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HIGH-PERFORMANCE LIQUID CHROMATOGRAPHIC DATA FOR 166 PESTICIDES

JAMES F. LAWRENCE and DAVIDA TURTON

Food Research Division, Health Protection Branch, Tunney's Pasture, Ottawa, Ontario K1A 0L2 (Canada)

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INTRODUCTION

High-performance liquid chromatography (HPLC) is becoming widely used in the determination of pesticides either as a final measurement step or as a separation technique. Samples have varied in type from formulations where quality control is monitored, to foods where sensitivity is of prime importance. HPLC continues to expand in this area at a rapid rate.

The purpose of this review is to tabulate (Table I) the HPLC systems which have been employed for pesticide analysis. (In several instances industrial contaminants such as PCB's are also included). It is intended to serve as an aid in selecting an HPLC system for a given pesticide or to offer one or more alternative systems for confirmatory purposes. The information given in the table includes the common name of the pesticide where possible, column characteristics, mobile-phase composition, elution volume of the pesticide, substrate (sample matrix), the type of detector and the literature reference. Elution volume was used as an indication of compound retention and is defined as the product of the retention time and the mobile phase flow-rate. Capacity factors (k') were calculated from chromatograms when either the flow-rate or retention time was not given. Column dimensions are given as length × I.D. in millimeters.

Since the detector employed for most of the determinations was the ultraviolet (UV) absorbance detector, the UV wavelengths used for detection are also listed. Other detectors are indicated in this column when used.

The pesticides are divided into classes based on chemical composition (*e.g.*, ureas, organophosphates, carbamates), with individual pesticides being in alphabetical order within each group. Also included in Table 1 are data for about 50 pesticides, compiled in our laboratory.

Table 2 shows the range of UV sensitivites for the various classes of pesticides.

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TABLE I

HPLC SYSTEMS FOR PESTICIDE ANALYSIS

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (mm)*					
Carbamates							
Aldicarb	Varian Si-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	20	std	220	11
	Varian CN-10	250 × 2.1	1–10% 2-Propanol in heptane (convave gradient)	22	std	220	11
	Varian NH_2-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	21	std	220	11
	μBondapak C_{18}	250 × 2.1	20–60% Acetonitrile in H_2O	20	std	220	11
	Permaphase ETH	1000 × 2.0	1% 2-Propanol in hexane	3.1	std	220	12
	μBondapak C_{18}	300 × 4.0	25%–60% Dioxane in H_2O (concave gradient)	11.5	celery, cabbage, lettuce	fluorescence reaction detection	16
Aminocarb	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	2.0	std	254	12
	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	9.5	corn	254	13
Banol™	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	5.2	std	254	13
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	45.1	std	220	11
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	3.6	std	254	12
Barban	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	62	std	220	11
	Permaphase ETH	1000 × 2.0	1% 2-Propanol in hexane	7.4	std	254	12
Benomyl	Varian Si-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	3.5	std	220	11
	Varian CN-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	5.0	std	220	11
	μBondapak C_{18}	300 × 4.0	25–60% Acetonitrile in H_2O (concave gradient)	7.0	std	220	11
	Permaphase ODS	1000 × 2.0	30% MeOH in H_2O	6.1	std	254	12

Bufencarb	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	7.2	std	254	12
Butylate	μBondapak C_{18}	300 × 4.0	50% Acetonitrile in H_2O	29	std	220	11
	Permaphase ETH	1000 × 2.1	10–30% Acetonitrile in H_2O (linear gradient)	15.4	std	220	11
Bux	Varian Si-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	8, 10 (two peaks)	std	220	11
	Varian CN-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	11, 13 (two peaks)	std	220	11
	μBondapak C_{18}	300 × 4.0	25–60% Acetonitrile in H_2O (concave gradient)	23	std	220	11
	Varian NH_2-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	9, 11 (two peaks)	std	220	11
	Permaphase ODS	1000 × 2.0	30% MeOH in H_2O	3.5	std	254	12
Carbaryl	Varian Si-10	250 × 2.1	3% 2-Propanol in heptane	6.7	std	220	11
	Varian CN-10	250 × 2.1	3% 2-Propanol in heptane	9.1	std	220	11
	Varian NH_2-10	250 × 2.1	3% 2-Propanol in heptane	11.0	std	220	11
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	38	std	220	11
	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	9.7	wheat, potato	254	13
	Carbowax 400/Porasil	609 × 3.2 (o.d.)	20% Chloroform in TMP	4.5	std	254	14
	Corasil II (37–50 μm)	1200 × 2.3	8% Hexane in chloroform	26	std	254	15
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	2.7	std	254	13
	μBondapak C_{18}	300 × 4.0	25%–60% Dioxane in H_2O (concave gradient)	18.5	celery, cabbage, lettuce	fluorescence reaction detection	16
	Vydac R.P.	1000 × 2.1	29% MeOH in H_2O	2.2	std	254	17
	Porasil (10 μm)	300 × 4.0	Dichloromethane	18.6	std	254	18
	Vydac silica gel	250 × 2.1	2–100% Chlorobutane in TMP (linear gradient)	9.3	std	280	19
Carbofuran	Varian Si-10	250 × 2.1	5% 2-Propanol in heptane	4.2	std	220	11
	Varian CN-10	250 × 2.1	5% 2-Propanol in heptane	6.0	std	220	11

(Continued on p. 210)

TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (mm)*					
Carbofuran	Varian NH_2-10	250 × 2.1	5% 2-Propanol in heptane	4.2	std	220	11
	μBondapak C_{18}	250 × 2.1	40% Acetonitrile in H_2O	10	std	220	11
	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	8.3	std	254	13
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	1.6	std	254	12
	μBondapak C_{18}	300 × 4.0	25–60% Dioxane in H_2O (concave gradient)	17	celery, cabbage, lettuce	fluorescence reaction detection	16
Chlorpropham	Varian Si-10	250 × 2.1	0.4% 2-Propanol in heptane	3.4	std	220	11
	Varian CN-10	250 × 2.1	0.4% 2-Propanol in heptane	2.7	std	220	11
	Varian NH_2-10	250 × 2.1	0.4% 2-Propanol in heptane	4.2	std	220	11
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	55	std	220	11
	μBondapak C_{18} (37–50 μm)	1830 × 4.5	50% Acetonitrile in H_2O	35	std	254	21
	Corasil C_{18} (37–50 μm)	609 × 2.3	50% MeOH in H_2O	2.2	std	254	18
	Permaphase ETH	1000 × 2.0	1% 2-Propanol in hexane	1.7	std	254	12
Cycloate	Varian Si-10	250 × 2.1	0.4% 2-Propanol in heptane	1.2	std	220	11
	Varian CN-10	250 × 2.1	0.4% 2-Propanol in heptane	1.9	std	220	11
	Varian NH_2-10	250 × 2.1	0.4% 2-Propanol in heptane	1.5	std	220	11
	μBondapak C_{18}	300 × 4.0	50% Acetonitrile in H_2O	22	std	220	11
Dazomet	Permaphase ETH	1000 × 2.0	4% 2-Propanol in hexane	3.8	std	254	12
Diallate	μBondapak C_{18}	300 × 4.0	50% Acetonitrile in H_2O	32	std	220	11
	Permaphase ETH	1000 × 2.1	10–30% Acetonitrile in H_2O (linear gradient)	27	std	220	11
Dichlormate	Permaphase ODS	1000 × 2.0	30% MeOH in H_2O	2.3 (2,3 isomer) 2.6 (3,4 isomer)	std	254	12
Dimetilan	Permaphase ETH	1000 × 2.0	1% 2-Propanol in hexane	2.2	std	254	12

EPTC	μBondapak C_{18}	300 × 4.0	50% Acetonitrile in H_2O	16	std	220	11
	Permaphase ETH	1000 × 2.1	10–30% Acetonitrile in H_2O (linear gradient)	7.7	std	220	11
	Corasil C_{18} (37–50 μm)	609 × 2.3	50% Acetonitrile in H_2O	3.3	std	254	18
Hopcide™	Micropak-CH	250 × 2.2	48% MeOH in H_2O	2.5	std	254	20
	Micropak-NH_2	250 × 2.2	5–25% Dichloromethane in hexane (linear gradient)	7.0	std	254	20
Isoprocarb	Micropak-CH	250 × 2.2	48% MeOH in H_2O	5.5	std	254	20
	Micropak-NH_2	250 × 2.2	5–25% Dichloromethane in hexane (linear gradient)	6.0	std	254	20
Landrin™	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	5.6	std	254	13
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	41.8	std	220	11
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	3.5	std	254	12
Macbal™	Micropak-CH	250 × 2.2	48% MeOH in H_2O	4.5	std	254	20
	Micropak-NH_2	250 × 2.2	5–25% Dichloromethane in hexane (linear gradient)	6.0	std	254	20
Meobal™	Micropak-CH	250 × 2.2	48% MeOH in H_2O	4.5	std	254	20
	Micropak-NH_2	250 × 2.2	5–25% Dichloromethane in hexane (linear gradient)	6.5	std	254	20
Methiocarb	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O	50	std	220	11
	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	6.6	std	254	13
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	7.5	std	254	12
	μBondapak C_{18}	300 × 4.0	25–60% Dioxane in H_2O (concave gradient)	19.5	celery, cabbage, lettuce	fluorescence reaction detection	16
Methomyl	Varian NH_2-10	250 × 2.2	50% 1,2-Dimethoxyethane in heptane	2.8	alfalfa, tobacco, beans, grapes, melons, sugar beets, soybeans, nectarines	233	25
	Varian Si-10	250 × 2.1	1–10% 2-Propanol in heptane (concave gradient)	31	std	220	11

(Continued on p. 212)

TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (mm)*					
Methomyl	Permaphase ETH	1000 × 2.0	4% 2-Propanol in hexane	4.8	std	220	12
	Varian CN-10	250 × 2.1	1–10% 2-Propanol in heptane	39	std	220	11
	Varian NH_2-10	250 × 2.1	1–10% 2-Propanol in heptane	52	std	220	11
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O	7	std	220	11
	μBondapak C_{18}	300 × 4.0	25–60% Dioxane in H_2O	7.4	celery, cabbage, lettuce	fluorescence reaction detection	16
Mobam™	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	9.8	corn	254	13
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	35	std	220	11
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	2.1	std	254	12
Pebulate	Corasil C_{18} (37–50 μm)	609 × 2.3	50% Acetonitrile in H_2O	5.1	std	254	18
	μBondapak C_{18}	300 × 4.0	50% Acetonitrile in H_2O	22	std	220	11
	Permaphase ETH	1000 × 2.1	10–30% Acetonitrile in H_2O (linear gradient)	12.6	std	220	11
Phenmedipham	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	53	std	220	11
Propham	Varian Si-10	250 × 2.1	0.4% 2-Propanol in heptane	2.9	std	220	11
	Varian CN-10	250 × 2.1	0.4% 2-Propanol in heptane	2.7	std	220	11
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	43	std	220	11
	Permaphase ETH	1000 × 2.0	1% 2-Propanol in hexane	1.5	std	254	12
	Corasil C_{18} (37–50 μm)	609 × 2.3	50% MeOH in H_2O	1.5	std	254	18
Propoxur	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	30	std	220	11
	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	5.8	cabbage	254	11
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	1.5	std	254	12
	μBondapak C_{18}	300 × 4.0	25–60% Dioxane in H_2O	16	celery, cabbage, lettuce	fluorescence reaction detection	16

	Micropak-CH (10 μm)	250 × 2.2	48% MeOH in H_2O	3.2	std	254, 270	20
	Micropak-NH_2 (10 μm)	250 × 2.2	5–25% Dichloromethane in hexane (linear gradient)	7.8	std	254, 270	20
SWEP	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	4.3	potato	254	13
	Permaphase ETH	1000 × 2.0	4% 2-Propanol in hexane	1.7	std	254	12
Terbucarb	Permaphase ODS	1000 × 2.0	30% MeOH in H_2O	6.4	std	254	12
Thiram	Permaphase ETH	1000 × 2.0	4% 2-Propanol in hexane	2.9	std	254	12
	Porasil (10 μm)	300 × 4.0	Dichloromethane	12.0	std	254	23
Triallate	μBondapak C_{18}	300 × 4.0	50% Acetonitrile in H_2O	48	std	220	11
	Permaphase ETH	1000 × 2.1	10–30% Acetonitrile in H_2O (linear gradient)	33	std	220	11
Tsumacide™	Micropak-CH	250 × 2.2	48% MeOH in H_2O	3.0	std	254	20
	Micropak-NH_2	250 × 2.2	5–25% Dichloromethane in hexane (linear gradient)	6.5	std	254	20
Vernolate	μBondapak C_{18}	300 × 4.0	50% Acetonitrile in H_2O	22.4	std	220	11
	Permaphase ETH	1000 × 2.1	10–30% Acetonitrile in H_2O (linear gradient)	12.6	std	220	11
Zectran™	LiChrosorb Si 60 (5 μm)	250 × 2.8	5% 2-Propanol in TMP	5.6	corn	254	13
	μBondapak C_{18}	300 × 4.0	20–60% Acetonitrile in H_2O (concave gradient)	52	std	220	11
	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	8.3	std	254	12
3-Isopropylphenyl-N-methylcarbamate	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	3.4	std	254	12
1-(5,6,7,8)-Tetrahydro)-naphthyl-N-methylcarbamate	Permaphase ODS	1000 × 2.0	6% MeOH in H_2O	3.5	std	254	12
Organochlorines							
Aldrin	Porasil 60 (37 μm)	1218 × 2.3	TMP	6.6	std	254	18
	Corasil I	–	Hexane	$k' = 0.13$	std	–	29
	Spherisorb S10-W	100 × 2.0	Hexane	0.25	std	230, electron capture	32

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TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (mm)*					
p,p'-DDD	10% OPN on Porasil 60 (37 μm)	1218 × 2.3	TMP	20	std	254	18
	Corasil I	—	Hexane	$k' = 0.63$	std	—	29
p,p'-DDE	LiChrosorb Si 60 (5 μm)	500 × 4.0	Hexane	8.0	std	254	28
	Vydac RP C_{18}	1000 × 2.1	50% MeOH in H_2O	20.4	std	254	17
o,p'-DDT	Perisorb A	500 × 2.0	Hexane	2.6	std	210	27
	LiChrosorb Si 60 (5 μm)	500 × 4.0	Hexane	10.5	std	254	28
	10% OPN on Porasil 60 (37 μm)	1218 × 2.3	TMP	10.6	std	254	18
p,p'-DDT	Perisorb A	500 × 2.0	Hexane	3.4	std	210	27
	Vydac C_{18}	1000 × 2.1	50% MeOH in H_2O	15.6	std	254	17
	Vydac silica	250 × 2.1	2–100% Chlorobutane in TMP (linear gradient)	0.65	std	254	19
	10% OPN on Porasil 60 (37 μm)	1218 × 2.3	TMP	13.3	std	254	18
	Corasil I	—	Hexane	$k' = 0.27$	std	—	29
	LiChrosorb Si 60 (5 μm)	500 × 4.0	Hexane	11.7	std	254	28
4,4'DDM	LiChrosorb Si 60 (5 μm)	500 × 4.0	Hexane	11	std	254	28
Dieldrin	Spherisorb S10-W	100 × 2.0	Hexane	6.2	std	230, electron capture	32
Endrin	Spherisorb S10-W	100 × 2.0	Hexane	5.4	std	230, electron capture	32
	Corasil I	—	Hexane	$k' = 5.5$	std	—	29
	Porasil 60 (37 μm)	1218 × 2.3	TMP	32	std	—	18
Heptachlor	Spherisorb S10-W	100 × 2.0	Hexane	0.3	std	230, electron capture	32
	Porasil 60 (37 μm)	1218 × 2.3	TMP	7.7	std	254	18
Lindane	Porasil 60 (37 μm)	1218 × 2.3	TMP	26	fish	254	18
	Corasil I	—	Hexane	$k' = 1.3$	std	—	29

	Porasil C	–	TMP	$k' = 6.0$	spinache	RI	18
	Spherisorb S10-W	100 × 2.0	Hexane	1.4	std	electron capture	32
Methoxychlor	Zipax	500 × 3.2	Hexane	103	std	254	30
	Vydac RP C_{18}	1000 × 2.1	50% MeOH in H_2O	5.9	std	254	17
	Vydac silica gel	250 × 2.1	2–100% Chlorobutane in TMP (linear gradient)	2.5	std	254	19
PCB's (Aroclor 1254)	Vydac RP C_{18}	1000 × 2.1	50% MeOH in H_2O	Cl_4 12 Cl_5 20 Cl_5 31 Cl_6 37 Cl_6 47	stds	254	17
Aroclor 1260	Spherisorb S10-W	100 × 2.0	Hexane	3 peaks, 0.2–0.4	stds	electron capture	32
PCB's	LiChrosorb Si 60 (5 μm)	500 × 4.0	Hexane	3 peaks, 7.0–8.4	stds	254	28
PCB's (as a group)	Perisorb A	500 × 2.0	Hexane	1.3	std	210	27
Aroclor 1232	Pyrocarbonsilica (31–40 μm)	500 × 2.1	90% Acetonitrile in H_2O	7 peaks, 1.0–15.0	stds, water	254	40
Pentachlorophenol	Carbowax 400 on Porasil	609 × 4.0 (O.D.)	20% Chloroform in TMP	2.3	std	254	14
Organophosphates							
CGA 18809	Permaphase ETH	500 × 3.0	H_2O	$k' = 1.8$	plum leaf	297, cholinesterase inhibition	35
Diazinon	Vydac RP C_{18}	1000 × 2.1	29% MeOH in H_2O	18.4	std	254	17
	μPorasil	300 × 4.0	Dichloromethane	29	std	254	23
Dicapthon	Vydac RP C_{18}	1000 × 2.1	29% MeOH in H_2O	6.8	std	254	17
Dicrotophos	Permaphase ETH	500 × 3.0	H_2O	$k' = 0.4$	std	297, cholinesterase inhibition	35

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TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (mm)*					
o,o'-Dimethylchloro-thio-phosphate	Porasil 60 (37 μm)	1218 × 2.3	TMP	17	std	—	28
Ethyl parathion	Vydac RP C_{18}	1000 × 2.1	29% MeOH in H_2O	10	std	254	17
	Vydac RP C_{18}	1000 × 2.1	50% MeOH in H_2O	3	std	254	17
Fenitrothion	LiChrosorb Si 60 (5 μm)	250 × 2.2	40% Dichloromethane in TMP	4.4	std	254	42
Fensulfothion	LiChrosorb Si 60 (5 μm)	250 × 2.2	40% Dichloromethane in TMP	2.0	std	254	42
Fenthion	LiChrosorb Si 60 (5 μm)	250 × 2.2	40% Dichloromethane in TMP	2.4	std	254	42
Fonofos	Corasil II	1000 × 2.0	2.5% Dichloromethane in TMP	5	alfalfa, potato, kidney, muscle	254	34
	Permaphase ODS	1000 × 2.0	33% MeOH in H_2O	4.6	potato	254	34
	Vydac silica gel	2500 × 2.1	2–100% Chlorobutane in TMP (linear gradient)	1.7	std	254	19
Imidan	Vydac silica gel	250 × 2.1	2–100% Chlorobutane in TMP	7.6	std	254	19
	Permaphase ETH	500 × 2.0	TMP	20	std	254	22
Malathion	μPorasil (10 μm)	300 × 4.0	Dichloromethane	14	std	254	23
Methylparathion	Vydac RP C_{18}	1000 × 2.1	29% MeOH in H_2O	3.6	std	254	17
	Vydac RP C_{18}	1000 × 2.1	50% MeOH in H_2O	2.8	std	254	17
	Porasil (10 μm)	300 × 4.0	Dichloromethane	5.1	std	254	23
	Porasil 60 (37 μm)	1218 × 2.3	TMP	5.3	std	—	18
	10% TMP on silanized Kieselguhr (28–40 μm)	180 × 2.7	38.8% ETOH, 60.1% H_2O, 0.8% acetic acid, 0.21% NaOH, 0.09% KCl (w/w)	1.5	std	polarographic	37
Parathion	10% TMP on silanized Kieselguhr (28–40 μm)	180 × 2.7	38.8% ETOH, 60.1% H_2O, 0.8% acetic acid 0.21% NaOH, 0.09% KCl (w/w)	4.2	std	polarographic	37
	Vydac silica gel	250 × 2.1	2–100% Chlorobutane in TMP (linear gradient)	3.3	std	254	19

Ronnel	LiChrosorb Si 60 (5 μm)	250 × 2.2	40% Dichloromethane in TMP	1.2	std	254	42
Temephos	μBondapak C_{18}	610 × 4.8	20% Acetonitrile in H_2O	30	std	254	36
Trithion	LiChrosorb Si 60 (5 μm)	250 × 2.2	20% Dichloromethane in TMP	4.5	std	254	42
Phenols							
Bromoxynil	LiChrosorb Si 60 (5 μm)	250 × 2.2	25% Dichloromethane in TMP + 0.025 *M* butyric acid	8.8	std	254	42
Dinoseb	LiChrosorb Si 60 (5 μm)	250 × 2.2	0.025% *M* Propionic acid in TMP	2.2	std	254	42
Dinoterb	LiChrosorb Si 60 (5 μm)	250 × 2.2	0.025% *M* Propionic acid in TMP	2	std	254	42
DNOC	LiChrosorb Si 60 (5 μm)	250 × 2.2	0.025% *M* Propionic acid in TMP	5	std	254	42
Ioxynil	LiChrosorb Si 60 (5 μm)	250 × 2.2	25% Dichloromethane in TMP + 0.025 *M* butyric acid	7.2	std	254	42
Triazines							
Ametryn	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	2.5	std	254	42
Anilazine	LiChrosorb Si 60 (5 μm)	250 × 2.8	1% 2-Propanol in TMP	1.5	corn, cabbage, potatoes	254	42
Atratone	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	5.5	std	254	42
Atrazine	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.6	soil, water	220	3
	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	3.0	stds	254	42
Cyanatryne	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.2	soil, water	245	3
Cyanazine	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	8.6	std	254	42
Cyprazine	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	3.2	std	254	42
Metribuzin	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	5.3	std	254	42
Prometone	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	3.8	std	254	42
Prometryn	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	1.6	std	254	42
Propazine	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	2.2	std	254	42
Simazine	PE C_{18},Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.6	soil, water	220	3
	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	3.1	std	254	42

(Continued on p. 218)

TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (mm)*					
Simetone	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	9.5	std	254	42
Terbuthylazine	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	2.4	std	254	42
Terbutryne	PE C_{18} Sil-X-11	500 × 1.7	50% MeOH in H_2O	1.7	soil, water	227	3
	Permaphase ETH	500 × 1.7	20% MeOH in H_2O	1.8	water	254	26
	LiChrosorb Si 60 (5 μm)	250 × 2.2	2% 2-Propanol in TMP	2.0	std	254	42
Velpar™	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.2	soil, water	245	3
Uracils							
Bromacil	PE C_{18} Sil-X-11	500 × 1.7	10% MeOH in H_2O	1.6	soil, water	280	3
Lenacil	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.2	soil, water	270	3
Terbacil	PE C_{18} Sil-X-11	500 × 1.7	10% MeOH in H_2O	1.7	soil, water	280	3
	LiChrosorb Si 60 (5 μm)	250 × 2.8	20% 2-Propanol in TMP	6.0	corn, potato	254	24
Phenoxy acids							
2,4-D	PXS-1025 ODS	250 × 4.6	20% Acetonitrile in 0.3 *M* NaH_2PO_4, pH 2.95	30	std	280	39
	Perisorb A	1500 × 2.0	7.5% Acetic acid in hexane	4	std	278	27
	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP + 0.5 *M* acetic acid	4.4	std	280	42
2,4-D-Butylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	20% Dichloromethane in TMP	6.0	std	280	42
2,4-D-Methylester	Perisorb A30	500 × 2.0	5% Ethyl acetate in heptane	1.7	std	254	28
	LiChrosorb Si 60 (5 μm)	250 × 2.2	20% Dichloromethane in TMP	9.5	std	280	42
2,4-D-2-Octylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	20% Dichloromethane in TMP	5.0	std	280	42
2,4-D-2-Propylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	20% Dichloromethane in TMP	7.0	std	280	42
Dichloroprop	Perisorb A	1500 × 2.0	7.5% Acetic acid in hexane	5.6	std	278	27
	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP + 0.5 *M* acetic acid	2.2	std	280	42

Fenoprop	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP + 0.5 *M* acetic acid	1.9	std	280	42
	PXS-1025 ODS	250 × 4.6	20% Acetonitrile in 0.3 *M* NaH_2PO_4, pH 2.95	95	std	280	39
MCPA	Perisorb A	1500 × 2.0	7.5% Acetic acid in hexane	7.4	std	278	27
	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP + 0.5 *M* acetic acid	3.0	std	280	42
MCPA-Methylester	Perisorb A30	500 × 2.0	5% Ethyl acetate in heptane	1.2	std	254	28
MCPB	Perisorb A	1500 × 2.0	7.5% Acetic acid in hexane	6.2	std	278	27
2,4,5-T	Perisorb A	1500 × 2.0	7.5% Acetic acid in hexane	8.6	std	278	27
	PXS-1025 ODS	250 × 4.6	20% Acetonitrile in 0.3 *M* sodium dihydrogen phosphate, pH 2.9	60	std	280	40
	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP + 0.5 *M* acetic acid	3.8	std	280	42
2,4,5-T *n*-Amylester	LiChrosorb Si 50 (5 μm)	250 × 2.2	10% Dichloromethane in TMP	8.8	std	280	42
2,4,5-T 2-Amylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP	10.8	std	280	42
2,4,5-T *n*-Butylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP	9.0	std	280	42
2,4,5-T Ethyl ester	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP	16.5	std	280	42
2,4,5-T Methylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP	20	std	280	42
2,4,5-T 2-Octylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP	9.0	std	280	42
2,4,5-T 2-Propylester	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP	9.3	std	280	42
Ureas							
Chlorbromuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	0.1% MeOH in dichloromethane	6.0	std	245	1
	C_{18} Silica (5 μm)	250 × 4.6	60% MeOH in H_2O	6.5	std	240	1
	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	13.2	river water	240	2
	LiChrosorb Si 60 (5 μm)	250 × 2.8	10% 2-Propanol in TMP	5.0	wheat	254	4
Chloroxuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% MeOH in dichloromethane	45.0	std	245	1
	LiChrosorb Si 60 (5 μm) C_{18}	250 × 4.6	70% MeOH in H_2O	26.0	std	240	1

(Continued on p. 220)

TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (nm)*					
Chloroxuron	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	16.2	river water	240	2
	LiChrosorb Si 60 (5 μm)	250 × 2.8	20% 2-Propanol in TMP	6.0	cabbage	254	4
Chlortoluron	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% MeOH in dichloromethane	33.0	std	245	1
	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	8.1	river water	240	2
	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.6	soil, water	215	3
	Merkosorb Si 60 (10 μm)	200 × 4.0	15% 2-Propanol in hexane	4.1	soil	240	6
Dimilin	Permaphase ODS	1000 × 2.1	50% MeOH in H_2O	3.6	milk	254	9
Diuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	0.5% MeOH in dichloromethane	23.0	std	245	1
	C_{18} Silica (5 μm)	250 × 4.6	65% MeOH in H_2O	12.5	std	240	1
	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	10.8	river water	240	2
	LiChrosorb Si 60 (5 μm)	250 × 2.8	10% 2-Propanol in TMP	5.5	corn	254	4
	LiChrosorb Si 60 (5 μm)	250 × 2.0	20% Hexane in 79% dichloromethane + 1% ethanol	4.2	std	247	5
Fenuron	Corasil C_{18} (37–50 μm)	609 × 2.3	50% MeOH in H_2O	.68	std	254	7
	LiChrosorb Si 60 (5 μm)	250 × 2.8	20% 2-Propanol in TMP	5.5	std	254	4
	LiChrosorb Si 60 (5 μm)	250 × 2.0	20% Hexane in 79% dichloromethane + 1% ethanol	7.1	std	247	5
Fluometuron	LiChrosorb Si 60 (5 μm)	250 × 2.8	20% 2-Propanol in TMP	5.0	potato	254	4
Isoproturon	PE-C_{18} Sil X-11	500 × 1.7	20% MeOH in H_2O	1.6	soil, water	240	3
Linuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	Dichloromethane	6.0	std	245	1
	C_{18} Silica (5 μm)	250 × 4.6	65% MeOH in H_2O	17.0	std	240	1
	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	12.0	river water	240	2
	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.6	soil, water	250	3
	LiChrosorb Si 60 (5 μm)	250 × 2.8	10% 2-Propanol in TMP	4.5	potato, turnip	254	4, 24
Methabenzthiazuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	0.5% MeOH in dichloromethane	25	std	245	1
	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.8	soil, water	225	3
Metobromuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	Dichloromethane	7.0	std	245	1
	LiChrosorb Si 60 (5 μm) C_{18}	250 × 4.6	60% MeOH in H_2O	11.0	std	240	1

	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	7.8	river water	240	2
	LiChrosorb Si 60 (5 μm)	250 × 2.0	20% Hexane in 79% dichloromethane + 1% ethanol	5.3	std	247	5
Metoxuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% MeOH in dichloromethane	78	std	245	1
	LiChrosorb Si 60 (5 μm) C_{18}	250 × 4.6	60% MeOH in H_2O	5.5	std	240	1
Monolinuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	Dichloromethane	7.0	std	245	1
	LiChrosorb Si 60 (5 μm) C_{18}	250 × 4.6	60% MeOH in H_2O	9.0	std	240	1
	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	7.2	river water	240	2
Monuron	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% MeOH in dichloromethane	36	std	245	1
	C_{18} Silica (5 μm)	250 × 4.6	60% MeOH in H_2O	7	std	240	1
	Spherisorb ODS (5 μm)	300 × 4.6	60% MeOH in 0.6% NH_3/H_2O	6.6	wheat, soil, river water,	240	2
	PE C_{18} Sil-X-11	500 × 1.7	20% MeOH in H_2O	1.8	soil, water	250	3
	LiChrosorb Si 60 (5 μm)	250 × 2.8	10% 2-Propanol in TMP	5.0	corn	254	4
	LiChrosorb Si 60 (5 μm)	250 × 2.0	20% Hexane in 79% dichloromethane + 1% ethanol	5.6	std	247	5
Tebuthiuron	μBondapak C_{18} (5 μm)	300 × 4.0	55% Acetonitrile in H_2O	10	std	254	10
	μBondapak-nitrile	300 × 4.0	1% Acetonitrile in *n*-butyl chloride	5.0	std	254	10
1,1-Dimethyl-3-(1,1,1-trifluoro-*o*-tolyl) urea	Bondapak C_{18} (37–50 μm)	1300 × 2.0	80% Acetonitrile in H_2O	18.9	std	254	8
1,1-Dimethyl-3-(1,1,1-trifluoro-*n*-tolyl) urea	Bondapak C_{18} (37–50 μm)	1300 × 2.0	80% Acetonitrile in H_2O	33.9	std	254	8
1,1-Dimethyl-5-(1,1,1-Trifluoro-*m*-tolyl) urea	Bondapak C_{18} (37–50 μm)	1300 × 2.0	80% Acetonitrile in H_2O	48.0	std	254	8
1,3-bis (1,1,1-Trifluoro-*o*-tolyl) urea	Bondapak C_{18} (37–50 μm)	1300 × 2.0	80% Acetonitrile in H_2O	56.9	std	254	8

(Continued on p. 222)

TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (nm)*					
1,3-bis(1,1,1-Trifluoro-*m*-tolyl) urea	Bondapak C_{18} (37–50 μm)	1300 × 2.0	80% Acetonitrile in H_2O	61.4	std	250	8
Others							
Abate	1% OPN on Zipax	1000 × 1.2	–	–	std	254	31
Benzoyl-propethyl	LiChrosorb Si 60 (5 μm)	250 × 2.8	2% 2-Propanol in TMP	4.5	corn	254	24
Biphenyl	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% Ethanol in 0.2% morpholine/chloroform	1.0	citrus fruit	254	41
Captafol	μBondapak C_{18}	300 × 4.0	20–60% MeOH in H_2O (concave gradient)	58	std	220	11
	μPorasil (10 μm)	300 × 4.0	Dichloromethane	10.2	std	254	23
Captan	μPorasil (10 μm)	300 × 4.0	Dichloromethane	6.0	std	254	23
Carbendazim	LiChrosorb Si 60 (5 μm)	50 × 4.6	1% Ethanol in 0.2% morpholine/chloroform	5.0	citrus fruit	288	41
Chloramben	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP + 0.5 *M* acetic acid	2.5	std	254, 280	42
Decanol	Carbowax 400 on Corasil I	500 × 2.3	Hexane	1.6	std	254	38
Dibutylphthalate	μPorasil (10 μm)	300 × 4.0	Dichloromethane	10.0	std	254	23
Dicamba	LiChrosorb Si 60 (5 μm)	250 × 2.2	10% Dichloromethane in TMP + 0.5 *M* acetic acid	2.5	std	280	42
Dicloran	LiChrosorb Si 60 (5 μm)	250 × 2.8	2% 2-Propanol in TMP	8	corn	254	24
Dinobuton	LiChrosorb Si 60 (5 μm)	250 × 2.2	0.025 *M* Propionic acid in TMP	8.6	std	254	42
Dinocap	μPorasil (10 μm)	300 × 4.0	Dichloromethane	5.0	std	254	23
Dithianone	Perisorb A	500 × 2.0	3.5% Ethyl acetate in heptane	$k' = 8$	apples	254	27

Ethafluralin	μBondapak C_{18}	300 × 4.0	28% MeOH in 30% acetonitrile/ H_2O	19	std	254	10
Ethofumesate	PE C_{18} Sil-X-11	500 × 1.7	25% MeOH in H_2O	1.7	soil, water	225	3
Folpet	μPorasil (10 μm)	300 × 4.0	Dichloromethane	5.2	formulations	254	23
	Permaphase ETH	500 × 2.0	TMP	0.9	std	254	22
Naphthalene-acetic acid	Permaphase ETH	500 × 3.0	0.1 *M* Citrate buffer, pH 4.3	$k' = 3$	citrus fruit	254, fluorescence	33
	μBondapak CN	300 × 4.0	0.1 *M* Phosphate buffer, pH 7	$k' = 2$	citrus fruit	254, fluorescence	33
Oryzalin	μBondapak C_{18}	300 × 4.0	55% Acetonitrile in H_2O	10	std	383	10
2-Phenylphenol	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% Ethanol in 0.2% morpholine/chloroform	2.0	citrus fruit	254	41
Phthalimide	μBondapak (10 μm)	300 × 4.0	Dichloromethane	52	std	254	23
Picloram	LiChrosorb Si 60 (5 μm)	250 × 2.2	0.5% MeOH in dichloromethane + 1.0 *M* acetic acid	4.0	std	254	42
	PXS-1025 ODS	250 × 4.6	20% Acetonitrile in 0.3 *M* NaH_2PO_4, pH 2.95	6.8	std	280	39
Piperonylbutoxide	μPorasil (10 μm)	300 × 4.0	Dichloromethane	4.1	std	254	23
Propanil	Carbowax 200 on Corasil II	500 × 2.0	20% TMP in chloroform	8.0	potato	254	34
	LiChrosorb Si 60 (5 μm)	250 × 2.8	10% 2-Propanol in TMP	4.0	cabbage, wheat	254	24
Propargite	μPorasil (10 μm)	300 × 4.0	Dichloromethane	5.2	std	254	23
Pyrazone	PE C_{18} Sil-X-11	500 × 1.7	2.5% MeOH in H_2O	1.3	soil, water	230	3
Pyrethrins (major peaks)	μPorasil (10 μm)	300 × 4.0	Dichloromethane	24	std	254	23
Quintozene	μPorasil (10 μm)	300 × 4.0	Dichloromethane	4.4	std	254	23
Rotenone	μPorasil	300 × 4.0	Dichloromethane	77	std	254	23
Sulfur	μPorasil (10 μm)	300 × 4.0	Dichloromethane	3.9	std	254	23

(Continued on p. 224)

TABLE I *(continued)*

Pesticide	*Column*		*Mobile phase*	*Elution volume (ml)*	*Substrate*	*UV wavelength (nm)*	*Reference*
	Packing	*Dimensions (nm)*					
Thiabendazole	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% Ethanol in 0.2% morpholine/chloroform	4.0	citrus fruit	288	41
Thiophanate-methyl	LiChrosorb Si 60 (5 μm)	150 × 4.6	1% Ethanol in 0.2% morpholine/chloroform	2.5	citrus fruit	254	41
Trifluralin	μBondapak C_{18}	300 × 4.0	28% MeOH in 30% acetonitrile/H_2O	22	std	254	10
	Vydac R.P. C_{18}	1000 × 2.1	29% MeOH in H_2O	7.8	std	254	17
1-Methyl-3-phenyl-5-[3-(trifluoromethyl) phenyl]-4-(1-H)-pyridinone	μBondapak C_{18}	300 × 4.0	28% MeOH in 30% acetonitrile/H_2O	11	std	254	10

These must be considered approximate, since variation within each group is often very large depending upon chromophoric substituents, column efficiency and retention volume. Also the wavelengths used for the determinations in Table 1 are not necessarily the most sensitive for the pesticides. Often 254 nm is used when variable-wavelength detectors are not available. Wavelength selection is very important if maximum sensitivity is to be achieved. This is shown effectively in Table 2 where wavelengths below 254 nm often improve sensitivity 10–100-fold.

TABLE II

UV ABSORPTION SENSITIVITIES OF PESTICIDES

Pesticide class	*Sensitivity (μg)* **	*Wavelength (nm)*
Phenyl ureas	0.03 – 0.06	254
Phenyl carbamates	0.05 – 0.08	254
Phenyl carbamates	0.005– 0.01	207
Methyl carbamates	0.5 –20	254
Methyl carbamates	0.2 – 2	200–206
Triazines	0.1 –10	254
Triazines	0.01 – 0.02	220
Organophosphates	0.5 –16	254
Phenoxy acids	0.05 – 0.35	280
Phenoxy esters	15	254
Organochlorines (DDT type)	1 –15	254
Anilides	0.05	254
Nitrophenols	0.02 – 0.05	254
Uracils	0.2	254
Uracils	0.06 – 0.07	270–280
Thiocarbamates	0.07 – 0.60	205
Thiocarbamates	0.3 –10	254

* Amount injected to produce a response equivalent to 0.01 absorbance units.

Definitions of terms and abbreviations used in this work are as follows.

Capacity factor (k') = $(t_r - t_0)/t_0$ where t_r = retention time of the compound and t_0 = time of an unretained solute.

elution volume (ml) = t_r (min) × flow-rate (ml/min).

std = standard solution.

TMP = trimethylpentane.

MeOH = methanol.

RI = refractive index.

SUMMARY

High-pressure liquid chromatographic data of 166 pesticides and related compounds are tabulated. Included are chromatographic conditions such as type of packing material, column dimensions and mobile phase composition. Elution volumes or capacity factors are listed as a measure of compound retention. The types of substrate and detectors used for the analysis are also included. Where UV detectors were employed, the wavelength used is also given.

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