# Benefits of cleaning products containing the repellent methyl neodecanamide against *Blatella germanica* (L.)

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**Abstract:** Repellency of methyl neodecanamide (MNDA), a known insect repellent, to German cockroaches, *Blattella germanica* (L.), was investigated in laboratory tests and in homes. Liquid–cleaner formulations which contain 2% MNDA and applied at the recommended 8 to 1 dilution with water, delivered more than one day of nearly complete (90%) repellency. Full strength application to various surfaces repelled 90% of roaches for over one week. The effectiveness of the products was documented in consumer–user tests in homes. The benefits of combining a cleaner and repellent to improve cockroach control and enhance the quality of the indoor environment is discussed.

## Introduction

Several surveys of pest control operators (PCOs), entomologists and the general public conclude that cockroaches are by far the most pestiferous, especially in urban situations. Because of their movement between sewers (and bathrooms) and kitchens (human food materials), cockroaches can acquire, carry, and transfer pathogens either mechanically or in their digestive system. Although cockroaches generally do not support multiplication of *Salmonella*, they have a significant vector potential bacause a high percentage of cockroaches in large infestations may be infected.

Recent work demonstrated that cockroaches could acquire *S. typhimurium* from an infected food source, and infect non–contaminated cockroaches, food and water through contact (Kopanic *et al*, 1994). Hypersensitivity to cockroaches is particularly common among inner–city residents who experience high intensity and long duration of exposure to cockroaches. Thus, effective suppression of cockroach populations is needed to alleviate health–related problems and is mandated in many areas by federal and local regulations.

Some chemical insecticides applied by homeowners or commercial applicators (PCOs) have provided relief from cockroach infestations. However, recent concerns about human and environmental exposure to pesticides, as well as insecticide resistance, especially in the German cockroach, have prompted a re–examination of the concepts of integrated pest management (IPM) in urban pest control. IPM is a "pest population management system that utilizes all suitable techniques in a compatible manner to reduce pest populations and maintain them at levels below those causing economic injury" (Smith and Reynolds, 1966).

A plethora of pest management options have been conceived for implementation in homes and public buildings where food is stored, prepared or served (e.g., restaurants, schools, prisons). These include monitoring, trapping, biological–, genetic–, and chemical–approaches, and most importantly, cultural and physical approaches (Schal and Hamilton, 1990). The latter include proper construction and sanitation, both of which aim to reduce resources that support population growth (i.e., water, food, shelter), facilitate movement that increases contact with residual insecticides, and reduce areas that require coverage by insecticides.

Moreover, proper sanitation has been shown directly to influence other pest management procedures: it increases the efficacy of caulking as a means of reducing cockroach shelters; it retards cockroach population growth relative to apartments with poor sanitation; and removal of grease from surfaces enhances the efficacy of contact insecticides (Schall, 1988; Rust and Reierson, 1988).

Repellents, compounds that elicit directed orientation of pest insects away from a treated surface but generally lack insecticidal activity, are commonly used for protection from public health and nuisance pests (mosquitoes, flies, gnats). While a variety of natural (Inazuka, 1982a) and synthetic (Bodenstein and Fales, 1976) compounds have been reported as cockroach repellents, for unknown reasons (perhaps cost, stability, effectiveness over time, safety) none of these materials has been incorporated into cleaning products that can be applied to surfaces in order to create "pest exclusion zones".

Recently, methyl neodecanamide (MNDA), a secondary amide member of a large class of alkyl neoalkanamides, has been shown to a highly effective cockroach repellent (Steltenkamp *et al*, 1992; US Patent # 5,182,304; US Patent # 5,391,578). Favorable characteristics of MNDA include high intrinsic repellency (ability to stimulate insect movement) and persistence on various substrates (substantivity) which results in long lasting repellency.

MNDA is in a liquid physical state with a mild pleasant odor, is economical to produce, is noninsecticidal, and has a favorable safety profile (Bagley, 1994). These properties make MNDA ideal for incorporation into cleaner formulations. This study reports laboratory and in–home evaluation of liquid all purpose cleaning products containing 2% MNDA against German cockroaches. We conclude that these products effectively deposit MNDA on cleaned surfaces, thereby combining the benefits of improved sanitation and repellency.

## Materials and Methods

*Insects*: Male German cockroaches were collected from an established insecticide–susceptible colony maintained at 27°C on a 12:12 light–dark photocycle and fed commercial rat chow. Males between 10 and 25 days old were used in the assays.

*Laboratory repellency bioassay*: We used a modification of the method of Goodhue and Tissol (1952) to evaluate the repellency of test solutions. With few exceptions, this is similar to the methods reported by Steltenkamp *et al* (1992) in our comparison of various cockroach repellents. Briefly, each test consisted of replicated two–choice assays, over time, in which cockroaches were offered treated vs. untreated shelters (Fig. 1). Repellency was quantified, based on the

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relative distribution of resting cockroaches during the light phase of their light–dark cycle.

Forty–eight hours prior to initiation of an assay, 50 male German cockroaches were acclimated to plastic test cages (51 x 28 x 20 cm); a thin film of petroleum jelly (Vaseline) on the inner sides of the cages restricted the insects to the floor of the cage. Food and water were provided in the center of each cage, outside of the shelters.

In previous tests with MNDA we used absorbent 8 oz (237 ml) paper cups as shelters (Steltenkamp *et al* 1992). In the present assays we used shelters constructed of materials found on surfaces in homes, such as standard vinyl floor tile and ceramic tile. Six 3 x 3 inch square tiles, each 58.1 $cm^2$ were thoroughly washed with distilled water. Notches were cut into two of the tiles to provide entry to the shelters. The tiles were treated with 0.62 ml of diluted test product using a pipette, air dried 4–6 hours, and then each set of six tiles was assembled into a shelter with adhesive tape. The floor of the shelter was left unattached, allowing us to lift the shelter for daily counts of cockroaches. Control tiles were treated identically with water alone.

Repetitive treatments of a microemulsion formula were made with a sponge. Undilted (full strength) or diluted cleaner was applied to shelters at a rate of 4–6 mg product/$cm^2$ before they were assembled. This treatment approximates the amount of product delivered to surfaces when people use liquid cleaners (Colgate–Palmolive, unpublished results).

One product–treated shelter and one control shelter were placed into a cage. The number of insects resting inside each shelter was recorded daily during the middle of the 12 hr light portion of the photocycle. After each reading all cockroaches were removed from each shelter and the positions of the shelters were reversed. Assays terminated after 25 days or when equal numbers of insects were found in treated and control shelters.

Percent repellency was calculated as:

$$\% \text{ Repellency} = (100 * (N_t/[N_t + N_c)])$$

where $N_t$ is the number of insects on the treated surface and $N_c$ is the number on the untreated control surface. To evaluate the repellency, we used (i) the number of days of complete (100%) repellency, and (ii) a maximum likelihood probit analysis of time/repellency (SAS Institute, 1985) from which a measure was calculated of the number of days of 90% repellency ($RT_{90}$ – 10% of the insects on the treated surface, 90% on the control surface).

*Test Products*: Laboratory evaluations were made with two liquid cleaners. Each contained 2% MNDA, typical cleaning agents (anionic/nonionic surfactants and solvent), color and fragrance. One cleaner was in the form of a clear solution. The other was a clear microemulsion cleaner.

*In–home Testing*: Three field studies aimed to (i) demonstrate the repellency of cleaning products containing 2% MNDA, and (ii) quantify the amount of MNDA deposited on floors after in–home cleaning.

In 1992, a study in Vera Cruz, Mexico, was designed to test the idea that routine cleaning of homes with cleaners containing MNDA would reduce the number of cockroaches entering and sheltering in the home. Subject homes were selected based on the level of cockroach infestation. Prior to introduction of the cleaners two trapping sessions were made during a 10 day period using standard cardboard glue traps placed on kitchen floors. Homes with consistent cockroach counts of at least 10 were then selected for further testing. equal number of homes in each. One group used a cleaning product containing MNDA, whereas the other group used a commercial cleaning product without repellent.

After using the respective product daily for three days, traps were introduced again to assess any changes in the cockroach population. Four consecutive trapping sessions were conducted over a two week treatment period.

In 1993, a four week study in Guatemala City, Guatemala aimed to determine whether cleaning products deposit MNDA when used by consumers. Eighteen homes were selected on the basis of commitment by residents to the test period and having a cockroach problem. Vinyl tiles (12 x 12 inches) were placed on the kitchen floor of each home. At the end of each week, MNDA was extracted from the tiles with organic solvent and the level determined by gas chromatography. Residents were also requested to evaluate changes in cockroach numbers based on frequency of sightings.

Quantification of MNDA deposits on surfaces was also conducted in a 1995 study involving homes near Rome, Italy. Sixteen homes were selected on the basis of commitment of residents to clean their kitchens every evening for two weeks. Vinyl tiles (12 x 12 inch) were secured to the kitchen floor of each home. Smaller tiles (3 x 3 inch) were placed on counter tops in six of the 16 homes. The large tiles on the floor were washed exclusively with 2% MNDA–containing cleaner diluted with 8 parts water. The counter top tiles were washed once a week with undiluted cleaner with MNDA and the rest of the week with diluted product. At the end of each week, MNDA was extracted from the tiles with organic solvent and its level determined by gas chromatography. Additionally, MNDA was determined immediately after each full strength treatment of the counter top tiles.

#### Results and Discussion

*Repellency of MNDA in a liquid cleaner*

We used a maximum likelihood probit analysis to quantify repellency as a function of cleaner/MNDA amount. The resulting estimates of duration of repellency are thus extrapolated from a "best fit" regression of the empirical daily data. We chose the time until 10% of the insects were on the treated surface (90% repellency) as an arbitrary threshold measure of repellency.

All–purpose liquid cleaner without MNDA results in minimal repellency in laboratory bioassays. However, the addition of 2% MNDA to the cleaner contributed a significant repellency benefit compared to the cleaner without MNDA (Fig. 2). All–purpose cleaners are typically diluted prior to use. MNDA–containing cleaner diluted with 50% water repelled 90% of the cockroaches for more than eight days.

For daily cleaning, the recommend dilution for MNDA–containing cleaners is one part product to eight parts water. At this dilution the cleaner containing MNDA delivered at least one day of repellency to vinyl tile surfaces. Thus, cockroach repellency was related to the amount of cleaner and MNDA, as the duration of repellency was longest when the product was applied relatively undiluted.

This result agrees with our previous study (Steltenkamp *et al*, 1992) which showed that MNDA repellency is directly related to the amount delivered to a surface. In addition, all–purpose household cleaners are recommended for use at full strength for difficult cleaning chores. The undiluted cleaner containing 2% MNDA provided almost three weeks of repellency under our test conditions.

It is noteworthy that alternative statistical procedures, such as Chi–square and the binomial test, applied to our data

more stringent 90% criterion. For example, even at a 4 to 1 dilution, insects were significantly repelled from the treated surface at the conclusion of the assays after 25 days ($P < 0.05$, Chi–square test).

All–purpose cleaners can be formulated as microemulsions which are transparent dispersions of oil, surfactant, and water (Rosen, 1989). Often these compositions provied superior cleaning performance compared with traditional liquid cleaner formulations (US Patent # 5108492). MNDA can be incorporated into a microemulsion without sacrificing cockroach repellency (Table 1).

The microemulsion containing 2% MNDA was applied with a sponge either once undiluted or repetitively after diluted 8 to 1 with water. Repetitive applications were made once on each of seven consecutive days. A single full strength application provided repellency for over two weeks. Seven applications using 8:1 dilution delivered approximately five days of 90% repellency. Similar results were obtained with a single application of the undiluted cleaner followed by seven daily applications of the diluted cleaner (Table 1). Other laboratory studies showed that MNDA accumulated when MNDA–containing cleaners were used repetitively to clean surfaces (Connors, 1994).

*Repellency from various household surfaces*

Cleaning products containing MNDA repel German cockroaches from various household surfaces. A single full strength treatment (4–6 mg product/cm$^2$ using a sponge) provided over one week of cockroach repellency on all surfaces tested. In general, greater repellency was attained on porous surfaces (e.g., unglazed ceramic tile, granit flooring) which retained MNDA better than on slick non–porous substrates (e.g., vinyl tile, glazed ceramic tile, Formica tile).

*MNDA effect on cleaning*

MNDA is a water insoluble oil, but it does not affect the performance of cleaner formulations (Fig. 3). Cleaning was evaluated by applying soil (thin beef tallow film) on Formica tiles which were then washed for a set number of strokes in a controlled manner with a Gardner Abrasion Tester (Pacific Scientific, Silverspring, Maryland). The abrasion tester held a typical household sponge which was pre–saturated with full strength cleaning product. Percent cleaning was determined from reflectance measurements (Cleaning protocol adapted from an American Society Testing Materials Method ASTM D1792).

*In–home testing*

The 1992 study in Vera Cruz, Mexico tested whether routine cleaning of homes with an MNDA–containing cleaner would reduce the number of cockroaches in traps. The homes that were included in our study contained both German and American cockroaches (*B. germanica* and *Periplaneta americana*, respectively). A reduction in cockroach count was observed after use of a cleaning product with 2% MNDA following the recommende dilution of 8 parts water and 1 part product. Trap catch was reduced 31 to 36% over the four trapping sessions in homes using the MNDA–containing cleaner. This was a significantly greater reduction in trap catch than the control group which showed 16 to 25% reduction over the four readings.

These results demonstrate that while cleaning alone might influence cockroach populations, the combination of repellency and cleaning significantly reduced trap catch in treated areas. Reduced trap catch suggests that cockroaches were repelled from treated floors; this will likely translate to fewer sightings of cockroaches.

The 1993 Guatemala City study demonstrated that cleaning products deposited MNDA when used by consumers. Although many consumers did not follow product use instructions, MNDA was detected in six of the 18 homes. MNDA levels ranged from 0.2 to 32.1 micrograms/cm$^2$. Considering only tiles on which MNDA was detected, the average level was 7.3 micrograms/cm$^2$. This level would be sufficient to provide 1–2 days of cockroach repellency extrapolated from the MNDA dose–response for German cockroaches (Fig. 4). At the conclusion of the test, a survey of participants showed that all experienced fewer sightings of cockroaches.

Much greater cooperation and adherence to label directions were obtained in our Rome, Italy tests. MNDA was detected in every home and one all tiles. An average of 31.0 micrograms/cm$^2$ of cleaned surface was delivered by daily cleaning with products containing 2% MNDA. This included both full–strength and dilute use. Based on the MNDA dose–response for German cockroaches (Fig. 4), the predominant species in these studies, 5–6 days of 90% repellency is predicted. An average of 9.2 micrograms/cm$^2$ was deposited when the product was used exclusively at the recommended dilution of 8 parts water and 1 part product. This level is sufficient to provide 1–2 days of repellency of German cockroaches.

These results from in–home tests demonstrate that when liquid cleaning products containing 2% MNDA are used as intended, sufficient MNDA is delivered which provides a meaningful repellency benefit.

## Conclusions

The repellency of liquid cleaning products containng methyl neodecanamide is related to the amount of MNDA deposited on a surface. In turn, the amount of MNDA deposited on a surface depends on product dilution, time after deposition and surface characteristics. Full strength undiluted product repels cockroaches for at least a week, while an 8 to 1 dilution with water reduces repellency to about a day.

When surfaces are cleaned daily as recommended, these cleaners will deposit MNDA at levels that provide extended repellency. The strategy of modifying and "manipulating" cockroach behavior is especially promising. For example, insect–repellent cleaners could be used to render cleaned areas "inhospitable" to cockroaches (Brenner, 1993), and "move" cockroaches away from indoor areas where use of conventional insecticides is discouraged.

In conjunction with judicious use of appropriate insecticides, cleaning products that are repellent could also be used in an integrated approach to manage cockroach populations by providing sanitation, creating "pest exclusion zones" and increasing the frequency and duration that cockroaches are in contact with insecticides (Schal and Hamilton, 1990).

Any reduction in human exposure to German cockroaches is important due to the allergenic potential (Kang and Chang, 1985) and bacterial load (Rivault *et al*, 1993) of these pests.

## Acknowledgements

We wish to thank John H. Puckhaber and Henry Stinga of Colgate–Palmolive for their contribution to the in–home study in Mexico. We also thank Rick Cooper (Rutgers University), Hugh Young and Jason Herber (North Carolina State University) and Dave Suriano (Colgate–Palmolive) for laboratory evaluations of cleaning products.

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**Table 1:** *Repellency to German cockroaches of surfaces treated with a microemulsion containing 2% MNDA.*

| Application[1] | Days Repellency[2] |
|---|---|
| One full-strength undiluted application | 15 |
| Seven applications at 8:1 dilution | 5 |
| [illegible]th followed by [illegible]8:1 dilution | 5 |

[illegible] were applied with a sponge. Eac application [illegible]mg product/cm$^2$.
[illegible]es obtained from probit analysis.