Journal of the American Mosquito Control Association, 24(1):127–129, 2008

OPERATIONAL NOTE

PERMETHRIN DECOMPOSITION AFTER FOUR MONTH STORAGE IN THE SPRAY TRUCK TANKS DURING MOSQUITO OFF SEASON

RUI-DE XUE,[1] WHITNEY A. QUALLS,[1] HE ZHONG,[2] AND CATE L. BROCK[2]

ABSTRACT. The concentrations of permethrin in the Aqua-Reslin® formulation stored in the insecticide mixers/pumps, 16 ultra-low volume (ULV) truck-mounted spray tanks, and a stock container were sampled and analyzed by gas chromatography. The result showed that an average of 55.53% and 70.32% permethrin in Aqua-Reslin were decomposed in the ULV spray truck tanks and in the mixers/pumps, respectively, during the 4-month mosquito off-season. The degradation may directly result in economic loss. Also, the mosquito control efficacy may be compromised if the concentrations are inappropriate. The permethrin analytical method, economic cost, and degradation-prevention methods are discussed in this article.

KEY WORDS Permethrin, decomposition, adulticide, mosquito control

Permethrin is a broad-spectrum pyrethroid insecticide used to kill a variety of pest and vector insects. Permethrin as an active ingredient (AI) has been formulated in a variety of pest and vector control products, including several mosquito adulticides, such as Aqua-Reslin® (Bayer Environmental Science, Montvale, NJ), Aqua-Kontrol (Univar, Redmond, WA), and Aqualuer™ 20–20 (Allprovector, St. Joseph, MO). Adulticides for mosquito control are usually applied at ultralow volume (ULV), by plane or helicopter, and/or by ground, with the use of truck-mounted ULV sprayers or hand foggers. Most ground application for adult mosquito control is conducted by using ULV spray trucks.

The Anastasia Mosquito Control District (AMCD) of St. John's County, located in northeast Florida, predominantly applies permethrin (Aqua-Reslin), with the use of ULV spray trucks to control adult mosquitoes from June to November. The AMCD has 16 ULV spray trucks, and the tanks mounted on the spray trucks are always filled to capacity with the permethrin product mixture during the mosquito season. The time to stop mosquito adulticide application is heavily dependent on the mosquito activity in a given year and could vary from location to location. Therefore, all 16 tanks on the ULV spray trucks were loaded with Aqua-Reslin during the mosquito off-season from December to June. Most of the spray trucks were also used by the field inspectors daily and therefore, the diluted Aqua-Reslin agitated inside the tanks through the field trips daily.

This purpose of this study was to examine whether permethrin in the truck-mounted spray tanks and in the mixers or pumps was decomposed after several months or during the mosquito off-season. The resulting economic cost of the degradation and its prevention were also studied.

The assessment was conducted by taking the insecticide samples from each spray tank and the mixers/pumps in all 4 AMCD substations. The sampling process includes agitating the mixture for 5 min with a handheld agitator before taking samples from each spray tank. The water-mixed insecticide solution from the mixers/pumps was drained to a plastic bucket and sampled from the bucket after agitation. Control samples were obtained from the insecticide stock containers following the agitation after circulation. A 10-ml sample from the middle of the spray tank and 1 ml from the stock container were taken with the use of a 10-ml disposable pipette. The samples were immediately placed into 50-ml centrifuge tubes and labeled according to the truck tank number and date. The control sample was diluted 1:10 times by using 1 part of Aqua-Reslin and adding 9 parts of well water. All samples were sealed, stored with coolants, and transferred to the Florida Agricultural and Mechanical University, Public Health Entomology and Education Center (FAMU/PHEREC), Panama City, FL for analysis.

Within 36 h of arriving at the laboratory, all samples (Aqua-Reslin) were analyzed for permethrin residue by using a gas-chromatography (GC) method developed at FAMU/PHEREC, Panama City, FL. All samples were diluted through a series of dilution. A Varian 3400 GC configured with electron capture detector (ECD) and an 8200 autosampler (Varian Analytical Instruments, Walnut Creek, CA) were used for the permethrin analysis. A GC CP-Sil 8 CB low-

[1] Anastasia Mosquito Control District, 500 Old Beach Road, St. Augustine, FL 32085.
[2] FAMU, Public Health Entomology Research and Education Center, 4000 Frankford Ave., Panama City, FL 32405.

bleed capillary column (30 m × 0.25-mm inner diameter, 0.25-μm film thickness) bonded with fused silica (Varian, Inc., Palo Alto, CA) was used. Chromatograph data were acquired on a Dell Computer (Dell Computer Corporation, One Dell Way, Round Rock, TX) equipped with a data-handling software, Star Chromatography Workstation, Version 4.51 (Varian Analytical Instruments). The GC injector was operated isothermally at 220°C in splitless mode, and the detector block was maintained at 300°C. The GC column oven temperature was held at 130°C for sample introduction, ramped at 20°C/min to 200°C and held for 1 min, ramped again at 25°C/min to 280°C and held for 2 min, and then ramped a 3rd time at 25°C/min to 300°C and held for 3 min. The total analysis time was 13.50 min per sample. Retention time of the permethrin group was 10.20 min. The GC method was streamlined to calculate permethrin ''group'' concentrations so that reported values were reflective of both the cis and trans isomers. An injection volume of 1 μl was used for all standards and samples.

A 5-point calibration curve (minimum 3-point), covering a permethrin concentration range from 0.10 to 1.60 μg/ml, was generated for the analysis. Correlation coefficients required for the calibration curves were at least 0.995 ($R^2 \geq 0.995$). The analytical standard used for the calibration was obtained from Bayer Crop Science US with certified 96.6% pure permethrin. The analytical-grade permethrin was dissolved in a small volume of hexane to make a primary stock standard solution with a concentration of 1 mg/ml. The permethrin stock solution was subsequently diluted to prepare for calibration solutions. A new permethrin calibration curve was generated for analysis of samples for each field trial. During analysis, continuous calibration at a ~0.52-μg/ml level was conducted every 10 samples with the use of a recovery criterion of 100 ± 10%. This continuing calibration solution was intentionally prepared from a secondary source—different analytical standard lot number than that used to generate the calibration curve. Hence, this continuing calibration also served as a confirmation standard to verify the primary analytical standard concentration. The secondary source of analytical standard for the continuing calibration solution was also obtained from Bayer Crop Science US with certified purity of permethrin. Field blanks, laboratory blanks, and instrument blanks were used to check for possible contamination.

The result showed that an average of 44.47% ± 12.68% ($n = 16$) and 29.68% ± 14.13% ($n = 6$) original Aqua-Reslin remained inside the spray tank mounted on the truck and in the insecticide mixers/pumps, respectively, after 4 months during the mosquito off-season. This suggested that Aqua-Reslin formulation, after dilution with well water, was subjected to significant degradation, compared to the original stock solution. The control efficacy could be compromised with an estimated loss of 55.3% and 70.32% permethrin (AI), respectively, if the remaining diluted products are sprayed in the following year.

Many factors may contribute to permethrin decomposition (Bouma et al. 1996, Gonzalez et al. 2002). The insecticide efficacy against target mosquitoes may also be influenced by other factors (Bouma et al. 1996), such as sprayer calibration, rate of application, timing, temperature (Hodiati and Curtis 1999), rainfall, water pH, sunlight, and the suitability of the chemical to its purpose. The permethrin decomposition in the ULV spray tanks during the mosquito off-season may be caused by photodegradation, hydrolysis exposure, and high or low temperatures due to everyday use of the trucks.

The tank size of each spray truck is 15 gal and was typically filled with 1.5 gal (5.67 liters) of Aqua-Reslin and 13.5 gal (56.77 liters) of water. The insecticide cost ($225 per gallon) in each tank is about $337.5. During the 4-month period, the estimated loss of permethrin was about 50%. This required an additional 0.75 gal (2.8 liters) of Aqua-Reslin, at a cost of about $168.75 per truck. Typically, the diluted Aqua-Reslin will be stored in the spray truck tanks for 6–7 months. Without spraying, it is assumed that all permethrin (AI) is probably completely lost during that period of time. A spray truck with a full tank of degraded compound is sent out for a 3–4-h spray mission. The estimated cost for 1 truck includes the spraying labor, overtime pay, and gas cost of about $150–$200. Therefore, a total estimated cost per truck spray will be $500–$600 during an ineffective mission, with a grand total of $8,000–$9,600 for a spraying mission with all 16 spray trucks.

To minimize or prevent the possibility of breakdown of Aqua-Reslin inside the holding tank on a spray truck, we recommend continually applying a spray until the tank is empty during the final seasonal mission. However, this is not always possible. For instance, sudden weather changes may cause a delay or interruption of the ULV spraying operation, or a sudden rise in temperature may increase adult mosquito activity late in the season, necessitating an additional insecticide application. The tank mixture may be stored in the trucks for an unacceptable length of time. If this occurs, a chemical residue analysis must be made to determine the lost amount of active ingredient, and the difference must be made up by adding more Aqua-Reslin stock.

In addition, the remaining water-mixed insecticide solution siphoned out from the spray tanks or mixers/pumps after the season in 2006 was analyzed. The test result showed that the

permethrin concentration in siphoned insecticide solution stored in a sealed container for 4–5 months was similar to the concentration in the spray truck tank stored for 4–5 months.

In conclusion, compared with freshly mixed samples, water-diluted permethrin in Aqua-Reslin product decomposed inside the holding tanks mounted on spray trucks after being stored in the tanks for several months. This loss of permethrin does not only affect control efficacy, but also causes the economic loss. The decomposition could be detected by residue analysis that will help the determine the make-up concentration, and could be prevented by spraying until the tank is empty and other practice measures. Analyses of the synergist, pipernyl butoxide (PBO) and inert material in the product were not made. This is a research report only and the AMCD neither endorses nor opposes the commercial products mentioned here.

REFERENCES CITED

Bouma MJ, Parvez SD, Nesbit R, Sondorp HE. 1996. Rapid decomposition of permethrin in the outer fly of an experimental tent in Pakistan. *J Am Mosq Control Assoc* 12:125–129.

Gonzalez Audino P, Licastro SA, Zerba E. 2002. Thermal decomposition and isomerization of *cis*-permethrin and beta-cypermethrin in the solid phase. *Pest Manag Sci* 58:183–189.

Hodiati MH, Curtis CE. 1999. Effects of permethrin at different temperatures on pyrethroid-resistant and susceptible strains of *Anpoheles*. *Med Vet Ent* 13:415–422.