MOTHPROOFING STUDIES WITH FENVALERATE[1]

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ABSTRACT

Fenvalerate (cyano(3-phenoxyphenyl)methyl 4-chloro-α-(1-methylethyl)benzeneacetate) applied to woolen cloth as a pressurized solvent-based formulation protected the cloth against feeding damage by larvae of the black carpet beetle, *Attagenus unicolor* (Brahm), of the furniture carpet beetle, *Anthrenus flavipes* LeConte, and of the webbing clothes moth, *Tineola bisselliella* (Hummel), both initially and after the treatments had aged for 15 months. The fenvalerate treatments that had aged for 6 months were also effective against the adults of the above species of fabric insects.

Key Words: Fenvalerate, mothproofing, *Attagenus unicolor, Anthrenus flavipes, Tineola bisselliella,* fabric protectants.

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INTRODUCTION

Many synthetic pyrethroid insecticides have been evaluated and recommended as mothproofers and several are currently labeled for use as pressurized spray fabric protectants in the home (Bry et al. 1973; Bry et al. 1979; Bry et al. 1980; Bry et al. 1981). The synthetic pyrethroids as a group generally possess low mammalian toxicity combined with high insecticidal activity. Mayfield and Russell (1979) reported on the evaluation of five synthetic pyrethroid insecticides applied to woolen in the dyebath. One of the pyrethroids that Mayfield and Russell evaluated against the webbing clothes moth, *Tineola bisselliella* (Hummel), the casemaking clothes moth, *Tinea pellionella* L., and the furniture carpet beetle, *Anthrenus flavipes* LeConte, was fenvalerate (cyano(3-phenoxyphenyl)methyl 4-cholor-α-(1-methylethyl)benzeneacetate). They concluded that this pyrethroid showed enough promise to be investigated further as a mothproofing agent. Also Bry and Lang (unpublished data) have shown that fenvalerate was effective against larvae of the black carpert beetle, *Attagenus unicolor* (Brahm), when it was applied to woolen cloth from a simulated dyebath. Since fenvalerate showed promise as a fabric protectant applied in the dyebath, we decided that it would be desirable to evaluate the efficacy of this material when it was applied to woolen cloth as a pressurized solvent-based spray.

The objectives of this research were to determine: (1) the effectiveness of a pressurized solvent-based fenvalerate formulation sprayed on woolen cloth to protect it against damage by larvae of the black carpet beetle, the furniture carpet beetle, and the webbing clothes moth both initially and after aging; (2) the amount

[1] This paper reflects the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the USDA nor does it imply registration under FIFRA as amended. Mention of a proprietary product does not constitute an endorsement by the USDA.

of insecticide on the cloth both initially and after aging; (3) the effectiveness of the fenvalerate spray applied directly to both larvae and adults of the above fabric insects; and (4) the toxicity of the aged treated cloth to adult carpet beetles and clothes moths.

MATERIALS AND METHODS

Moth test cloth, 100% wool, the material designated as the standard test fabric for mothproofing tests by the American Association of Textile Chemists and Colorists (AATCC) (Anon. 1977) and the Chemical Specialities Manufacturers Association (CSMA) (Anon. 1971) was used as the test fabric.

The treatments were applied with 8-oz cans supplied by McLaughlin Gormley King Company containing 0.25% fenvalerate (TL-2176), a light isoparaffinic oil and CO_2 as the propellant.

Sixteen (30.5 cm)^2 swatches of moth test cloth were sprayed from a distance of 36 - 46 cm for 5 and 10 seconds, respectively, according to the method described by Bry and Simonaitis (1975). Then the swatches were dried at room temperature, ca. 24°C, for 4 days. Four swatches from each treatment were sampled for feeding tests and for chemical analyses by cutting a (20.3 cm)^2 sample from the center of each swatch. A 5.1 - × 15.2-cm strip of each sample was analyzed for fenvalerate; the remainder of the sample was cut into 2.5- × 5.1-cm pieces for feeding tests. The other 12 swatches from each treatment were hung in a dark closet in a room maintained at ca. 24°C, and four were similarly sampled and tested after 3, 6, and 15 months.

The feeding tests (Objective 1) were made with larvae from the laboratory colonies according to the excrement-weight or fabric-weight-loss procedures established by CSMA (Soap and Chemical Specialties 1971). Thus, each of four 2.5- × 5.1-cm samples cut from the dried treated swatches was tested for its resistance to damage by larvae of each of the three species. The samples were each exposed to ten larvae for 14 days in a darkened cabinet in a room maintained at 27 ± 1°C and 60 ± 5% RH.

The chemical analyses (Objective 2) were conducted as follows: The wool samples were weighed, transferred to a Soxhlet extraction apparatus, and extracted under nitrogen for 3 hr at the rate of ca. six solvent exchanges per hour with 150 ml of acetonitrile-methanol (4:1 vol/vol). The extract was evaporated to dryness on a 60°C water bath under a stream of dry nitrogen. The residue was transferred to a 10 cm Florisil® column for cleanup, washed with 70 ml of 3% ethyl acetate in hexane, and eluted with 60 ml of a 10% (vol/vol) ethyl acetate-hexane solution. The eluate was evaporated to dryness with a stream of dry nitrogen and made up to the appropriate volume with hexane. Aliquots of this sample were injected into a gas chromatograph equipped with a flow ionization detector operated under the following conditions: column, 183 cm × 4 mm ID glass; packing, a mixed liquid phase of 2% QF-1 plus 2% DC-200 on 80/100 Gas-chrom Q conditioned overnight at 250°C with nitrogen purging; gases: nitrogen (carrier), 28.7 ml/min, hydrogen, 30 ml/min, air, 240 ml/min; temperatures: injection port, 320°C, detector, 320°C, column oven, 220°C. At these conditions the retention time for fenvalerate was ca. 43.3 min.

Spray applications (Objective 3) were made with the 0.25% formulation being applied directly to forty larvae and adults (ten/petri dish of either larvae or adults)

as described by Bry and Simonaitis (1975). The rate of delivery was ca. 1.1 g of the formulation per second. All applications were replicated three times. After treatment the petri dishes containing the insects were placed in a darkened cabinet in a room maintained at 27 ± 1°C and 60 ± 5% RH. Toxicity was determined after 24 hours.

In the test to determine the toxicity of cloth treated 6 months previously (Objective 4) with fenvalerate spray, adults of the three species were exposed to aged samples in 0.24-liter jars covered with Whatman No. 1 filter paper discs secured with screw-type rings. The cloth samples were ca. 25 sq cm and substantially covered the bottom of the jar. Forty newly emerged (1- to 2-day-old) adult carpet beetles or clothes moths were introduced into each of four jars (10 per jar) containing samples from each of the treatments. The jars were place in a darkened cabinet in a room maintained at 27 ± 1°C and 60 ± 5% RH, and toxicity (number of knocked down and dead + moribund insects) was determined after 24, 48, and 168 hours. Then the jars were returned to the holding cabinet for an additional six weeks and the cloths were examined to determine whether any of the beetles or moths had oviposited.

RESULTS AND DISCUSSION

The average formulation delivery rate was ca. 1.1 g/second (Table 1). The 5 and 10-second applications resulted in the sprayed fabric feeling "slightly damp" and "damp," respectively. Initial fenvalerate deposits, on the cloth from the 5 and 10-second applications were 0.025 and 0.044 percent by weight, respectively. The residues remaining after 15 months for the 5 and 10-second applications were ca. 4% and 9% lower, respectively, than the initial deposits, indicating only slight degradation.

Table 1. Deposits of fenvalerate on cloths sprayed with a pressurized formulation and residues on cloths after the treatments had aged as indicated.

Formulation	Time sprayed (sec)	Amt spray dispensed* (g)	Fenvalerate deposit† (% by wt)	Residue (% by wt) on cloths† after indicated months		
				3	6	15
TL-2176	5	5.5	0.025	0.025	0.024	0.024
	10	10.8	0.044	0.039	0.039	0.040

* Each figure is the average of 16 applications.
† Each figure is the average of 4 anlayses.

The moth test cloth was protected by fenvalerate from feeding by larvae of black and furniture carpet beetles both initially and after the treatments had aged for 15 months; however, it did not produce a high degree of mortality among larvae of either species of carpet beetles (Table 2). Likewise, fenvalerate protected all cloth samples against feeding damage by webbing clothes moth larvae (Table 3). In fact, the adjusted-weight-losses were very low, even after the treatments had aged for 15 months. Fenvalerate was highly toxic to webbing clothes moth larvae (100% mortality in all feeding tests).

Table 2. Excrement weights per larva and mortality in feeding tests with black (BCBL) and furniture (FCBL) carpet beetle larvae exposed 14 days to 2.5- × 5.1-cm cloth samples treated with fenvalerate; average for 16 samples each exposed to 10 insects.

Formulation	Time sprayed (sec)	Excrement per larva* (mg) after cloth aged indicated months				Mortality among larvae (%) after cloth aged indicated months			
		0	3	6	15	0	3	6	15
					BCBL				
TL-2176	5	0.14	0.20	0.18	0.16	2	1	0	0
	10	0.13	0.18	0.12	0.18	4	1	3	3
None (untreated check)	–	2.08	2.68	2.59	3.37	0	0	0	0
					FCBL				
TL-2176	5	0.13	0.22	0.14	0.06	5	3	4	9
	10	0.12	0.13	0.11	0.06	6	7	8	10
None (untreated check)	–	3.04	2.38	1.63	1.81	0	0	0	0

* Samples considered satisfactorily resistant if average weight of excrement did not exceed 5.0 mg (0.5 mg per larva) if no sample in a series had an amount exceeding 6.0 mg (0.6 mg per larva).

Results of the exposures of the adult insects to cloth samples treated 6 months previously are shown in Table 4. All of the insects were knocked down after a 24-hour exposure to the fenvalerate-treated cloths. After a 168-hour exposure, all of the webbing clothes moth adults and almost all of the furniture carpet beetle adults were dead or moribund. Also, the 5 and 10-second applications resulted in 78% and 98% mortality or moribundity, respectively, of the black carpet beetle adults. Six weeks after the last mortality determinations were made, the cloth was examined and no eggs or larvae were observed on the cloth exposed to black and furniture carpet beetles. A few dessicated eggs were present on the cloth exposed to webbing clothes moth adults; however, as in the carpet beetle exposures, no larvae were observed. The untreated checks for all species had numerous living larvae present.

Fenvalerate was also very effective as a direct contact spray against both adults and larvae of the black and furniture carpet beetle and the webbing clothes moth. All insects were dead 24 hours after treatment.

In the course of these studies, no staining was observed on the white undyed test fabric. Likewise, the dried treated fabric did not have an objectionable odor.

A solvent-based pressurized formulation of fenvalerate protected woolen cloth against larvae of black and furniture carpet beetles and of the webbing clothes moth both initially and after the treatments had aged 15 months. Adult insects that came into contact with cloth that was treated 6 months previously were knocked down or killed and no reproduction occurred. Our studies also showed that fenvalerate was effective as a direct contact spray against both adults and larvae of the aforementioned fabric insects. Since this formulation of fenvalerate met all efficacy requirements, did not stain the fabric or impart an objectionable

Table 3. Adjusted weight loss of 2.5- × 5.1-cm cloth samples treated with a fenvalerate pressurized formulation and mortality among webbing clothes moth larvae exposed 14 days in feeding tests; average for 16 samples each exposed to 10 insects.

Formulation	Time sprayed (sec)	Adjusted weight loss*† (mg) after cloth aged indicated months				Mortality among webbing clothes moth larvae (%) after cloth aged indicated months			
		0	3	6	15	0	3	6	15
TL-2176	5	0.16	-0.17	0.44	0.79	100	100	100	100
	10	0.13	0.05	0.12	-0.29	100	100	100	100
None (untreated check)	–	39.89	51.02	40.83	47.51	0	0	0	0

* Samples considered satisfactorily resistant if average loss of weight did not exceed 8.0 mg and if no sample in a series had a weight loss exceeding 10 mg.

† A figure preceded by a minus sign indicates that the humidity control samples lost more weight during the test period than did the samples exposed to the insects.

Table 4. Effect of exposing adult black carpet beetles (BCBA), furniture carpet beetles (FCBA), and webbing clothes moths (WCMA) to cloths treated 6 months previously with a pressurized formulation of fenvalerate; average for 4 samples each exposed to 10 insects.

Formulation	Time sprayed (sec)	% knocked down (KD) and dead + moribund (D+M) after indicated hours of exposure					
		24 hr		48 hr		168 hr	
		KD	D+M	KD	D+M	KD	D+M
				BCBA			
TL-2176	5	100	53	100	78	100	78
	10	100	78	100	88	100	98
None (untreated check)	–	0	0	0	0	0	0
				FCBA			
TL-2176	5	100	100	100	100	100	100
	10	100	100	100	98	100	98
None (untreated check)	–	0	0	0	0	0	0
				WCMA			
TL-2176	5	100	85	100	100	100	100
	10	100	100	100	100	100	100
None (untreated check)	–	0	0	0	0	0	0

odor, the results suggest that a solvent-based pressurized spray formulation of fenvalerate merits consideration for development as protectant for woolens stored in the home.

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