Mass Loss (%) | **Mean % Mass Loss** | **SD** | Workers alive | Soldiers alive | Total % Mortality | **Mean % Mortality** | **SD** |
| **Untreated Insulation** | C1 | | 7.50 | **7.50** | **0.00** | 2.61 | 2.51 | 3.83 | **8.49** | **6.00** | 102 | 17 | 40.50 | **37.10** | **37.22** |
| | C2 | | 7.50 | | | 2.28 | 1.99 | 12.72 | | | 153 | 20 | 13.50 | | |
| | C3 | | 7.50 | | | 2.44 | 2.11 | 13.52 | | | 135 | 19 | 23.00 | | |
| | C4 | | 7.50 | | | 2.08 | 1.83 | 12.02 | | | 164 | 19 | 8.50 | | |
| | C5***** | | 7.50 | | | 2.92 | 2.91 | 0.34 | | | 0 | 0 | 100.00 | | |
| **Treated Insulation (TAP)** | T1 | | 3.00 | **2.76** | **0.60** | 2.43 | 2.42 | 0.41 | **0.25** | **0.23** | 0 | 0 | 100.00 | **100.00** | **0.00** |
| | T2 | | 2.30 | | | 2.51 | 2.51 | 0.00 | | | 0 | 0 | 100.00 | | |
| | T3 | | 3.70 | | | 2.55 | 2.54 | 0.39 | | | 0 | 0 | 100.00 | | |
| | T4 | | 2.50 | | | 2.44 | 2.44 | 0.00 | | | 0 | 0 | 100.00 | | |
| | T5 | | 2.30 | | | 2.20 | 2.19 | 0.45 | | | 0 | 0 | 100.00 | | |

***** In replicate C5 (untreated insulation), termites tunneled completely through the arena, but were unable to locate the wood wafer in Vial #2 before dying.
This indicates that the untreated cellulose insulation was not an adequate food source, and that termites died when they were unable to find wood to feed upon.