[Cover Story] Silica Gel: A Better Bed Bug Desiccant

FEATURES - COVER STORY

Dusts are becoming more popular for bed bugs. Although earlier trials with diatomaceous earth were disappointing, University of Kentucky researchers and pest professionals are seeing exciting things with silica gel.

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Bed bugs have long been drenched and dusted with insecticides. While toxicants were more typically applied as liquids, infested beds and belongings also were dusted with such materials as sulfur, pyrethrum and 10 percent DDT powder. Without a simple one-shot solution, companies are again employing dusts in their bed bug management programs.

Today's dust formulations often contain pyrethroids (e.g., Tempo Dust [Bayer Environmental Science], DeltaDust [Bayer Environmental Science]) or neonicotinoids (Alpine [BASF Corp.]) as active ingredients. While such materials can be efficacious, resistance and other factors have fueled interest in dusts that kill via desiccation. *(photo 1)*. In previous studies with diatomaceous earth, the compound performed well in the lab, but poorly in the field (Romero et al. 2009, Potter et al. 2013). The present study focuses on another dust desiccant, silica gel, evaluated in both the lab and in bed bug-infested apartments.

Understanding Silica Gel.

Silica gels are white, fluffy, powders manufactured from silica. Silica (Si) comprises more than a quarter of the earth's crust in the form of sand, quartz, clay and other materials. Many plants, including those we eat, absorb soluble forms of silica from soil. Silica does not occur naturally in its pure form, reacting instead with oxygen and water to form silicon dioxide (SiO_2). Thus, the terms "silica" and "silicon dioxide" are often used interchangeably.

Photo 1. Several dusts are available for bed bug management.

Both silica gel and diatomaceous earth (DE) are comprised of silicon dioxide but their origins and manufacture are different. DE is mined from fossilized remains of microscopic plants (diatoms) whose hardened shells contain silica. Silica gel however is synthetically produced, often from sand, via various manufacturing processes. The term "gel" is somewhat misleading since the

material is hard and often formed into beads or granules. Silica gel is also *amorphous* (non-crystalline), which greatly diminishes its potential hazard to humans.

Silica gel and other forms of synthetic amorphous silica have many industrial uses beyond insecticides. They are efficient desiccants (drying agents), which is why small bags of the material are often packaged with electronics to prevent moisture accumulation during shipping and storage. Due to their anti-clumping properties, silica gels are sometimes added to powdered foods, pharmaceuticals and cosmetics.

Role as Insecticides. Products containing silica gel have been used by the pest control industry for more than a half century. The first such product (Dri-Die, Fairfield American Corp.) was registered in 1956. Formulations employed for pest control tend to be light, fluffy powders comprised of very small, porous particles. The tiny particles often have an electrostatic charge that helps them adhere to insects crawling over treated surfaces. Sometimes referred to as “aerogels,” the resultant dusts can be so light that a pint-size bottle weighs just a few ounces. Because the particles are so lightweight, they often suspend in the air following application. To overcome this, some formulations contain additives such as petroleum distillate (e.g., Drione, Bayer Environmental Science), or are dispensed as liquid aerosols (Tri-Die, BASF Corp.). These two formulations also contain pyrethrins and piperonyl butoxide. Recently, another formulation (CimeXa) containing 100 percent amorphous silica gel and no other additives, was introduced by Rockwell Labs.

Mechanism of Action. Both silica gel and diatomaceous earth kill insects by removing a portion of the razor-thin, waxy outer coating that helps them conserve moisture. As a result, they desiccate and die from dehydration. Like super-fine sandpaper, DE acts principally by *abrading* the protective outer layer of wax as the insect crawls over or through the particles. Instead of causing abrasion, silica gel functions more like a sponge to *absorb* the cuticular waxes onto the particles. Silica gels have tremendous oil-absorbing capability. Studies have shown that such highly “sorptive” dusts are generally more effective than abrasive, less absorptive dusts (such as DE), especially under field conditions (Ebeling 1961, 1971; Subramanyam and Roesli 2000). It should be noted that boric acid is not a desiccant and has little effect on bed bugs since it must be ingested. None of the aforementioned dusts kill insects by clogging the breathing pores (spiracles) as is sometimes erroneously believed.

Safety Profile. Silica gel has low toxicity to mammals. The acute oral LD_{50} is comparable to table salt. As noted previously, the compound is routinely added to foods and pharmaceuticals to prevent clumping. With respect to inhalation hazard, an important distinction must be made between synthetically produced, *non-crystalline* silica gel and naturally occurring *crystalline* silica such as quartz dust. Inhaling tiny particles of crystalline silica as might occur during sandblasting or mining operations can cause silicosis and other chronic respiratory illnesses. This is not a concern with non-crystalline silica gel insecticides. (Authors’ note: While inhalation of crystalline silica should not be a concern with diatomaceous earth the risk is even lower with silica gel. Synthetically produced silica gel is nearly 100 percent pure non-crystalline silica. Diatomaceous earth is also largely comprised of amorphous [non-crystalline] silica, but may contain impurities, including small amounts of crystalline silica.)

As with any dusty material, airborne silica gel particles can be somewhat irritating to the eyes and respiratory tract. Due to its desiccating properties, the dust also has a drying effect on skin which can be avoided by wearing gloves or washing after use.

Laboratory Trials.

A series of experiments were conducted to evaluate effects of silica gel on bed bugs. CimeXa insecticide dust (Rockwell Labs, North Kansas City, Mo.) containing 100 percent amorphous silica gel was used in all experiments.

Lab Test #1. In this experiment, adult bed bugs from three different bed bug populations were exposed to surface deposits of either CimeXa dust, Temprid SC (ß-cyfluthrin + imidacloprid, 0.075 percent) or water alone. The populations collected from Lexington (LEX-6) and Cincinnati (CIN-TS) were previously determined to be highly resistant to pyrethroid insecticides. The third population, collected six years ago from New York (NY-1), was initially highly resistant but has since reverted to being somewhat less resistant. Twenty adult males from each population were confined individually on treated discs of black filter paper. The CimeXa dust was applied with a small hobby brush, leaving a fine, barely visible deposit on the black paper surface. Discs wetted with Temprid or water alone were allowed to dry completely before bugs were placed on treated surfaces. Mortality was recorded after 1, 2, 3 and 7 days of continuous exposure to each treatment.