VAPOR TOXICITY OF RESIDUAL INSECTICIDES AGAINST MOSQUITOES[1]

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ABSTRACT. In laboratory screening tests of 321 insecticides as vapor toxicants against susceptible and DDT-resistant *Anopheles quadrimaculatus* Say, 44 caused 90 percent or better knockdown after an exposure of 60 minutes. Also, 5 of the 44, BAY 78537, 2,3-dihydro-2,2-dimethyl-7-benzofuranyl acetylmethylcarbamate; metalkamate (Chevron Ortho RE-5305); Mobil MC-3470, 2,2-dichloro-1-pyrazol-1-ylvinyl diethyl phosphate; propoxur; and Shell SD-22639, *O*-butyl *O*-methyl *O*-1,2,5-thiadiazol-3-yl phosphorothioate caused 100% knockdown and also 100% mortality at 24 hours after exposure for 15 minutes.

The vapor toxicant properties of some insecticides have been well-known for a number of years; for example, lindane vapor was shown to be toxic to insects by Slade in 1945, and his data were confirmed by Hoffman and Lindquist (1949) and Fulton et al. (1950). However, vapor toxicants with residual activity, a class of compounds that has not been extensively investigated, could have an important place in mosquito control programs. Many vector species that enter inhabited buildings seldom contact walls or ceilings before leaving the premises; and consequently they are not affected by conventional residual insecticides. If a treatment also acted as a vapor toxicant, higher mortality might result from even a brief exposure.

MATERIALS AND METHODS. Two strains of *Anopheles quadrimaculatus* Say, one "susceptible" and one "resistant," were used in the test. The susceptible colony has been maintained at the Insects Affecting Man Research Laboratory at Gainesville, Florida, for over 30 years and has never purposely been subjected to selection with insecticides. The resistant strain was originally received at the laboratory in 1965 (Hartwell Dam Strain) from the CDC Technical Development Laboratory of the U. S. Public Health Service in Savannah, Georgia. At that time, it showed moderate resistance to DDT, and we have increased the level of resistance by continuous selection with DDT. Currently, the adults can be maintained in cages with interiors coated with technical DDT. With these 2 strains, we could determine the relative effectiveness of vapor toxicity with the presently most promising residual insecticides. Also, the speed of knockdown would provide evidence of cross-resistance.

A total of 321 compounds was evaluated. All test compounds were received from commercial sources. The designation, chemical name, and acute oral LD_{50} in rats or mice (based on information from the manufacturer when available) of 44 of the vapor toxicants are given in Table 1.

The procedure was as follows: Plywood panels were sprayed with acetone solutions of the compounds at a rate of 1 g/m^2 and aged in a well-ventilated room. After 1 week, 40 one-day-old female mosquitoes from each strain were exposed for 1 hour to the chemical vapors emanating from the panels by placing them under half sections of petri dishes that were inverted on a screen (13 cm x 13 cm) elevated 1.5 cm above the treated surface by metal bands from Mason jar lids (same circumference as the petri dishes). Propoxur was included as the standard. Knockdown counts were recorded at 15, 30, and 60 minutes; then the knocked-down mosquitoes were removed, transferred to holding cages provided with sugar-water in pads of absorbent cotton, and held for 24-hour mortality counts. A compound was considered a vapor toxicant if it caused >89% knockdown after a 1-hour exposure.

RESULTS. Forty-four of the 321 compounds produced 100 percent mortality

[1] This paper reflects the results of research only. Mention of a pesticide in this paper does not constitute a recommendation by the USDA.

Table 1. Company designation, chemical name, knockdown effectiveness after various exposure periods and acute LD_{50} to rats or mice of 44 vapor toxicants effective against a susceptible strain of adult *Anopheles quadrimaculatus*. (Treatments applied to plywood panels as acetone solutions at the rate of 1 g/m²; average of 2 replications of 20 females each.)

Company designation	Chemical name	Acute oral LD_{50} in rats (mg/kg)
	Insecticides causing 100% KD at 15 minutes	
BAY 78537	2,3-dihydro-2,2-dimethyl-7-benzofuranyl acetylmethylcarbamate	200
metalkamate (Chevron Ortho RE-5303)	*m-sec*-butylphenyl methylcarbamate	~10
Mobil MC-3470	2,2-dichloro-1-pyrazol-1-ylvinyl diethyl phosphate	25
Shell SD-22639	*O*-butyl *O*-methyl *O*-1,2,5-thiadiazol-3-yl phosphorothioate	100–200 (mice)
propoxur (standard)	*O*-isopropoxyphenyl methylcarbamate	104
	Insecticides causing 100% KD at 30 minutes	
BAY KUE 2302	*o*-isopropoxyphenyl[(dichlorofluoromethyl)thio]methylcarbamate	500–1000
d-trans-resmethrin	(5-benzyl-3-furyl)methyl *trans*-(+)-2,2-dimethyl-3-(2-methylpropenyl)cyclopropanecarboxylate	8400–10,000
Diamond Shamrock DS-15647	3,3-dimethyl-1-(methylthio)-2-butanone *O*-(methylcarbamoyl) oxime	8.5
Hercules 5727	*m*-cumenyl methylcarbamate	17–63
Mobil MC-3815	2-chloro-1-pyrazol-1-ylvinyl diethyl phosphate	25
BAY 39731	o-cumenylcarbamate	284–375
Hercules 9007	*m*-cumenyl (chloroacetyl)methylcarbamate	356
	2,2-dichlorovinyl diethyl phosphate	NA[a]
Hercules 9485	*o*-(allyloxy)phenyl methylcarbamate	200
Sandoz 52114	1-ethyl-r-methyl-2-propynyl 3-hydroxycrotonate dimethyl phosphate	41–55
	Insecticides causing 100% KD at 60 minutes	
Chevron RE-5353	*m*-(1-methylbutyl)phenyl phenyl methylcarbamate	87–170
Upjohn U-12379	6-chloro-3,4-xylyl acetylmethylcarbamate	>4000
BAY HOX 1619	2-chloro-5,5-diethyl-1,3,2-dioxaphosphorinane 2-sulfide	>1000
Hercules 9326	5-*tert*-butyl-2-chlorphenyl methylcarbamate	54
BAY 62863	2,3-dihydro-2-methyl-7-benzofuranyl methylcarbamate	58–66
Shell SD-24794	*O,O*-dimethyl *S*-[1-(5-methyl-1,2,4-oxadiazol-3-yl) ethyl]phosphorodithioate	100
Stauffer B-10341	*O*-ethylmethylphosphonothioate *O*-ester with *p*-hydroxybenzonitrile	NA[a]
Sandoz 52092	2-methoxy-1-methylethyl 3-hydroxycrotonate dimethyl phosphate	10–13
Fisons NC-6897	2,3-(isopropylidenedioxy)phenyl methylcarbamate	80
BAY KUE 2327	*o*-isopropoxyphenyl methyl[(trichloromethyl)thio]carbamate	>2500
Upjohn U-18120	*o*-isopropoxyphenyl (methoxyacetyl)methylcarbamate	70
International Minerals and Chemical Corp. IMC-48003	2-chloro-*m*-tolyl methylcarbamate	66 (mice)
diazinon	*O,O*-diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate	150–220
promecarb	*m*-cym-5-yl methylcarbamate	35
Upjohn U-38099	*m*-cumenyl methylpropionylcarbamate (60%) mixture with *p*-cumenyl methylpropionylcarbamate (40%)	400–800
Chevron RE-11775	*m-sec*-butylphenyl methyl(phenylthio)carbamate (approximately 58%), mixture with *p*- and *o*-isomers (29% and 5%, respectively)	82

[a] NA=Not available.

Table 1.—Continued.

Company designation	Chemical name	Acute oral LD_{50} in rats (mg/kg)
Hercules 14469	*m*-cumenyl (mercaptoacetyl)methylcarbamate *S*-ester with *O,O*-dimethyl phosphorodithioate	432
methomyl	*S*-methyl *N*-[(methylcarbamoyl)oxy]thioacetimidate	17–24
BAY 30237	*O*-methyl *O*-(*p*-methylthio)phenyl methylphosphonothioate	NA[a]
Chemagro 5777	diethyl [(1,2,2-trichloroethyl)sulfinyl]phosphinate	50
Pennwalt TD-8550	methyl (mercaptoacetyl)methylcarbamate *S*-ester with *O*-methyl methylphosphonodithioate	59–75
Sandoz 52117	methyl (*E*)-3-hydroxycrotonate methyl ethylphosphoramidate	14–17
Stauffer R-15022-B	*O*-ethyl ethylphosphonothioate *O*-ester with *p*-hydroxybenzaldehyde *O*-[(*m*-chlorophenyl)carbamoyl]oxime	7
Stauffer R-22500	(ethylthio)methyl isopropyl ethylphosphonotrithioate	68
	Insecticides causing <100% but >89% KD at 60 minutes	
chlorpyrifos	*O,O*-diethyl *O*-(3,5,6-trichloro-2-pyridyl)phosphorothioate	145
Union Carbide UC-8454	5,6,7,8-tetrahydro-1-napthyl methylcarbamate	325
Stauffer R-26375	2-thiopheneglyoxylonitrile oxime *O,O*-dimethyl phosphorothioate	1470
Sandoz 52097	isopropyl (*E*)-3-hydroxycrotonate methyl propylphosphoramidate	60–73
carbanolate	6-chloro-3,4-xylyl methylcarbamate	30

[a] NA=Not available.

among both susceptible and resistant strains and were classed as vapor toxicants. The results of these tests (compounds listed in descending order of effectiveness) are given in Table 1. Also, 5 compounds, BAY 78537, metalkamate (Ortho RE-5305), Mobil MC-3470, propoxur, and Shell SD-22639, caused 100% knockdown at 15, 30, and 60 minutes. Ten of the remaining 39 compounds caused 100% knockdown at 30 and 60 minutes; 24 caused 100% knockdown after 60 minutes; and the other 5 compounds produced 90 to 98% knockdown at 60 minutes. There was some indication of cross resistance in the resistant strain to *d-trans*-resmethrin and BAY HOX 1619, and 2,2-dichlorovinyl diethyl phosphate, from the speed of knockdown resulting from the 30- and 60-minute exposures.

Literature Cited

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