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OPERATIONAL NOTE

AQUA-RESLIN® DROPLET ANALYSIS[1]

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ABSTRACT. Aerosol droplets were collected, counted, and sorted using a laser system, the Army Insecticide Measuring System, Teflon®-coated slides, and magnesium oxide-coated slides. All droplets, for each method and replication, were generated by a London Aire 1820 or a Leco Model 1600. These data indicate that the Army Insecticide Measuring System or Teflon-coated slides are so closely similar to the laser that they could effectively be used in the field without an overwhelming loss in precision.

KEY WORDS: Aerosol droplet measurement, laser system droplet analysis, aerosol, hot wire, Aqua-Reslin®, Teflon® slides, mosquito control, adulticide

The role of aerosol droplets in insecticide application technology for disease vector control has been amply described in the literature (Rathburn 1970, Matthews 1992). The literature is also replete with field studies describing the influence of environmental parameters such as vegetation, wind, temperature, relative humidity, and release altitude on insecticide efficacy (Akesson and Yates 1974, 1982; Armstrong 1979). Although mosquito control personnel often understood the optimal method for applying an insecticide under local conditions, broader, national concerns also came into play. For example, the droplet spectra analysis, an understanding of which may determine the success and safety of an application, is often not available for selected machines and chemicals. For performance of droplet spectra analysis, a method of collecting droplets must be available to demonstrate the droplet size achieved by the sprayer. Rathburn (1970) described a variety of aerosol spectra analysis methods. Since his report, the availability of laser systems has added greater precision in the analysis of aerosol droplet spectra. However, the high cost and the limited operational practicality of lasers in the field have kept them out of reach for most mosquito control organizations. An alternate method is to use one of the older field methods that show a high correlation with a laser system. This study was initiated to compare and correlate the analysis of droplet size data collected through the use of Teflon®-coated slides, magnesium oxide (MgO_2)-coated slides, the Army Insecticide Measuring System (AIMS) unit, and a forward scattering laser system. The objective of this study was to determine which of these 3 methods would exhibit the highest correlations with the laser system.

Two aerosol machines were used for droplet analysis: a Leco Model 1600 (Lowndes Engineering Co., Inc., Valdosta, GA) and a London Aire 1820 (London Fog Inc., Long Lake, MN). Both of these machines are advertised as heavy-duty, vehicle-mounted aerosol generators. They are able to satisfactorily atomize the commonly used mosquito adulticides if operated according to machine operator manuals and to label specifications of the chemical being used.

A permethrin formulation developed specifically for dilution with water was described by Groome et al. (1989). Spray characteristics and biological performance comparing that formulation with a petroleum diluent formulation and against a variety of insect types and under different climactic conditions were described by Slatter et al. (1993). A newer formulation used in this test was Aqua-Reslin®, a water-based formulation manufactured by AgrEvo (Montvale, NJ). It contained permethrin (20%), piperonyl butoxide (20%), and inert ingredients (60%) (per Aqua-Reslin label). It was diluted as one part Aqua-Reslin to 4 parts water. Table 1 indicates the flow rates used.

Aerosol droplets were collected using a laser-based system (Particle Measuring Systems [PMS], Inc., Boulder, CO), the AIMS (KLD Labs, Inc., Huntington Station, NY) (water setting), Teflon-coated slides, and hand-waved MgO_2-coated slides. The PMS system uses a forward scattering spectrophotometer probe (model FSSP-100), a data acquisition card, and software for an MS-DOS microcomputer. All droplet collections, for each method and replication, were performed during one run of the aerosol generator to ensure that samples were as similar as possible. After collection, each slide was covered with an additional glass slide, taped to prevent evaporation of the insecticide droplets (Anonymous 1985), and read within 2 days. Drop-

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Table 1. Aqua-Reslin® droplet study.

Treatment mean (fl. flow rate[1] oz./min)	Sprayer and psi	Temperature (°C)	Volume mean diameter of droplets (μm)			
			Laser	AIMs[2]	Hand-waved slides: Teflon®-coated	Hand-waved slides: MgO_2-coated
4	Leco 1600 1	29	16.2 ± 0.1	14.9 ± 0.1	19.7	31.1
8	Leco 1600 2.5	28	18.7 ± 0.4	20.1 ± 1.1	19.9 ± 1.1	35.2 ± 3.4
4	London Aire 1820 3	29	17.0 ± 0.2	16.9 ± 1.8	17.7 ± 3.8	31.1 ± 3.7
8	London Aire 1820 4.5	28	18.3 ± 0.4	18.1 ± 0.3	18.5 ± 0.4	31.6 ± 5.9

[1] Two replications were performed at each flow rate for each machine except for Teflon-coated and MgO_2-coated slides for the Leco 1600 at 1 psi.
[2] AIMS, Army Insecticide Measuring System.

lets were collected approximately 3 m inside a warehouse doorway with the insecticide generator nozzle directed out of the warehouse. Ambient temperature ranged between 24 and 28°C; relative humidity was 70–75% during the 4-h test period. Two replications were performed for each collection method except with the Teflon and MgO_2 techniques with the Leco 1600 operated at 1 pound per square inch (psi), for which only one replication was completed. This was a very low and unusual pressure (psi) setting for the Leco 1600 and the machine is not normally run under that condition. One hundred droplets were measured on each slide with a compound microscope equipped with a graticule scale (Yeomans 1949). Volume mean diameters (VMDs) were calculated using VecTor® (VecTec, Orlando, FL). An analysis of variance was calculated on the VMD. The AIMS droplet-collecting wand was handheld and inserted into each aerosol cloud at a distance at which the air velocity was between 3 and 7 m/sec as measured by a handheld anemometer. Probes were cleaned by dipping 3 times in xylene and alcohol after each exposure. The air velocity was measured for each machine after each run. The reader should note that this distance was a function of the pressure setting on the aerosol generator and, therefore, slightly different for each test. Data are presented in Table 1.

The VMD ranged from 14.9 ± 0.1 to 35.2 ± 3.4 μm (20.3 μm difference) for droplets collected by all methods (laser, AIMS, Teflon, and MgO_2). The MgO_2 method recorded a larger VMD (2-fold increase in one case, see Table 1) for both machines and all psi settings than did the other methods. This result differs from an earlier report in which Groome et al. (1989) used MgO_2 with an ultraviolet tracer, allowing easier detection of smaller droplets. An ultraviolet-fluorescent tracer was not used in this test. Typically the tracer allows measurement of very small drops that would otherwise be difficult to measure. Analysis of larger drops with a tracer is adequate because drop craters are easily seen. The VMD ranged from 14.9 ± 0.1 to 20.1 ± 1.1 μm (5.2 μm difference) for both machines and all psi settings when just the laser, AIMS, and Teflon methods were compared. The variability for each measurement method across each machine–psi combination was 2.5, 5.2, 2.2, and 4.1 μm for the laser, AIMS, Teflon, and MgO_2 methods, respectively. Differences in pressure (psi) may account for this variation. The variability for each machine–psi combination across each measurement method was 16.2, 15.4, 14.2, and 13.5 μm for the Leco 1600 at 1 psi, Leco 1600 at 2.5 psi, London Aire 1820 at 3 psi, and London Aire 1820 at 4.5 psi, respectively. However, variability decreased to 4.8, 0.3, 1.3, and 1.1 μm for the Leco 1600 at 1 psi, Leco 1600 at 2.5 psi, London Aire 1820 at 3 psi, and London Aire 1820 at 4.5 psi, respectively, when the laser, AIMS, and Teflon measurement methods alone (MgO_2 method omitted) were examined. The replication variance for each collection method was 0.4, 1.7, 3.4, and 2.5 μm for the laser, AIMS, Teflon, and MgO_2 methods, respectively, indicating good reproducibility. The laser method showed the least variability (0.4 μm) and Teflon slides (3.8 μm) had the greatest variability. The percent differences between the laser method and the AIMS, Teflon and MgO_2 methods were 4.8 ± 2.9, 2.3 ± 1.6, and 41.5 ± 2.3, respectively (Table 2). These data (Tables 1

Table 2. Percent difference between the laser system and the Army Insecticide Measuring System (AIMS), Teflon®-coated slides, and magnesium oxide-coated slides.[1]

Sprayer	psi	AIMS	Teflon	MgO_2
Leco 1600	1	−8.0	+21.6	+92.0
Leco 1600	2.5	+7.5	+6.4	+88.2
London Aire 1820	3	−0.6	+4.1	+82.9
London Aire 1820	4.5	−1.1	+1.1	+72.7
Mean[2]	—	−1.9 ± 4.8	+3.9 ± 2.7	+81.3 ± 7.9

[1] + or − indicates increase or decrease in volume mean diameter.
[2] The mean excludes the Leco 1600 1 psi reading.

Table 3. Results from analysis of variance.

Statistic	Value
df (treatment)	3
df (error)	12
Sum of squares (treatment)	581.04
Sum of squares (error)	35.41
Total sum of squares	616.45
Mean squares (treatment)	193.68
Mean squares (error)	2.95
Significance level	0.05
F	65.64
P value	9.37×10^{-7}

and 2) clearly indicate that the AIMS or Teflon-coated slides are in such close similarity to the laser that they could be effectively used in the field without an overwhelming loss in precision. An analysis of variance (Table 3) indicated that the null hypothesis of equal means should be rejected. No separation of means was calculated.

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