Evaluation of Decamethrin as an Insectproofing Agent for Wool

The application of decamethrin to wool by exhaustion from a dye bath and the durability of the treatment have been investigated. Significant loss of the pyrethroid from the wool occurred on prolonged boiling in the dye bath. The fastness to washing and dry-cleaning of decamethrin was similar to that of permethrin, but its light stability was much lower. Decamethrin was at least six times more active than permethrin to *Tinea metonella*, but exhibited similar activity to *Anthrenus flavipes*. Decamethrin is less cost-effective than permethrin for the insectproofing of wool.

The new synthetic pyrethroids show considerable promise as durable insectproofing agents for wool. Permethrin has been the subject of several studies (Carter and Duffield, 1976, 1977; Bry et al., 1976; Duffield, 1977; Friedman et al., 1979) and recently has been compared with fenvalerate and fenpropanate (Mayfield and Russell, 1979). Decamethrin (NRDC 161), another new synthetic pyrethroid, has become available recently for agricultural use and is reported (Elliot et al., 1978) to be more active than permethrin to several insect species by a factor of at least 10. Decamethrin is costly to manufacture, but its higher insecticidal activity is likely to make it more cost-effective than permethrin in some uses. In this communication we report the results of a comparison of the application, durability, and insecticidal activity of decamethrin and permethrin to determine which is the more satisfactory and cost-effective pyrethroid for protecting wool from insect damage.

MATERIALS AND METHODS

Formulation of Pyrethroids. Decamethrin [(−)-α-cyano-3-phenoxybenzyl (+)-*cis*-2,2-dimethyl-3-(2,2-dibromovinyl)cyclopropanecarboxylate, NRDC 161] and permethrin [3-phenoxybenzyl *cis,trans*-(+)-2,2-dimethyl-3-(2,2-dichlorovinyl)cyclopropanecarboxylate, NRDC 143] were supplied by Wellcome Australasia. They were formulated as self-emulsifiable concentrates (10% w/w) containing insecticide (0.1 g), xylene (0.7 g), Teric N-13 (ICI, 0.1 g), and Alkanate CS (ICI, 0.1 g).

Application to Wool. The formulations were applied to wool fabric (25 g) in an Ahiba Turbomat dyeing machine at a liquor-to-wool ratio of 20:1. The fabric was wetted out and placed in the bath liquors which contained ammonium sulfate (4% w/w) and glacial acetic acid (1% w/w). The insecticide was emulsified with water (50 mL) and added to the bath. The bath temperature was raised to boiling over a 30-min period (of 2 °C/min) and maintained at boiling for 60 min. The fabric was then removed, hydroextracted, and air-dried.

Analysis of Pyrethroids. A sample of wool (0.2 g) in a 10-mL ampule containing 0.5 M hydrochloric acid (7 mL) saturated with sodium sulfate and dichloromethane–isooctane (1:9, 2 mL) was heated with shaking at 80 °C for 2 h. The organic phase (20 μL) was automatically injected (Varian 8000 Series autosampler) into a stainless steel column (3 × 250 mm) packed with silica particles (5 μm). The mobile phase was 0.1% (v/v) isopropyl alcohol in isooctane fed at 2 mL/min by an Altex Model 100 pump. The eluant was monitored by a Perkin-Elmer variable wavelength detector at 220 nm, and peak areas were determined with a Spectra-Physics System I computing integrator.

Biological Assay. Treated fabrics were bioassayed with larvae of a dieldrin-resistant wild strain of the case-bearing clothes moth (*Tinea metonella*, Pierce and Metcalfe) and a laboratory strain of the furniture carpet beetle (*Anthrenus flavipes*, Le Conte) according to the fabric-weight loss method as described in the AATCC Standard Test Method 24-1963 (AATCC Manual, 1970).

Durability Testing. Methods for determining fastness to hand laundering, dry-cleaning, and light exposure have been described previously (Hoskinson and Russell, 1973; Mayfield and Russell, 1979).

Table I. Residues of Decamethrin and Permethrin on Wool after Application and Subsequent Fastness Testing

application level, % (w/w)	pyrethroid % (w/w) on wool and % of applied amount (in parentheses)	
	decamethrin	permethrin
	After Application	
0.005	0.0041 (82)	0.0043 (86)
0.01	0.0088 (88)	0.0089 (89)
0.02	0.0174 (87)	0.0186 (93)
0.03	0.0260 (87)	0.0283 (94)
	After 10 Handwashes	
0.02	0.0078 (39)	0.0097 (48)
	After 10 Dry-Cleans	
0.02	0.0128 (64)	0.0126 (63)
	After Accelerated Light Exposure for 4 Weeks[a]	
0.02	0.0018 (9)	0.0088 (44)

[a] Equivalent to a Blue Scale rating of 7 (BS 1006, 1961).

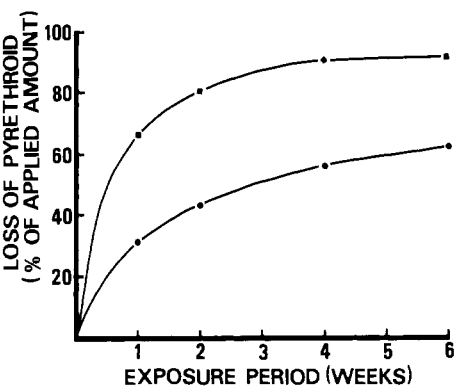

Figure 1. Comparison of the rate of loss of permethrin (-●-) and decamethrin (-■-) on light exposure of wool fabric treated at the 0.02% (w/w) level.

RESULTS AND DISCUSSION

Chemical Assays. The residues of decamethrin found on wool after exhaustion from a boiling dye bath were slightly less than those found for permethrin at the four application levels examined (Table I). Several synthetic pyrethroids, including permethrin, do not suffer significant loss on prolonged boiling (2 h, pH 4.5–5.5) in a dye bath (Mayfield and Russell, 1979). Application of decamethrin at boiling, however, did result in steady loss with time,

0021-8561/80/1428-0886$01.00/0

Table II. Biological Assays of Wool Treated with Decamethrin and Permethrin

pyrethroid and application level % (w/w)		feeding damage (mg) after: treatment AF[b]	TM[c]	10 washes AF	TM	10 dry-cleans AF	TM	light exposure[a] AF	TM
decamethrin	0.005	11(F)[d]	1	16(F)	1	20(F)	1	13(F)	1
permethrin	0.005	10(F)	5	24(F)	22(F)	19(F)	12(F)	14(F)	8
decamethrin	0.01	2	1	8	1	8	0	10(F)	0
permethrin	0.01	4	2	16(F)	8	8	10(F)	7	5
decamethrin	0.02	2	1	3	1	2	0	9(F)	0
permethrin	0.02	2	1	7	3	2	4	3	0
decamethrin	0.03	2	2	2	1	1	0	2	0
permethrin	0.03	2	1	4	4	2	3	3	0

[a] Equivalent to Blue Scale rating of 7. [b] AF is the furniture carpet beetle (*Anthrenus flavipes*, Le Conte). [c] TM is a dieldrin-resistant strain of the case-bearing clothes moth (*Tinea metonella*, Pierce and Metcalfe). [d] (F) signifies unsatisfactory proofing according to AATCC Standard Test Method 24-1963. This test method uses 10 larvae of the test insect. Proofing is considered satisfactory if feeding damage is reduced to 8 mg or less.

residues of 0.0190, 0.0174, and 0.0152% (w/w) being found on the wool after application of 0.02% (w/w) at boiling for 30, 60, and 120 min, respectively.

An unidentified peak, which increased in size with the boiling period of the dye bath, appeared in the LC chromatogram of these treated samples and was probably due to a rearrangement or degradation product of decamethrin.

The fastness to washing and dry-cleaning of both pyrethroids was similar. However, there was a marked difference in their fastness to light (Table I). Exposure equivalent to a Blue Scale rating of 7 (BS 1006, 1961) of fabrics treated at the 0.02% (w/w) level resulted in a 90% loss of decamethrin compared with a 53% loss of permethrin. The loss of decamethrin and permethrin with time on accelerated exposure of wool fabrics is compared in Figure 1.

Biological Assays. The biological assays in Table II show decamethrin to have much higher insecticidal activity toward the case-bearing clothes moth (*T. metonella*) than permethrin. Feeding damage by this insect to fabric treated with 0.005% (w/w) decamethrin did not exceed 1 mg even after 4 weeks of light exposure which is known to degrade 90% (Table I) of the applied decamethrin. Thus *T. metonella* was controlled by less than 0.0005% (w/w) decamethrin. Permethrin was at least six times less active than decamethrin against this insect, 0.003% (w/w) being required to reduce the feeding damage to a satisfactory level (8 mg).

Both pyrethroids, particularly decamethrin, were less active to the furniture carpet beetle (*A. flavipes*), 0.007–0.01% (w/w) being required for satisfactory control. For durable protection against this insect, 0.025% (w/w) decamethrin would be required, compared with 0.02% (w/w) permethrin, because of its inferior light fastness.

Decamethrin therefore only shows significantly greater activity than permethrin toward the clothes moth species of textile pest. The application rates of decamethrin and permethrin for durable proofing of carpets would need to be 0.02 and 0.025% (w/w), respectively. Decamethrin is several times more costly than permethrin and is therefore precluded from use as an industrial insectproofing agent for wool on a cost-effective basis.

ACKNOWLEDGMENT

The technical assistance of Paulene Dougherty is gratefully acknowledged.

LITERATURE CITED

American Association of Textile Chemists and Colorists, *AATCC Manual* **46**, 272 (1970).
British Standards Institution, "Determination of Fastness to Daylight of Coloured Textiles", London, BS1006, 1961.
Bry, R. E., Simonaitis, R. A., Lang, J. H., Boatright, R. E., *Soap, Cosmet., Chem. Spec.*, 31 (1976).
Carter, S. W., Duffield, P. A., *J. Text. Inst.* **67**, 77 (1976).
Carter, S. W., Duffield, P. A., *J. Text. Inst.* **68**, 330 (1977).
Duffield, P. A., *Pestic. Sci.* **8**, 279 (1977).
Elliot, M., Janes, N. F., Potter, C., *Ann. Rev. Entomol.* **23**, 443 (1978).
Friedman, M., Ash, J. F., Bry, R. E., Simonaitis, R. A., *J. Agric. Food Chem.* **27**, 331 (1979).
Hoskinson, R. M., Russell, I. M., *J. Text. Inst.* **64**, 412 (1973).
Mayfield, R. J., Russell, I. M., *J. Text. Inst.* **70**, 53 (1979).

Robert J. Mayfield*
Gary J. O'Loughlin

CSIRO Division of Textile Industry
PO Box 21
Belmont, Victoria, 3216, Australia

Received for review October 26, 1979. Accepted January 28, 1980.