Analytical Chemistry
Special Study 71-9
Job No. 13840

DETERMINATION OF POLYCHLORINATED BIPHENYL RESIDUES IN BEAGLE DOG TISSUES FROM A TWO YEAR ORAL CHRONIC TOXICITY STUDY

INTRODUCTION

This report covers the results of the analysis of tissues from IBT # C7299, "Two Year Chronic Toxicity Study with Aroclor 1242, Aroclor 1254, and Aroclor 1260 in Beagle Dogs", for PCB residues.

The specific objectives of this study were to establish the relationship between tissue storage levels and exposure period, exposure level, degree of chlorination and any observed toxic effects as well as determining the homolog distribution of the retained PCB residues. Enough animals were also included in this study to determine the rate at which the retained residues washed out once oral exposure to the PCB products was ceased.

SUMMARY

The PCB residues found in the dogs were an order of magnitude less than the PCB residues found in a similar study with rats.(1) Material balance calculations indicate that in all cases less than 1% of the total test material ingested was stored in any of the animal tissues.

Significant alterations of the homolog distributions of all products were observed. The amount of alteration was greatest for Aroclor 1242 and least for Aroclor 1260.

The estimated biological half lives of the residues retained from each product were: Aroclor 1242 - 47 days; Aroclor 1254 - 108 days; and Aroclor 1260 - 301 days. These half lives were found to be independent of both tissue type and exposure level.

DETAILS

The samples were analyzed as outlined in Analytical Chemistry Method 71-35. The method involves isolation of the PCB's by solvent extraction, followed by chemical and alumina column clean-up of the extract, and detection of the type and level of PCB's retained in the tissues by electron capture gas chromatography (EC/GC).

Standard solutions of the Aroclor fed were used to prepare the calibration curves for quantitation in the cases of Aroclor 1254 and Aroclor 1260. For Aroclor 1242, the Aroclor 1254 standard solutions were used to prepare the calibration curves, since the principal isomers found in the tissue extracts were those that are dominant in production Aroclor 1254.

The PCB residue levels found in each of the tissue samples are shown in Tables I and II. The values in Table I were calculated using the wet weight of the tissue, those in Table II were calculated on the basis of the hexane soluble lipid weight.

After the 24 month sacrifice samples had been analyzed, the large number of samples (180 total) and hence time and money needed for analysis of the complete set of samples prompted a reevaluation. It was decided that little information would be lost by analyzing only a balanced subset of the recovery samples and using multiple regression statistics to predict the remaining points.(2) The open boxes in Tables I and II represent the samples which were not analyzed. The regression equation obtained indicated that, relative to the rat study completed earlier, there was more scatter in the dog data. This increased variability is attributable to the lower storage levels observed and to the fact that the tissue samples from the recovery sacrifices were from individual animals rather than group composite samples analyzed in the rat study. However, an acceptable regression equation was obtained by eliminating results where the difference between the predicted and actual values exceeded two standard deviations. The predicted PCB residue levels (lipid weight basis) are shown in Table III.

Figures I thru IX are semi-logarithmic plots relating average PCB residue level to exposure period for each Aroclor and for each tissue (muscle, liver, and fat) at three exposure levels (1, 10 and 100 ppm). On these plots solid lines were used for actual data while dashed lines were used for predicted data. These figures illustrate the decrease of PCB residue levels with time in those animals placed on a recovery diet. The figures also show that the recovery was much slower for those animals fed the higher chlorinated products such as Aroclor 1254 and Aroclor 1260. There is little evidence, at least under the conditions employed in this study, that exposure level or tissue differences influenced the residue washout rate.

The significantly higher PCB residue levels found in liver seem to indicate this tissue is a primary storage area and/or site of metabolism.

Chromatograms I, II and III compare the typical homolog distributions of the retained residue to that of the Aroclor fed. Isomeric alterations were observed with each Aroclor at all feed levels. Aroclor 1242 was altered to a greater extent than either Aroclor 1254 or Aroclor 1260.

The chromatographic conditions employed while suitable for quantitation of the PCB residues in the tissues are not ideal for the identification of the specific isomers which are retained. Nevertheless with these limitations, the chlorine number(s) of the principal isomer(s) are shown above each peak on the chromatogram. An inspection

of the chromatograms reveals that the less chlorinated isomers are metabolized and/or excreted rapidly. Further inspection of the chromatograms from the recovery samples shows that the ratios of the peak heights continue to change which along with the decrease in PCB residue levels, indicates that the higher chlorinated isomers can also be metabolized and/or excreted, albeit more slowly. Chromatogram IV is a comparison of the extracts from the animals after 60 days on a recovery diet free from PCB's. It is evident, that the isomers observed are the same irrespective of the material fed. This again illustrates the much lower wash out rate encountered with the higher chlorinated isomers.

TOXICITY

No untoward behavorial reactions or significant abnormalities were observed during the two year study.(1)

REFERENCES

1. "Two Year Chronic Oral Toxicity Study With Aroclor 1242, Aroclor 1254, and Aroclor 1260 in Beagle Dogs", Industrial Bio-Test Laboratories Report (IBT # C7299).

2. "PCB Residues in Beagle Dogs", Statistics Special Study 71-25.

db

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12/72 - W. M. Mees, E. S. Tucker, W. J. Litschgi, J. Cowell

TABLE I

IBT #C7299 Two-Year Chronic Oral Toxicity Study of Aroclor in Beagle Dogs

ppm PCB in Dog Tissues (Wet Weight Basis)

Material	Tissue	1 ppm						10 ppm						100 ppm						Exposure Level
		24 mo.		30 d.		60 d.		24 mo.		30 d.		60 d.		24 mo.		30 d.		60 d.		Sacrifice
		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	Sex
Aroclor 1242	Muscle	0.07	0.08	0.09	0.06			0.3	0.2		0.2		0.04	0.6	0.5	0.3	0.4	0.5		
	Liver		0.08	0.3	0.04		0.04	0.2	0.1		0.1	0.05		0.6		0.4	0.3			
	Fat	2	2	1	0.5	0.5		1	1		2	1	2	4	4	9	2			
Aroclor 1254	Muscle	0.3	0.08	0.2		0.1	0.1	0.7	0.3		0.7			4	3				3	
	Liver	0.1	0.2		0.2			0.4	0.7			0.5		2	2	1				
	Fat	4	3	2			2	5	4		18			95	73				34	
Aroclor 1260	Muscle	0.2	0.4		1		0.2	1	0.4		6		3	26	10		34	26		
	Liver	0.2	0.1	0.1			0.3	2	0.7	2	1	0.9	1	11	4		2	9		
	Fat	11	14		14		4	101	31	40	47		62	93	221		352	173		

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TABLE II

IBT #C7299 Two-Year Chronic Oral Toxicity Study of Aroclor in Beagle Dogs

ppm PCB in Dog Tissues (Lipid Weight Basis)

Material	Tissue	1 ppm						10 ppm						100 ppm						Exposure Level
		24 mo.		30 d.		60 d.		24 mo.		30 d.		60 d.		24 mo.		30 d.		60 d.		Sacrifice
		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	Sex
Aroclor 1242	Muscle	2	2	1	2			6	3		2		1	19	20	10	10	6		
	Liver		4	11	2		2	8	8		9	4		29		23	18			
	Fat	2	3	1	1	0.6		1	2		2	2	2	6	7	13	3			
Aroclor 1254	Muscle	10	4	4		2	2	18	18		9			61	95				32	
	Liver	8	6		9			23	40			43		110	130	111				
	Fat	5	3	3			2	6	10		22			128	132				42	
Aroclor 1260	Muscle	9	7		8		3	78	20		66		37	716	100		491	301		
	Liver	17	13	11			21	175	43	112	135	55	120	762	269		81	659		
	Fat	14	18		20		5	159	39	54	72		78	1261	287		439	233		

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TABLE III

IBT #C7299 Two-Year Chronic Oral Toxicity Study of Aroclor in Beagle Dogs

Predicted ppm PCB in Dog Tissues (Lipid Weight Basis)

Material	Tissue	1 ppm						10 ppm						100 ppm						Exposure Level
		24 mo		30 d.		60 d.		24 mo.		30 d.		60 d.		24 mo.		30 d.		60 d.		Sacrifice
		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	Sex
Aroclor 1242	Muscle	2	2	1	1	0.7	0.7	5	4	4	3	2	2	20	10	9	6	6	4	
	Liver	3	3	2	2	1	1	10	8	7	5	5	4	28	18	18	12	11	8	
	Fat	2	2	1	1	0.7	0.7	5	4	4	3	2	2	20	10	9	6	6	4	
Aroclor 1254	Muscle	5	5	4	4	3	3	24	20	20	16	16	13	121	80	100	65	80	54	
	Liver	10	10	8	8	6	6	47	38	39	31	33	26	238	156	195	128	157	103	
	Fat	5	5	4	4	3	3	24	20	20	16	16	13	121	80	100	65	80	54	
Aroclor 1260	Muscle	8	8	8	8	7	7	54	44	50	40	47	38	355	233	333	217	308	202	
	Liver	16	16	14	14	14	14	106	84	98	80	91	74	698	457	654	426	605	397	
	Fat	8	8	8	8	7	7	54	44	50	40	47	38	355	233	333	217	308	202	

Regression Equation – log ppm PCB = −1.3450 − 0.0190 (day recovery) − 0.3888 (log ppm fed) + 0.2929 (if liver) + 0.0376 (% Cl_2) + 0.0202 (log ppm fed × % Cl_2) − 0.0917 (log ppm fed − if female) + [illegible]

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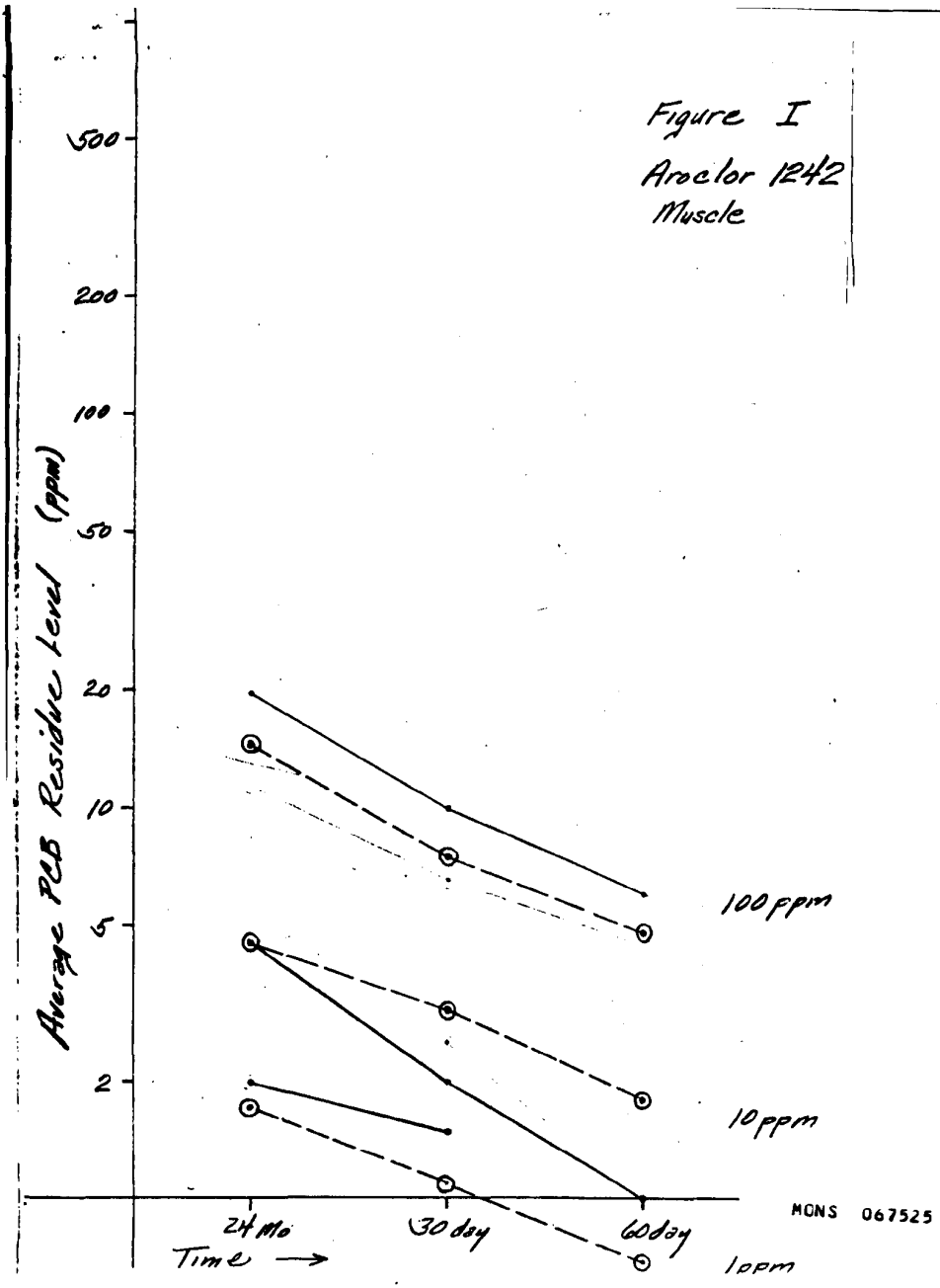


Figure I
Aroclor 1242
Muscle
Average PCB Residue Level (ppm)
500
200
100
50
20
10
5
2
100 ppm
10 ppm
1 ppm
24 Mo
30 day
60 day
Time →
MONS 067525

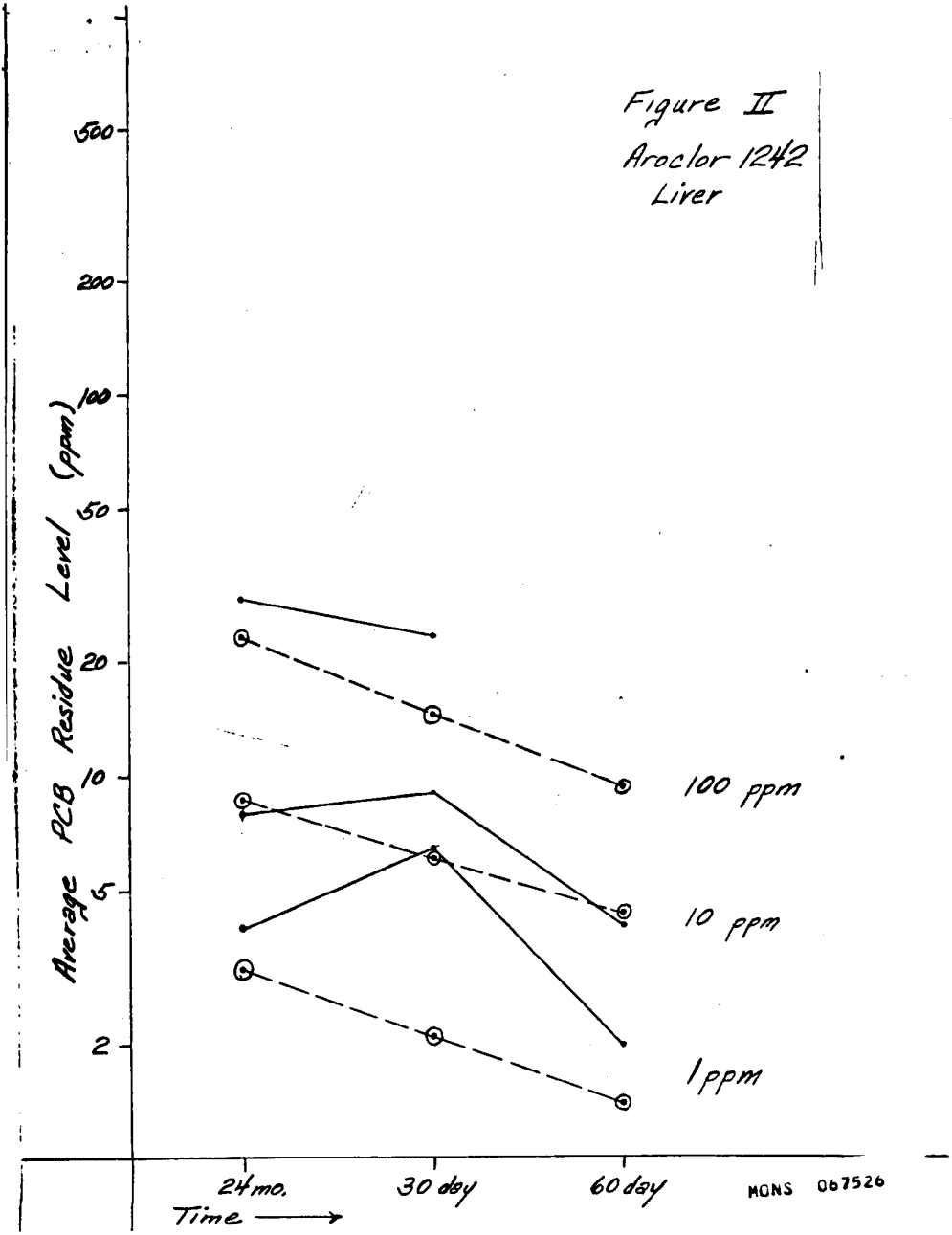


Figure II
Aroclor 1242
Liver
500
200
100
50
20
10
5
2
Average PCB Residue Level (ppm)
100 ppm
10 ppm
1 ppm
24 mo.
30 day
60 day
Time
MONS 067526

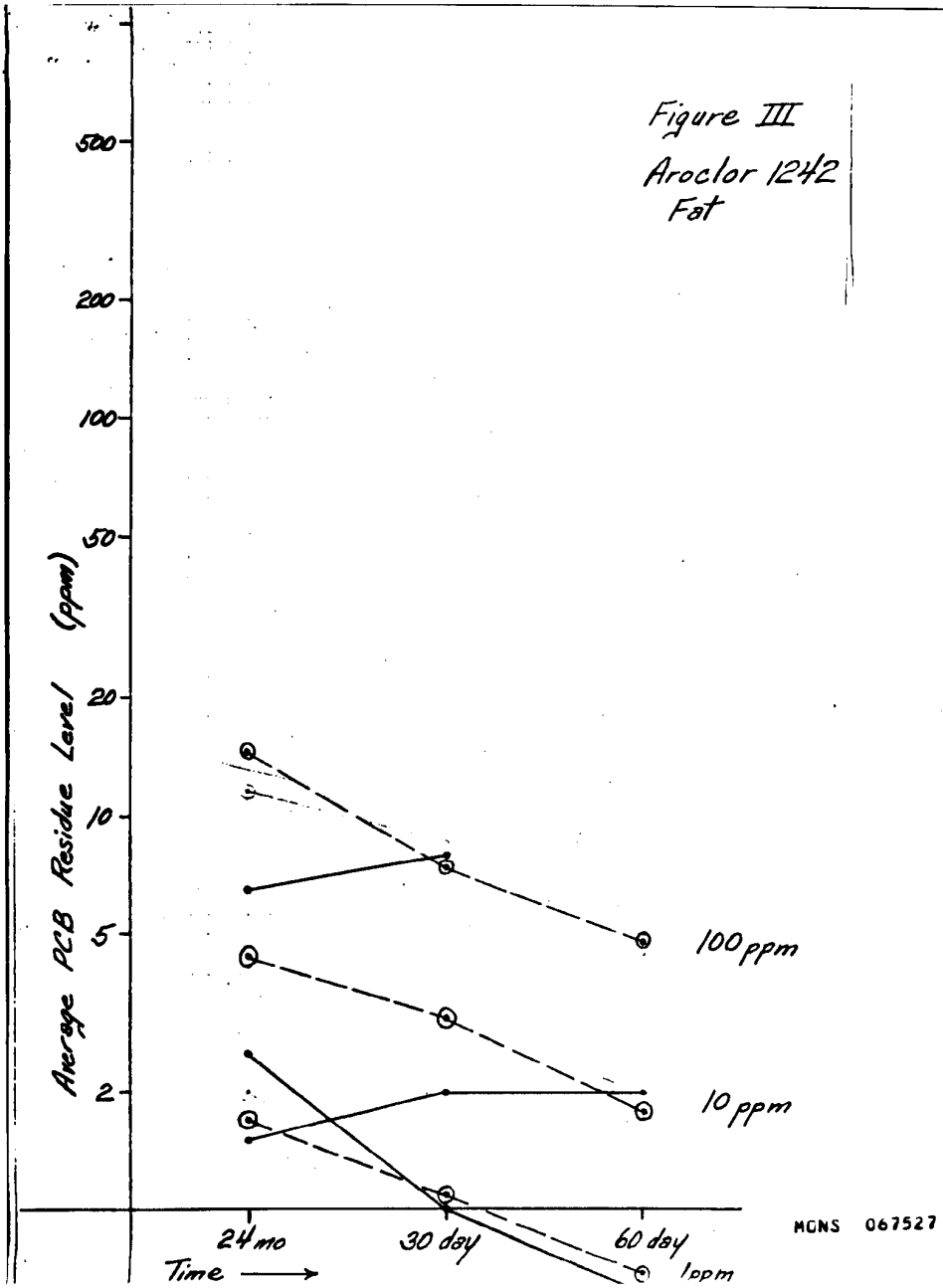


Figure III
Aroclor 1242
Fat
500
200
100
50
20
10
5
2
Average PCB Residue Level (ppm)
100 ppm
10 ppm
1 ppm
24 mo
30 day
60 day
Time
MONS 067527

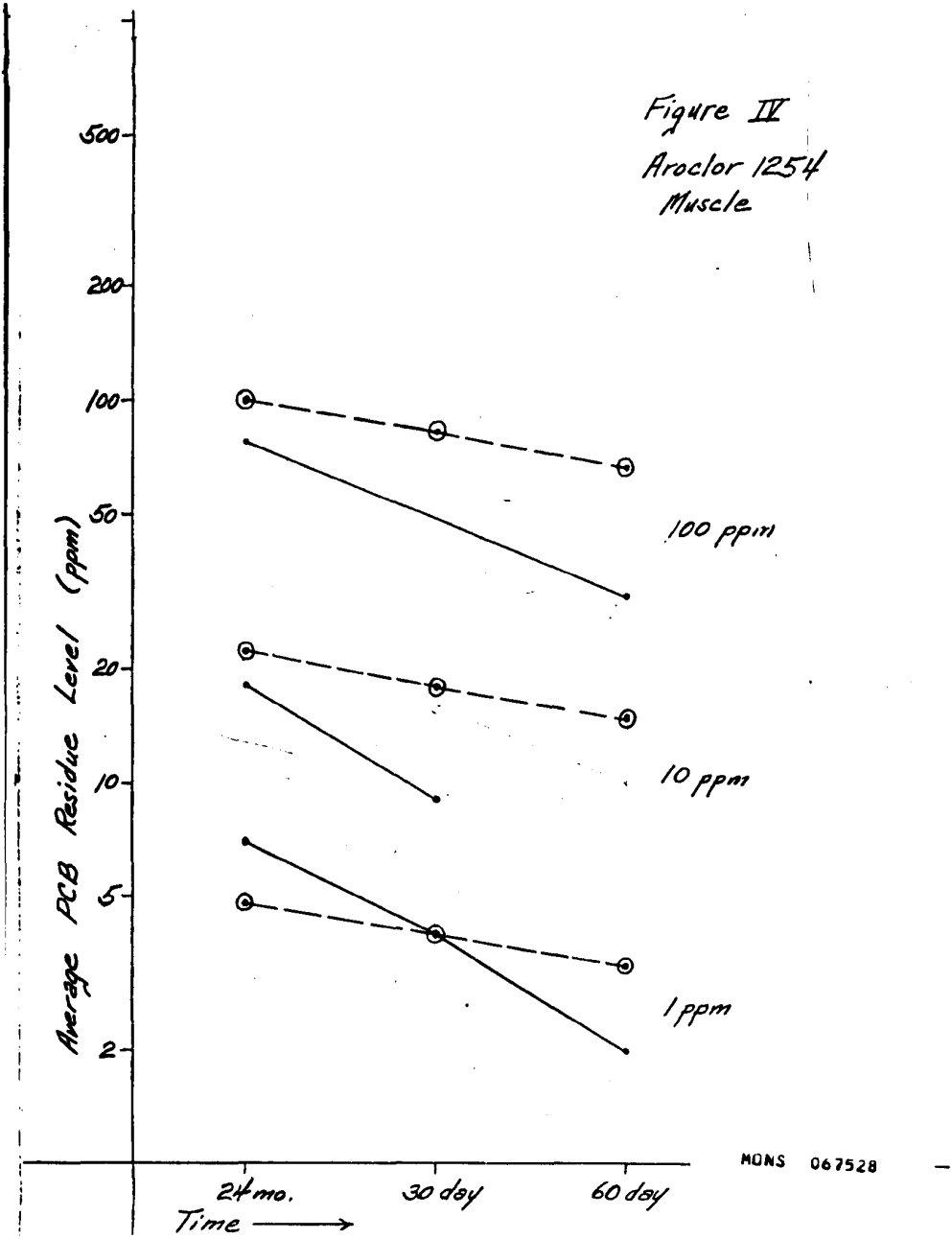


Figure IV
Aroclor 1254
Muscle
500
200
100
50
20
10
5
2
Average PCB Residue Level (ppm)
100 ppm
10 ppm
1 ppm
24 mo.
30 day
60 day
Time
MONS 067528

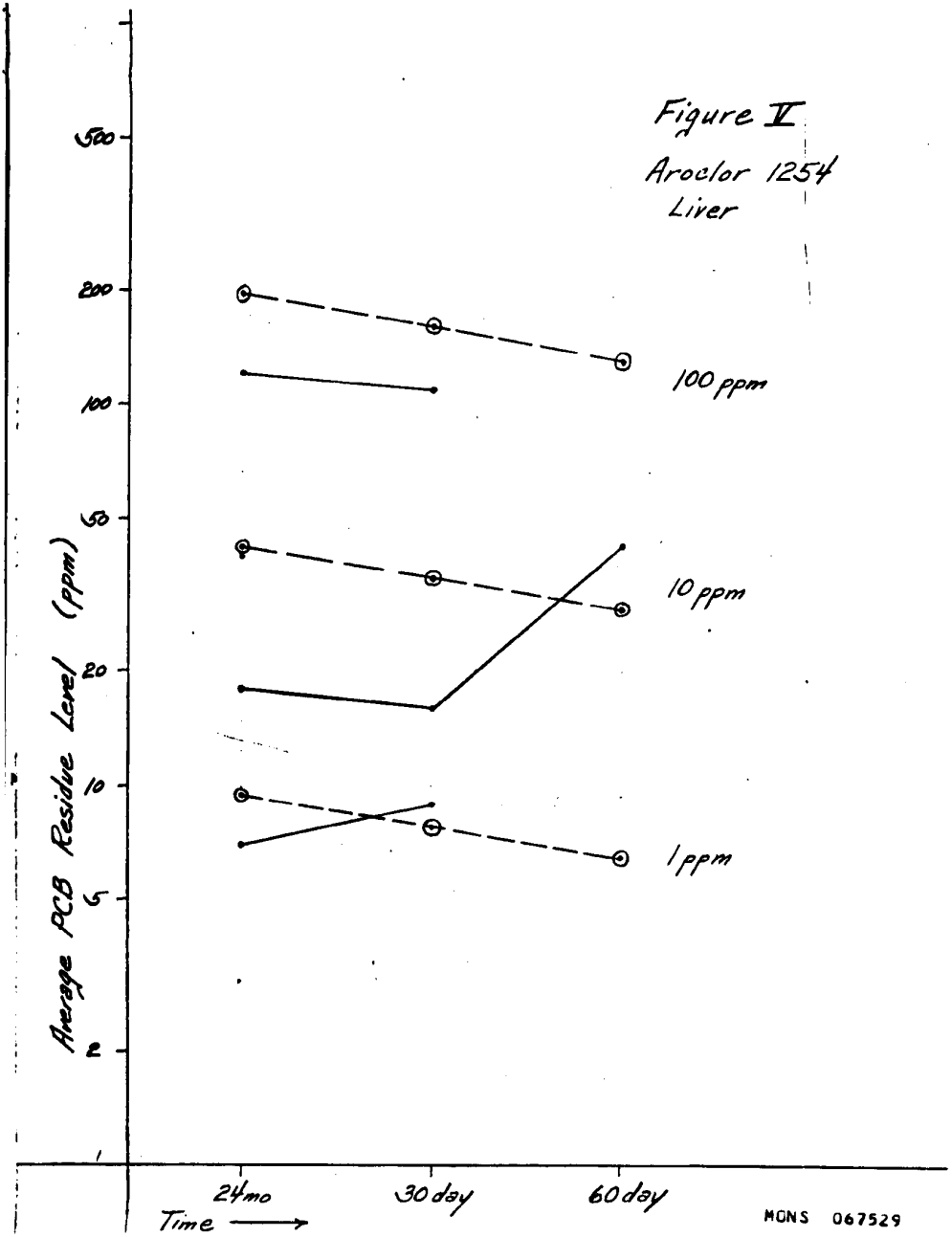


Figure II
Aroclor 1254
Liver
500
200
100
50
20
10
5
2
1
Average PCB Residue Level (ppm)
100 ppm
10 ppm
1 ppm
24 mo
30 day
60 day
Time
MONS 067529

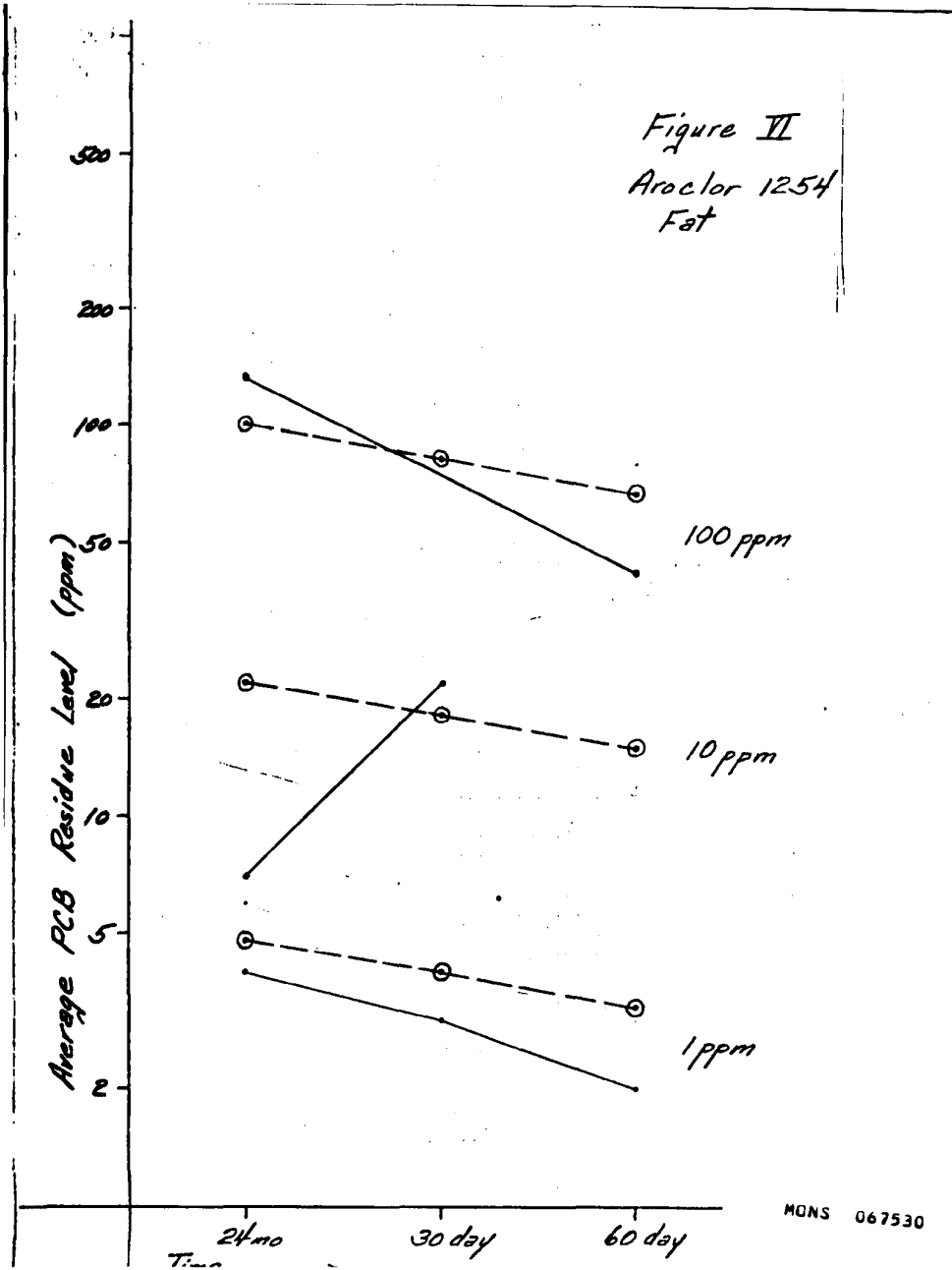


Figure VI
Aroclor 1254
Fat
500
200
100
50
20
10
5
2
Average PCB Residue Level (ppm)
100 ppm
10 ppm
1 ppm
24 mo
30 day
60 day
Time
MONS 067530

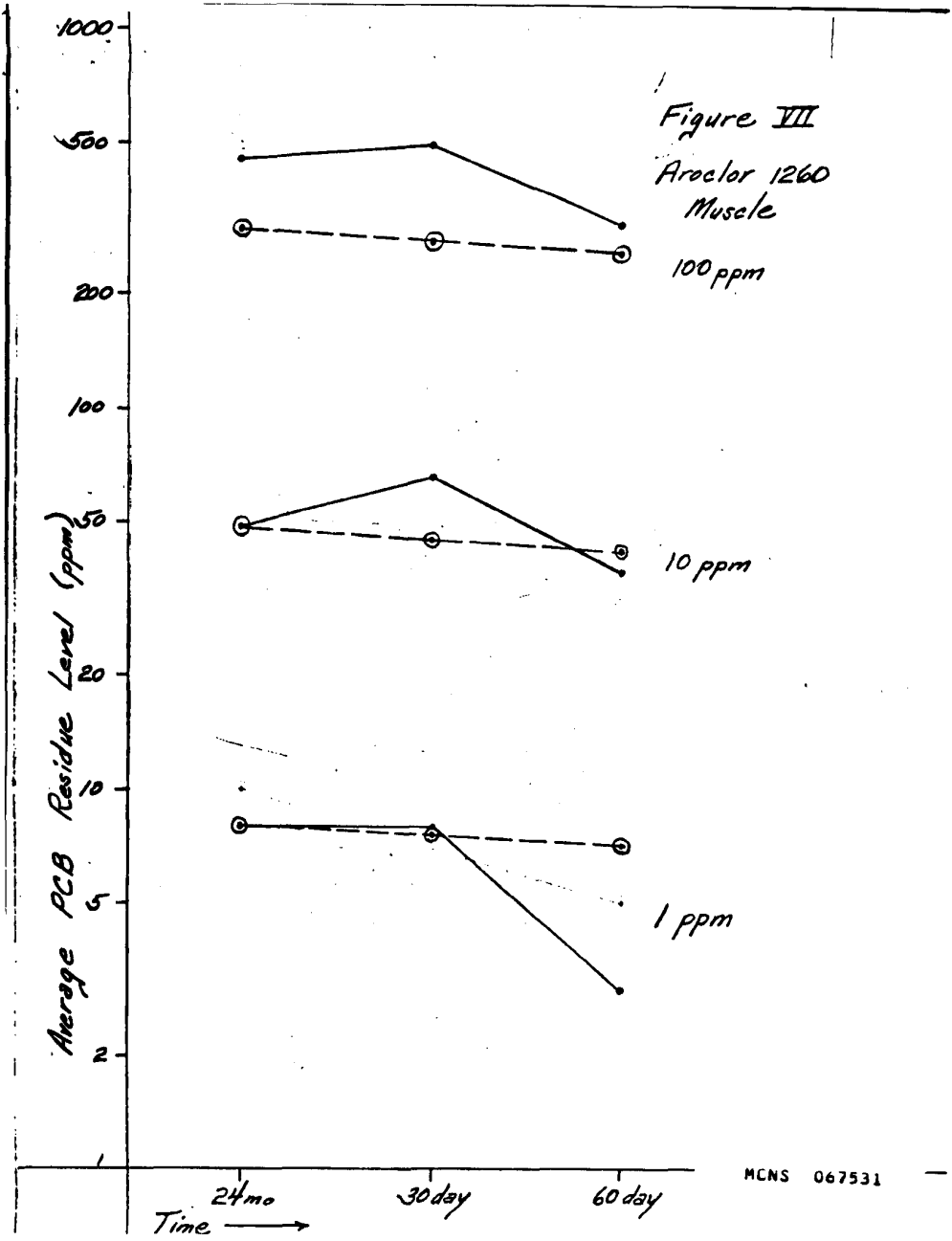


Figure III
Aroclor 1260
Muscle
100 ppm
10 ppm
1 ppm
Average PCB Residue Level (ppm)
1000
500
200
100
50
20
10
5
2
1
24 mo
30 day
60 day
Time
MCNS 067531

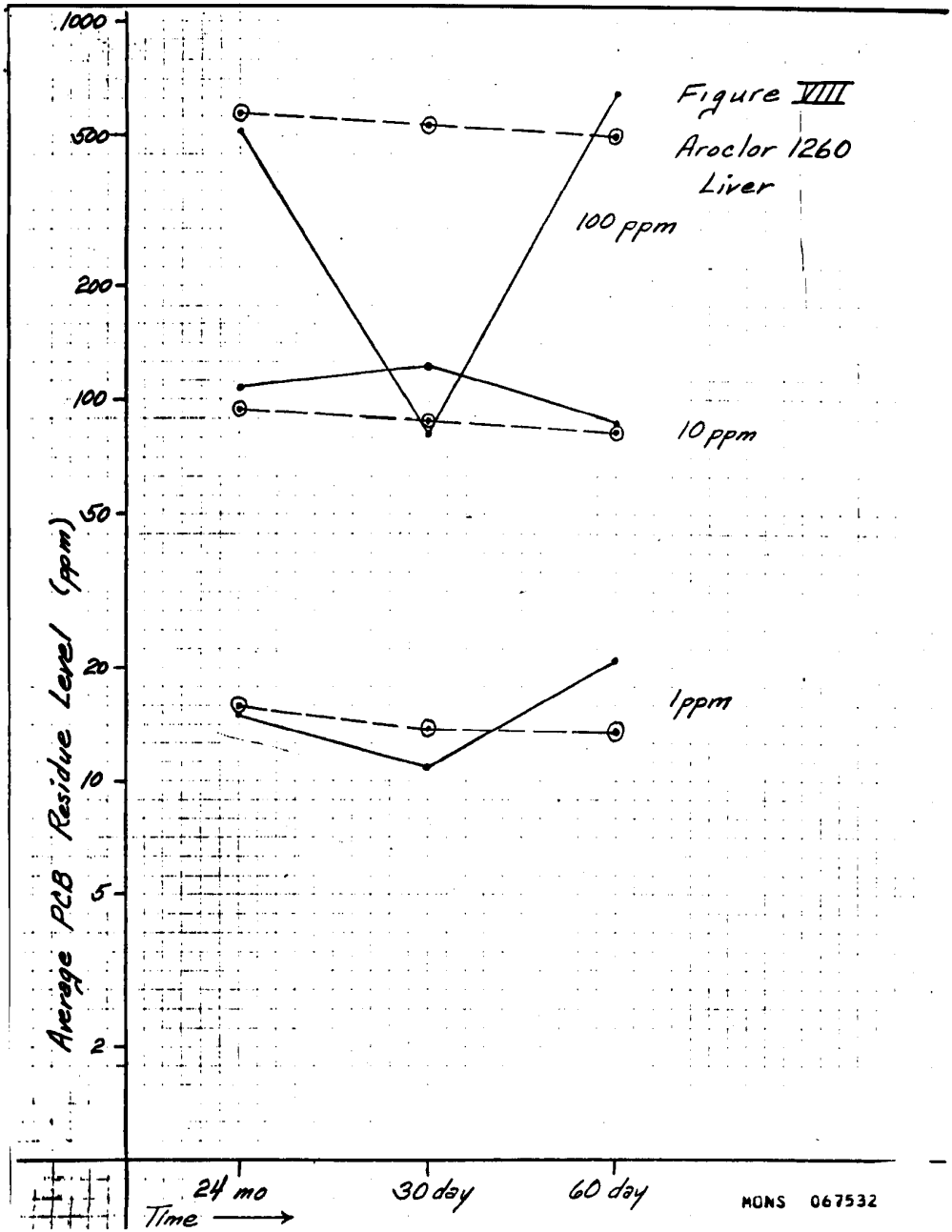


Figure VIII
Aroclor 1260
Liver
100 ppm
10 ppm
1 ppm
Average PCB Residue Level (ppm)
1000
500
200
100
50
20
10
5
2
24 mo
30 day
60 day
Time
MONS 067532

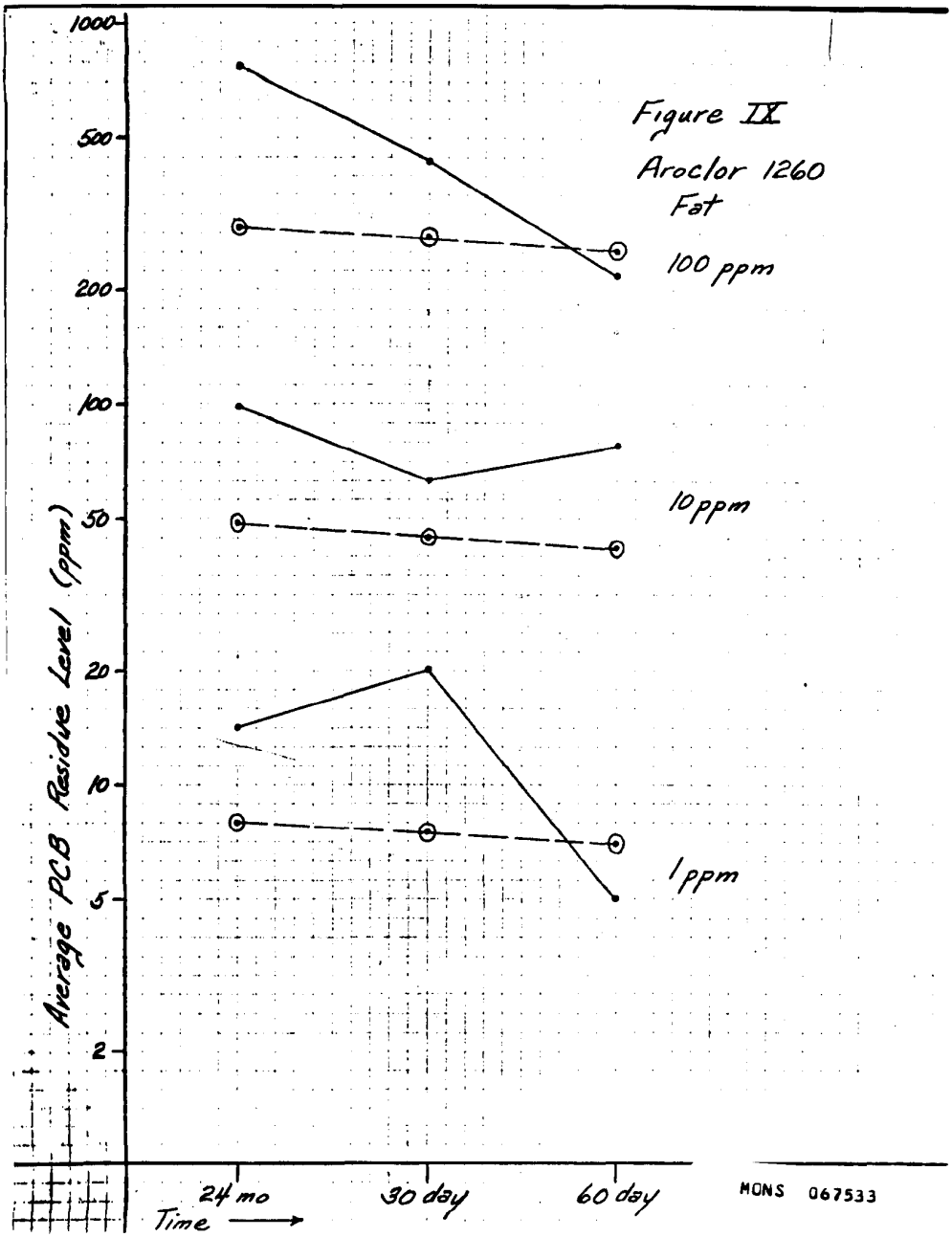
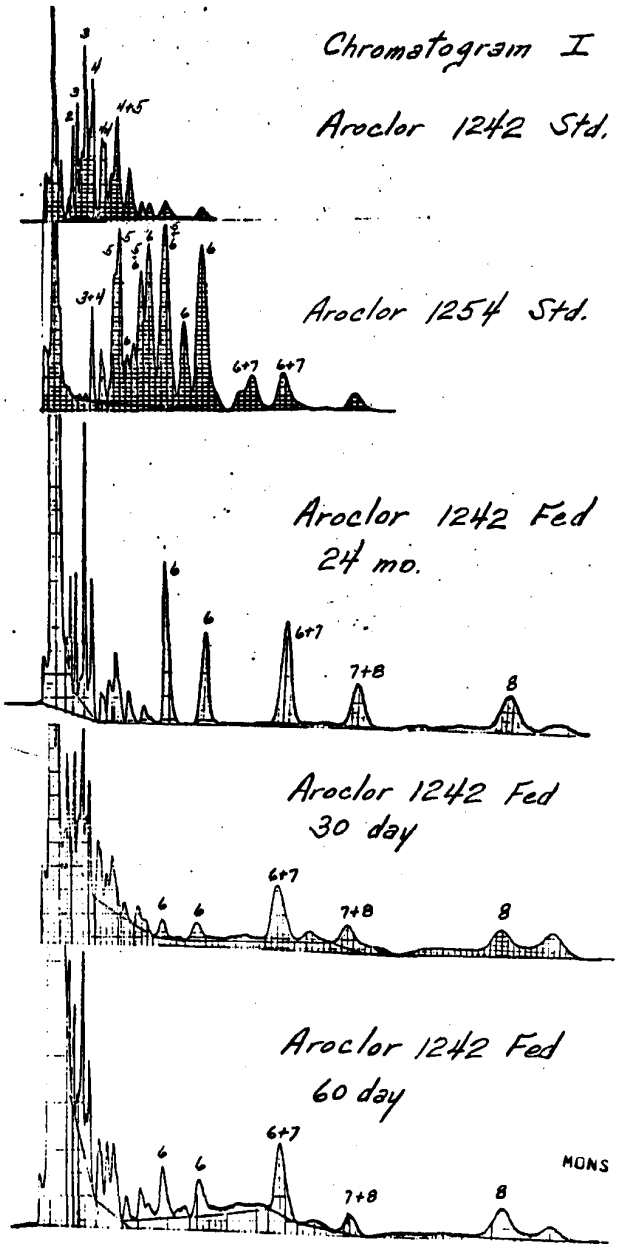


Figure IX
Aroclor 1260
Fat
100 ppm
10 ppm
1 ppm
Average PCB Residue Level (ppm)
1000
500
200
100
50
20
10
5
2
24 mo
30 day
60 day
Time
MONS 067533


Chromatogram I
Aroclor 1242 Std.
Aroclor 1254 Std.
Aroclor 1242 Fed
24 mo.
Aroclor 1242 Fed
30 day
Aroclor 1242 Fed
60 day
6+7
7+8
8

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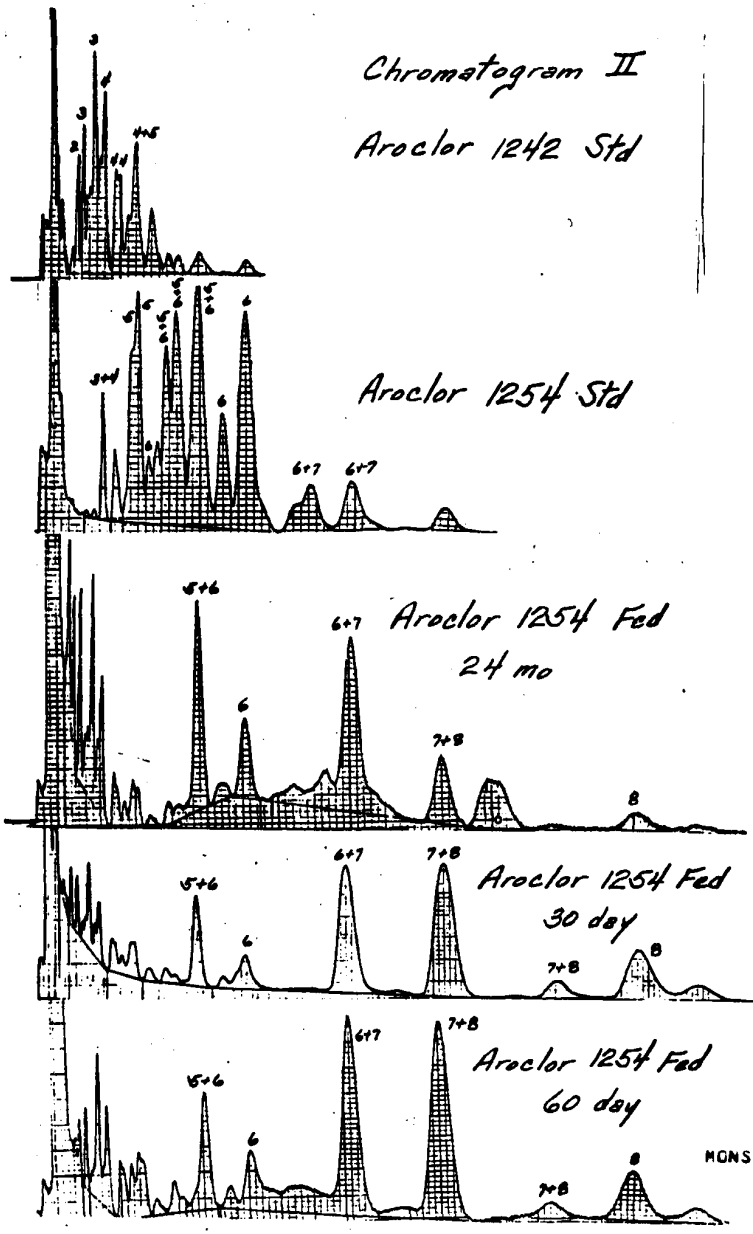
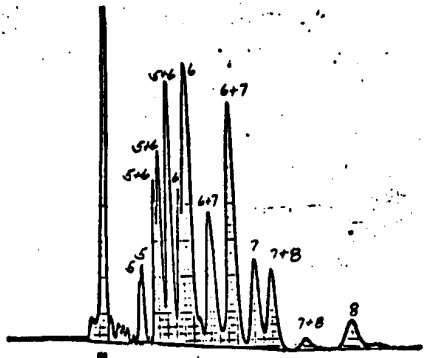
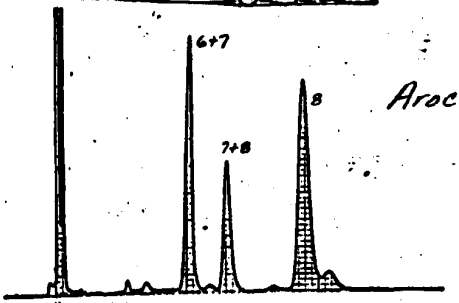

Chromatogram II
Aroclor 1242 Std
Aroclor 1254 Std
Aroclor 1254 Fed
24 mo
Aroclor 1254 Fed
30 day
Aroclor 1254 Fed
60 day
MONS 067535

Chromatogram III

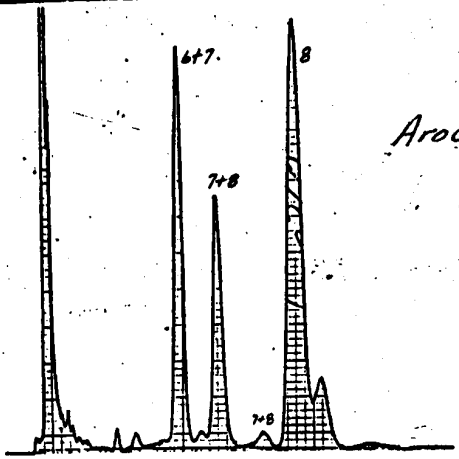


Aroclor 1260 Std



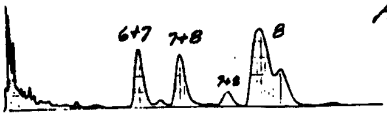
Aroclor 1260 Fed

24 mo



Aroclor 1260 Fed.

30 day



Aroclor 1260 Fed

60 day

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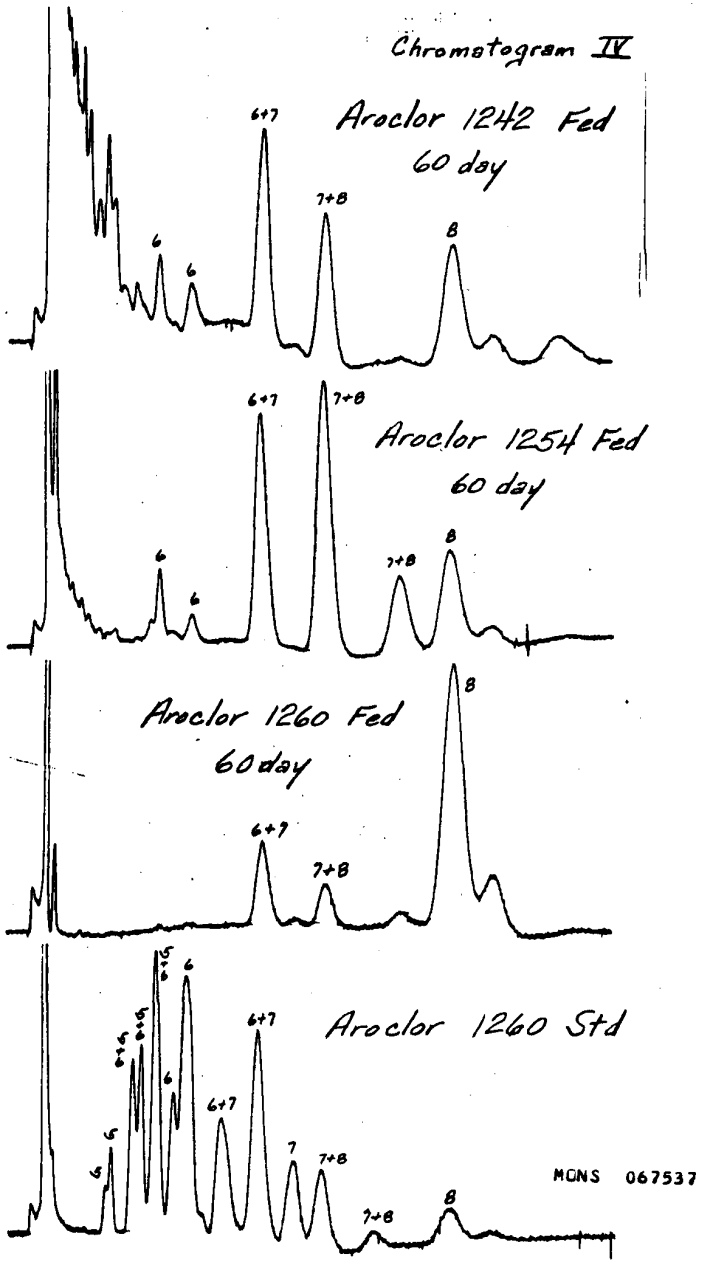
Chromatogram IV
Aroclor 1242 Fed
60 day
6+7
7+8
8
6
Aroclor 1254 Fed
60 day
Aroclor 1260 Fed
60 day
Aroclor 1260 Std
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Polycyclic Aromatic Hydrocarbons

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INTRODUCTION

In recent years there has been increasing concern about the possible harmful effects of organic compounds in the environment. An important class of pollutants are the polycyclic aromatic hydrocarbons (PAH) which have been shown to occur in air, water and food (see Table 1) *via* automobile and engine exhausts, the burning of fossil fuels, oil spills, food processing, tobacco smoking, and from natural sources. Moreover several PAH have been shown to possess carcinogenic (1-4) and mutagenic (5, 6) properties. This review is designed as an introduction to the general literature on PAH with particular emphasis on environmental analysis of these compounds.

NOMENCLATURE

Although several systems of nomenclature for polycyclic aromatic hydrocarbons have coexisted in the past (7, 8) the IUPAC system (9) is becoming generally accepted now.

Common names for the basic ring systems are retained (see Fig. 1 on page 2). For the construction of more highly condensed aromatic hydrocarbons the basic system is lettered (a, b, c, etc., (see Fig. 2 on page 3) and the "added" rings numbered in the fashion shown in Fig. 2.

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REACTIONS AND REACTIVITY

The standard reference books on the chemistry of polycyclic hydrocarbons are Clar's two volumes (10) and chemical-technical aspects of diphenyl and the terphenyls are discussed in an encyclopedia article (11). The analysis of PAH has been reviewed (12).

Most polycyclic hydrocarbons undergo the typical substitution reactions which are known from the parent compound, benzene.

In addition, many of the polycyclic hydrocarbons show a tendency for addition reactions (*cf.* Fig. 3 on page 3) ("fixed double bonds").

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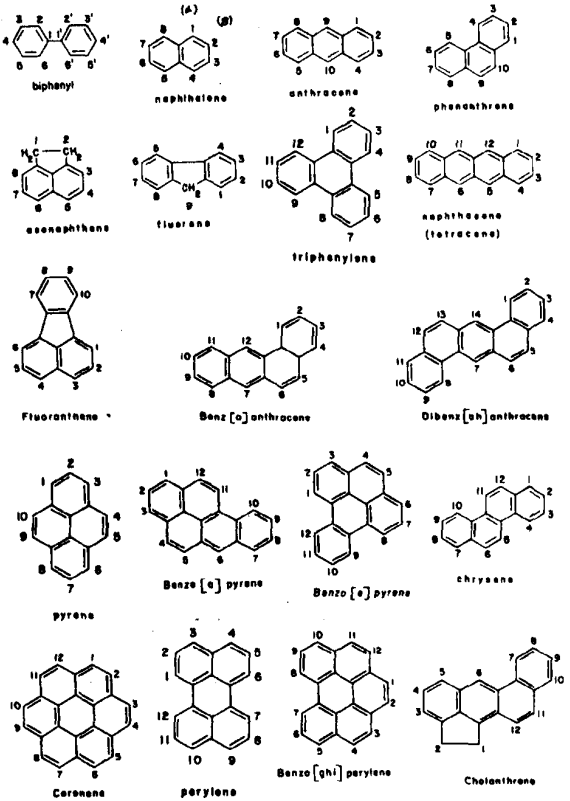
Fig. 1. Common names structure and numbering of basic ring systems.



The reactivity of polycyclic hydrocarbons towards addition reactions can be explained and predicted qualitatively by Clar's π -sextett theory (13, 14). A quantum mechanical explanation of Clar's theory has been given (15, 16).

The stability of polycyclic aromatic hydrocarbons depends on the structure as well as on the number of rings. Hexabenzocoronene (Fig. 4) for example is an extremely

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TABLE 1
Polycyclic hydrocarbons in man's environment*

Benzo [a] pyrene in city air (mcg/1000 m³)	
Los Angeles	5
London	68
Bonn	133
Benzo [a] pyrene in food (mcg/kg)	
Vegetables	10
Smoked foods	1-10
Carcinogenic Polycyclic Hydrocarbons in water (mcg/m³)	
Groundwater	1-10
Waste water	100,000
Benzo [a] pyrene in cigarette smoke	
1 mcg in the smoke of 40 cigarettes	

*Adapted from M. Zander, "Analysis of Polycyclic Aromatics" presented at the "Third Annual Symposium on Recent Advances in the Analytical Chemistry of Pollutants," Athens, Ga., May 1973.

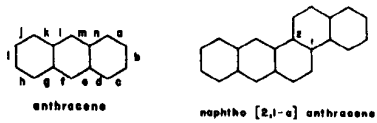

Fig. 2. Nomenclature for more highly condensed ring systems.

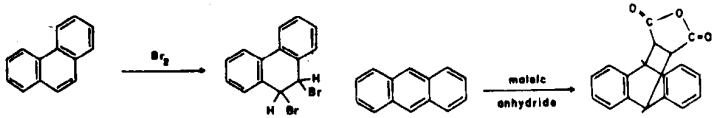

Fig. 3. Examples for addition reactions occurring with PAH.



Fig. 4. Hexabenzocoronene ring system.

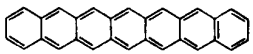

Fig. 5. Heptacene ring system.

stable hydrocarbon; even at 700°C neither decomposition nor melting takes place. Heptacene (Fig. 5) on the other hand, is extremely unstable with a reactivity that surpasses many free radicals.

The photochemical stability of a number of PAH has been investigated (17); the literature on the photodecomposition of the carcinogen benzo [a] pyrene is discussed in reference (18).

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OCCURRENCE OF PAH

PAH occur naturally in petroleum and are also synthesized by living organisms such as higher plants, algae and microorganisms (*cf.* 18, 19).

PAH are formed as pyrolysis products at high temperatures (20-22) and can, therefore, be found in coal tar, automobile exhaust, in emission from burning fossil fuels and tobacco smoke.

A panel, studying particulate polycyclic organic matter (POM) concluded recently that the nation-wide emmission of benzo [a] pyrene in the US amount to 500 tons from heat and power generation, 600 tons from refuse burning, 200 tons from coke production and 20 tons from motor vehicles (23).

The distribution of PAH is almost universal and numerous analyses show their presence (5, 18, 24-29) in air (particularly soot samples), water and soil. Polycyclic hydrocarbons and hetero-aromatic compounds, known to occur in coal tar and pitch are listed and described in references (30-32).

Because of the direct intake in human nutrition, much work has been carried out to develop analytical methods and determine levels of polycyclic aromatic hydrocarbons in foods (25, 33-43). Levels are highest in smoked foods (occasionally values > 10 ppm total polycyclic hydrocarbon are observed), whereas levels in unsmoked food products are generally lower than 1 ppm.

A large number of polycyclic aromatic (including benzo [a] pyrene) and heteroaromatic hydrocarbons as well as related compounds have been identified in tobacco smoke (44-46).

Polycyclic hydrocarbons are also released into the environment from general oil pollution and the ever-increasing oil spills (47, 48). Analytical methods for the identification of hydrocarbon pollutants on seas and beaches are reviewed in reference (49). The uptake and effect of oil (including the polycyclic aromatic hydrocarbons) on marine life is of increasing concern (50-52).

ANALYSIS

The extraction, separation (clean-up) and analysis of PAH have been extensively investigated (53-56) and a review article on chromatographic procedures gives a useful comparison of the various methods (57).

As is general for the analysis of any trace component, the need is felt (97) for an extended collection of reference standards of polynuclear hydrocarbons and their alkyl and hydro derivatives. The later type of derivatives is of great importance since it is not ordinarily discovered by the conventional UV or fluorescence methods and is best identified and measured by MS. The alkyl derivatives are in many instances more carcinogenic than the parent compound.

The carcinogenic PAH benzo [a] pyrene has understandably been studied in some detail and a thorough comparison of the analytical methods used in the determination of this compound from air particulates has been reported by Sawicki (58). Analysis of benzo [a] pyrene in cigarette smoke (59), air (60), bitumen and plants (61) and water and other commodities (62) has recently been described.

Thin layer and paper chromatography – TLC and paper chromatography has been used successfully for the separation of polycyclic hydrocarbons (57, 63). Cellulose, acetylated cellulose and aluminum oxide (64) and silica are the preferred layers. A methanol-ether-water (4:4:1) mixture (65) has been recommended for acetylated cellulose layers. A typical chromatogram employing this system is shown in Fig. 6. (66) Paper chromatography on acetylated paper has been used for the chromatography of PAH with solvents similar to the TLC separation on acetylated cellulose powder (67).

Electron acceptor reagents can be used to visualize PAH on paper and thin layer chromatograms. The hydrocarbons can be recovered unchanged from the characteristically colored charge transfer complexes (see section on mass spectrometry). The native fluorescence or phosphorescence of PAH, however, offers a much more sensitive method of detection (see section on luminescence spectroscopy).

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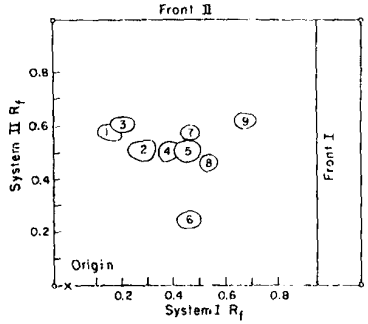

Fig. 6. Two dimensional thin layer chromatogram. Layer: acetylated cellulose – aluminum oxide, 1:2. Solvents: System I, n-hexane, n-pentane, toluene (90:5:5). System II, methanol, ether, water 4:4:1. Compounds 1, dibenzo [a, e] pyrene; 2, dibenz [a, h] anthracene; 3, dibenz [a, c] anthracene; 4, perylene; 7, benzo [e] pyrene; 8, pyrene; 9, anthracene.

Liquid chromatography – The behavior of 18 polycyclic hydrocarbons on two column materials (Durapak OPN and 40% cellulose acetate) were investigated using an ultraviolet detector (68). Although neither system could resolve all components of the mixture, the method was shown to be of potential utility. A number of pulynuclear aza-heterocyclic hydrocarbons were separated by high pressure liquid chromatography using Zipax packing impregnated with silver ions (69) and a chemically bonded phase (70). Polycyclic aromatic hydrocarbons were also separated by liquid chromatography using Corasil I impregnated with the complexing reagent 2, 4, 7-trinitrofluorenone (71). A number of column packings have been compared in the separation of polynuclear hydrocarbons in engine oils (72).

Gas chromatography – Ultraviolet absorption and luminescence analysis have dominated the analysis of polycyclic hydrocarbons for some time, more recently gas chromatography has played an important role in the separation, detection and identification of these compounds (57, 73-77).

The use of capillary gas chromatography with its great resolution potential has markedly increased the analytical potential of this technique. Application of capillary G. C. have been reported in the analysis of polycyclic aromatic hydrocarbons and related compounds in anthracene oil (78), cigarette smoke (45, 79), air and car exhaust (80, 81), soot samples (75) as well as for quantitative determinations (82). Gouw *et al.* (83) have shown that PAH can be separated effectively on short capillary columns (10 m). A typical capillary column chromatogram is shown in Fig. 7 (see Table 2).

Ultraviolet spectroscopy – U.V. spectra of PAH show in the spectral range accessible by commercial instruments three electronic transitions which are differentiated by oscillator-strength polarisation and temperature dependency. The most intense bands in the U. V.-spectra of PAH are the so-called β – or ^{1}Bb-bands which show a molar extinction coefficient of *ca.* (10^5). The extinction coefficient for the para – or ^{1}La-bands and the γ – or ^{1}Lb-bands are *ca.* 10^4 - 10^5 and (10^2 - 10^3) respectively. For analytical purposes, the para-bands are the most suitable.

U. V. spectra are usually recorded in liquid solution at room temperature. It is sometimes advantageous, to measure the U. V. spectra in a solid matrix at low temperatures, frequently the bands are more intense and very narrow (84).

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TABLE 2
Compounds separated on capillary column

No.	Compounds	No.	Compounds
1	Naphthalene	25a	Chrysene
2	Azulene	25b	Triphenylene
3	Diphenyl	26	Naphthacene/Tetracene
4	Acetylnaphthalene	27	7-Methyl-benz [a] anthracene
5	Acenaphtene	28a	Benzo [a] fluoranthene
6	Fluorene	28b	Benzo [b] fluoranthene
7	2-Methylfluorene	29	Benzo [k] fluoranthene
8	1-Methylfluorene	30	7, 12-Dimethyl-benz [a] anthracene
9	Trans-stilbene	31	Benzo [e] pyrene
10	Phenanthrene	32	Benzo [a] pyrene
11	Anthracene	33	Perylene
12	2-Methylanthracene	34a	3-Methylcholanthrene
13	4H-Cyclopenta [def] phenanthrene	34b	20-Methylcholanthrene
14	1-Methylphenanthrene	35	Dibenz [a, j] anthracene
15	9-Methylanthracene	36a	Dibenz [a, c] anthracene
16	Fluoranthene	36b	Dibenz [a, h] anthracene
17	Pyrene	37	Benzotetraphene
18	11H-Benzo [a] fluorene	38a	Benzo (g, h, i) perylene
19a	11H-Benzo [b] fluorene	38b	Picene
19b	7H-Benzo [c] fluorene	39	Anthanthrene
20	1-Methylpyrene	40	Dibenzo [a, e] pyrene
21	3-Methylpyrene	41	Coronene
22	Benzo [g, h, i] fluoranthene	42	Dibenzo [a,e] pyrene
23	Benzo [c] phenanthrene	43	Dibenzo [a, i] pyrene
24	Benzo [a] anthracene	44	Dibenzo [a, h] pyrene

Quantitative analysis of PAH by U. V. spectroscopy is possible after separation (*e. g.* by TLC). For the analysis in mixtures the qualitative composition must be known and a large number of key bands be mensured. Mathematical treatment of data is usually done by computer (85). A collection of U. V. spectra including a large number of polycyclic compounds is available (86).

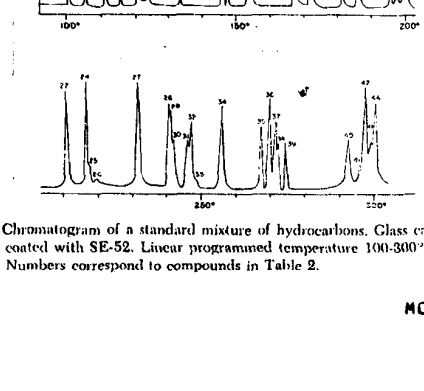

Fig. 7. Chromatogram of a standard mixture of hydrocarbons. Glass capillary column coated with SE-52. Linear programmed temperature 100-300°, rate 1.8/min. Numbers correspond to compounds in Table 2.

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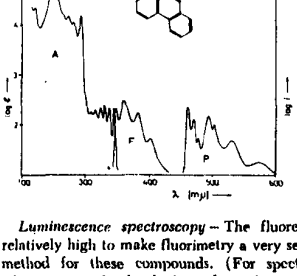

Fig. 8. Electronic spectra of phenanthrene. A. absorption (UV) spectrum (cyclohexane); F, fluorescence spectrum (benzene); P, phosphorescence spectrum (ethanol, isopentane, ether, 2:5:5; 77°K).

Luminescence spectroscopy – The fluorescence quantum yield for most PAH is relatively high to make fluorimetry a very sensitive and therefore widely used analytical method for these compounds. (For spectra of polycyclic hydrocarbons see (87). Fluorescence of individual members of a mixture can be observed when their absorption spectra differ and selective excitation wavelengths are used (88).

Fluorescence spectra are usually recorded in solution at room temperature. Spectra obtained at low temperature in a suitable matrix (n -alkanes, n -pentane to n -decane; cyclohexane) frequently give very characteristic spectra showing many bands (Shpol'skiispectra).

An interesting new technique is the so-called "quenchofluorimetry" (89) of multicomponent mixtures. This method is based on the fact that the fluorescence of some compounds is quenched more than of others if a "quencher" is added to the mixture. PAH with the fluoranthene ring system (89; quencher: nitromethane) and perylene (90; quencher; methyl iodide) for instance can be determined in complex PAH mixtures by this method.

Phosphorescence spectra which are measured in solid solution at low temperatures usually show a higher selectivity than fluorescence spectra. Fig. 8 shows the U.V.–fluorescence and phosphorescence spectrum of phenanthrene. A comparison of U. V.–fluorescence and phosphorescence spectroscopy is given in Table 3. For the analysis of PAH in the environment separation prior to analysis by U. V. or luminescence spectroscopy is necessary. The most commonly used combination is TLC fluorescence. Samples for quantitative analysis can either be eluted from the TLC plates or more elegantly determined by *in situ* measurements (91).

Mass spectrometry–Mass spectrometric analysis plays an important role in the identification of polycyclic aromatic hydrocarbons (92-96) and this technique is particularly useful in combination with gas chromatography. The combined GC-MS

TABLE 3

Comparison* of U.V. fluorescence and phosphorescence spectroscopy

Method	Selectivity	Sensitivity	Reproducibility
U. V.	+	+	++
Fluorescence	++	+++	++
Phosphorescence	+++	+++	++

+++ excellent
++ good
+ average

*Adapted from M. Zander, "Analysis of Polycyclic Aromatics" presented at the "third Annual Symposium on Recent Advances in the Analytical Chemistry of Pollutants," Athens, Ga., May 1973

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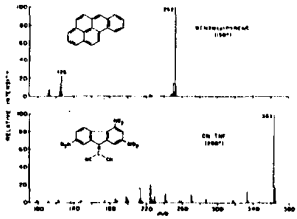

Fig. 9. 70 eV mass spectrum of benzo [a] pyrene 9-cyanomethylene-2, 4, 7-trinitrofluorene complex eluted from TLC at different sample temperatures (as indicated); (a), benzo [a] pyrene (b). CNTNF.

technique (97) has been used in studies in which the identity of the observed gas chromatographic peaks has been confirmed by the characteristic mass spectra of the components.

PAH may be located on TLC plates by the characteristic color they form with electron acceptor reagents. The complexes may be transferred directly to a mass spectrometer sample tube and individual spectra of the compounds be obtained by thermal dissociation and fractional sublimation in the ion source of a mass spectrometer (98). Mass spectra of benzo [a] pyrene and the complexing agent 9-dicyanomethylene-2, 4, 7-trinitrofluorene obtained at different sample temperatures from the complex are shown in Fig. 9.

The mass spectra of most polycyclic aromatic hydrocarbons exhibit several common fragmentation pathways; *i.e.*:

1) The molecular ion is usually the most abundant ionic species and this greatly facilitates the determination of the molecular formula of the hydrocarbon.
2) In addition, the M^{+}-1, M^{+}-2 and M^{+}-3 species are also relatively intense.
3) Methyl substituted aromatic hydrocarbons exhibit M^{+}-15 ions.
4) Doubly-charged ions are observed for most of the aforementioned ionic species.

These characteristics indicate that mass spectrometry does not readily distinguish between isomeric polycycolic aromatic hydrocarbons since very few fragment ions are produced and the molecular ion tends to dominate the spectra. This characteristic can, however, be an advantage with the GC-MS technique since the separation of many isomeric hydrocarbons can readily be effected by gas chromatography and the resulting mass spectra gives confirmation of the GC assignments.

Infrared spectra – IR spectra are useful for identifying alkyl derivatives of naphthalene. IR spectra, do not, however, have any advantages over U.V. spectra in the identification of unsubstituted PAH, but are very useful in the structure determination of new compounds (12).

Nuclear Magnetic Resonance Spectra

Proton magnetic resonance spectroscopy can be used for the identification of PAH and their alkyl derivatives (12, 14). Experimental difficulties exist with the highly condensed systems because of their low solubility.

220 MHz Proton magnetic resonance spectrum of benzo [a] pyrene has recently been published (99) and C-13 NMR spectra of several simple condensed systems have been recorded (100).

BIOLOGICAL ACTIVITY AND METABOLISM

It is now generally accepted (101) that to be carcinogenic, polycyclic aromatic hydrocarbons undergo metabolic activation. Epoxides (102, 103) may be involved and reaction with nucleic acid components (99, 103, 104) have been suggested. The

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molecular properties and chemical reactivity of carcinogenic hydrocarbons with respect to their biological activity has been intensively studied (for references see 99; see also 105-107).

Metabolism of polycyclic aromatic hydrocarbons (45, 108, 109) in mammals and microsomal enzyme preparations yield oxygenated derivatives. Hydroxy compounds are usually formed and epoxides (102, 109, 110) have been shown to be intermediates. The synthesis, properties and metabolism of PAH-epoxides has recently been extensively studied (111-114).

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Polynuclear Hydrocarbon Standards

Catalog #	Product	Synonym	Min. Purity	Price
RNH001	Acenaphthene		99%	7.00/100mg
RNH002	Acridine		99%	14.00/100mg
RNH003	Anthanthrene		99%	45.00/10mg
RNH004	Anthracene		99%	7.00/100mg
RNH005	Azulene		99%	10.00/10mg
RNH006	1, 2-Benzanthracene	Tetraphene	99%	7.00/10mg
RHN007	Benz [a] anthracene-7, 12-Dione	Benzanthraquinone	80%	14.00/100mg
———	2, 3-Benzanthracene	See Tetracene		
———	Benzanthraquinone	See Benz [a] anthrancene-7, 12-dione		
———	9, 10-o-Benzeno-9, 10-dihydroanthracene	See Triptycene		
RNH026	2, 3 Benzocarbazole 5H-Benzo [b] carbazole	5H-Benzo [b] carbazole See 2, 3-Benzocarbazole	98%	7.00/100mg
RNH027	1, 2-Benzocoronene		95%	14.00/10mg
RNH028	1, 2-Benzodiphenylene-sulfide		99%	12.00/100mg
RNH029	Benzo [b] fluoranthene		95%	13.00/100mg
RNH030	Benzo [g, h, i] fluoranthene		95%	17.00/100mg
RNH006	1, 2-Benzofluorene		99%	10.00/10mg
RNH031	2, 3-Benzofluorene		99%	10.00/10mg
RNH032	Benzo g,h,i, (gi), perylene	1, 12-Benzoperylene	99%	10.00/10mg
———	1, 12-Benzoperylene	See Benzo [g, h, i] Perylene		
———	9, 10-Benzophenanthrene	See Triphenylene		
RNH033	Benzo (a) pyrene	3, 4-Benzopyrene	98%	17.00/100mg
———	3, 4-Benzopyrene	See Benzo [a] pyrene		
RNH009	5, 6-Benzoquinoline	Benzo [f] quinoline or β -Naphthoquinoline	99%	10.00/100mg
	Benzo [f] quinoline	See 5, 6-Benzoquinoline		
RNH010	1, 1'-Binaphthyl		95%	10.00/100mg
RCS001	Biphenyl		99%	7.00/500mg
RNH011	Carbazole		99%	7.00/100mg
PRH012	Chrysene		99%	14.00/100mg
RNH013	Coronene		98%	18.00/10mg
RNH016	1, 2, 3, 4-Dibenzanthracene	Dibenz [a, c] Anthracene	99%	10.00/10mg
RNH017	1, 2, 5, 6-Dibenzanthracene	Dibenz [a, h] Anthracene	99%	7.00/10mg
RNH018	1, 2, 7, 8-Dibenzanthracene	Dibenz [a, j] anthracene	95%	12.00/10mg
———	Dibenz [a, c] anthracene	See 1, 2, 3, 4-Dibenzanthracene		
———	Dibenz [a, h] anthracene	See 1, 2, 5, 6-Dibenzanthracene		
———	Dibenz [a, j] anthracene	See 1, 2, 7, 8-Dibenzanthracene		
RNH019	2, 3, 5, 6-Dibenzfluoranthene		98%	14.00/10mg
RNH020	3, 4, 5, 6-Dibenzocarbazole		95%	8.00/10mg
RCS067	Dibenzo-p-dioxin		99%	15.00/50mg
RCS070	Dibenzofuran		99%	7.00/500mg
RNH021	1, 2, 4, 5-Dibenzopyrene		98%	17.00/100mg
RNH014	Dibenzothiophene	Diphenylenesulfide	99%	7.00/100mg
RNH015	1, 2, 8, 9-Dibenzpentacene		99%	14.00/10mg
RNH022	9, 10-Dihydroanthracene		99%	17.00/100mg
———	10, 15-Dihydro-5H-Diindeno [1, 2a-1', 2'-c] Fluorene	See Truxene		

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Polynuclear Hydrocarbon Standards

Catalog #	Product	Synonym	Min. Purity	Price
RNH023	Diindeno [1, 2, 3-cd-1', 2', 3'-lm] Perylene	Periflanthene	98%	9.00/100mg
RNH024	3, 6-Dimethylphenanthrene		99%	7.00/10mg
RNH025	9, 10-Diphenylanthracene		99%	7.00/100mg
———	Diphenylenesulfide	See Dibenzothiophene		
RNH034	Dodecahydrotriphenylene		99%	7.00/100mg
RNH034	Durene	1, 2, 4, 5-Tetramethylbenzene	99.9%	7.00/100mg
RNH036	Fluoranthene		99%	7.00/100mg
RNH037	Fluorene		99%	14.00/100mg
RNH038	Hexamethylbenzene		99%	7.00/100mg
	Indeno [1, 2, 3-cd] pyrene	See o-Phenylenepyrene		
RNH039	2-Methylanthracene		99%	8.00/100mg
RNH040	9-Methylanthracene		99.99%	14.00/100mg
RNH041	4-Methyl Biphenyl	4-Phenyltoluene	98%	10.00/100mg
RNH042	4, 5-Methylenephenanthrene		99%	19.00/100mg
RNH043	2-Methylfluorene		95%	7.00/100mg
RNH044	1-Methylphenanthrene		99%	7.00/100mg
RNH045	2-Methyl phenanthrene		99%	7.00/100mg
RNH046	3-Methyl phenanthrene		95%	7.00/100mg
———	Naphthacene	See Tetracene		
RCS072	Naphthalene		99%	7.00/500mg
	β -Naphthoquinoline	See 5, 6-Benzoquinoline		
RNH047	Octadecahydrochrysene		95%	14.00/100mg
RNH048	Pentacene		98%	18.00/10mg
	Periflanthene	See Diindeno [1, 2, 3-cd-1', 2', 3'-lm] perylene		
RNH049	Perylene		99%	14.00/100mg
RNH050	Phenanthrene		99%	7.00/100mg
RNH051	Phenanthrenequinone		95%	14.00/100mg
RNH052	9-Phenylanthracene		98%	14.00/100mg.
RNH053	o-Phenylenepyrene	Indeno [1, 2, 3-cd] pyrene	99%	7.00/10mg
RNH054	2-Phenylnaphthalene		99%	19.00/100mg
RNH055	4-Phenyltoluene	4-Methyl biphenyl	99%	
RNH056	Picene			12.00/100mg
RNH057	Pyrene		99%	7.00/100mg
RNH058	p-Quaterphenyl		98%	14.00/10mg
RNH059	m-Quinquephenyl		95%	32.00/10mg
RCS059	o-Terphenyl		99%	7.00/100mg
RCS060	m-Terpenyl		99%	7.00/100mg
RCS061	p-Terphenyl		99%	7.00/100mg
RNH060	Tetracene	Naphtacene	99%	14.00/10mg
RNH061	Tetradecahydrophenanthrene		95%	18.00/100mg
RNH062	1, 2, 3, 4-Tetrahydrofluoranthene		90%	18.00/100mg
———	1, 2, 4, 5-Tetramethylbenzene	See Durene		
———	Tetraphene	See 1, 2-Benzanthracene		
RNH063	1, 2, 3, 4-Tetraphenylnaphthalene		97%	7.00/100mg
RNH064	Triphenylene	9, 10-Benzophenanthrene	99%	10.00/10mg
RNH065	Triptycene	9, 10-o-Benzeno-9, 10-dihydroanthracene	98%	18.00/10mg
RNH066	Truxene	10, 15-Dihydro-5H-diindeno [1, 2-a 1', 2',-c] fluorene	95%	14.00/100mg

MONS 067550

THE SOLUBILITIES OF TWENTY-ONE CHLOROBIPHENYLS IN WATER

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Commercial PCB preparations consist of complicated mixtures of chlorobiphenyls with different chlorine content and their isomers. The composition of these technical products has only recently been established [1-5].

A knowledge of the solubilities of PCB components is necessary for experiments involving individual isomers and may also be useful for the evaluation of PCB distribution in natural waters.

Considerable differences in the solubilities of chlorobiphenyls with different numbers of chlorination as well as positional isomers were indicated by change in the GC peak pattern of Aroclor 1254 re-extracted from aqueous solutions with hexane[1] Solubilities of five mono-and dichlorobiphenyls also vary widely[6].

We wish to present the results of our study on the solubilities of twenty-one chlorobiphenyls in water. Most of the compounds investigated are major components of commercial PCB preparations. Since water soluble humic substances were recently reported to act as carriers for lipophylic compounds including pollutants[9, 10] the solubility of 4, 4'-dichlorobiphenyl in aqueous extracts of humic acid was also measured. The solubility of this compound was also determined in the presence of different concentrations of Tween 80. Aroclor preparations have an increased solubility in water in the presence of solubilizers[11] and the presence of the biologically relatively inert Tween 80 (e.g. 2% Tween 80 in nutrient solution showed no measurable growth inhibition in a number of microorganisms [12]) may allow the use of higher concentrations of chlorobiphenyl in many experiments.

EXPERIMENTAL

Instrumentation. Gas chromatography (GC) was carried out on a Varian 1800 instrument using a glass column (5 ft. x 2 mm i.d.) packed with 1.5% XE-60 on Anakrom Q operated at temperatures of 160-100°C depending on the compound. Carrier gas was nitrogen at a flow rate of 30 ml/min. Injector and electron capture detector were kept at 220°C.

Chemicals. Chlorobiphenyls (99% pure) were either Syntherized or obtained from Analabs Inc. (North Haven, Conn., U.S.A.). Humic acid was purchased from Aldrich Chem. Co. (Milwaukee, Wisc., U.S.A.).

Methods. An example for the determination of the solubility of one chlorobiphenyl in water is given below.

A hexane solution of the chlorobiphenyl (1 mg) was pipetted into a 300 ml Erlenmeyer flask and the solvent evaporated to give a thin film of the compound. Water (100 ml) was added, the flask sealed with parafilm and the mixture shaken at 30°C for 10 days. After this time the aqueous suspension was allowed to equilibrate at 22-24°C for 3 hr. Contact of aqueous chlorobiphenyl solution with glass was kept to a minimum after this step because of the known adsorption effects[13]. An aliquot (10 ml) was drawn using a syringe carrying a small filter compartment and immediately

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extracted with hexane (2 x 10 ml). The hexane extract was concentrated to 10 ml and 2 µl samples were injected into the gas chromatograph. Quantitative evaluation was carried out by measuring the peak height using calibration curve of known amounts of chlorobiphenyl standard in hexane. Sampling and analyses were carried out in duplicate.

RESULTS AND DISCUSSION

In view of the problems with adsorption and low solubility, the experiments were not designed to give solubility data as absolute physical constants but were intended to yield comparable values of reasonable accuracy for biological experiments.

The data for twenty-one chlorobiphenyls in water are shown in Table 1.

TABLE 1

Solubility of chlorobiphenyls in water

Compound	Solubility (mg)	(ppm)
Monochlorobiphenyls		
2-	6.0	5.8
3-	3.35	3.6
4-	1.20	1.17
Dichlorobiphenyls		
2, 4-	1.40	1.40
2, 2'-	1.56	1.44
2, 4'-	1.90	1.85
4, 4'-	0.08	0.07
Trichlorobiphenyls		
2, 4, 4'-	0.085	0.085
3, 4, 2'-	0.075	0.080
Tetrachlorobiphenyls		
2, 2', 5, 5'-	0.046	0.046
2, 3, 2', 3'-	0.037	0.030
2, 3, 2', 5'-	0.170	0.170
2, 4, 2', 4'-	0.070	0.065
2, 4, 3', 4'-	0.055	0.060
2, 5, 3', 4'-	0.041	0.041
3, 4, 3', 4'-	0.175	0.175
Pentachlorobiphenyls		
2, 3, 4, 2', 5'-	0.021	0.023
2, 4, 5, 2', 5'-	0.035	0.028
Hexachlorobiphenyl		
2, 2', 4, 4', 5, 5'-	0.0088	0.0088
Octachlorobiphenyl		
2, 3, 4, 5, 2', 3', 4', 5'-	0.0068	0.0072
Decachlorobiphenyl	0.015	0.015
4, 4'-Dichlorobiphenyl		
+ Tween 10 0.1%	6.2	5.5
+ Tween 80 1%	10.0	10.0
+ Humic acid extract	0.075	0.06

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PROGRESS REPORTS ON PCB ISOMERS

By: Michael Bolgar

Given the toxicity and persistence of the widely dispersed polychlorinated biphenyls (PCB's) it seems logical that the U.S. Interdepartmental Taskforce on PCB's in their 181-page May 1972 Report (Com-7_2-10419) would include as part of their recommendation (page 18) the following additional studies, (italics are ours):

1. *Toxicological evaluation of a select number of representative, purified PCB isomers as well as purified trace contaminants such as the chlorinated dibenzofurans.*

2. Definitive mammalian elaboration of the kinetics, absorption, distribution, metabolism, and excretion of the technical PCBs as well as *a number of key isomers and the chlorinated dibenzofurans.*

3. Elaboration of the subcellular and intracellular actions of the technical PCBs as well as *a number of representative isomers and chlorinated dibenzofurans.*

4. More definitive epidemiological studies of the PCBs with both more representative population sampling and standardization on the basis of lipid content of the tissues.

In our list of biphenyls and 50 isomers of the 209 possible chlorobiphenyls we included a great number of the major components present in the commercial mixtures. For

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instance, Willis and Addison[1] report that the major components of Aroclor 1221 accounting for 92.3 weight per cent are biphenyl, 2-Cl, 4-Cl, 2, 2'-Cl_2, 2, 4'-Cl_2 (all available from Analabs stock). From Sissons and Welti's[2] list of the major components of the more important Aroclor 1254 (we list more than half). Methods have been developed[3] to recover PCB's present in waste and river water and to increase detectability by perchlorinating the samples sensitizing them to electron-capture detection by gas chromatography[4].

We have made the tools available (polyurethane foam plugs and perchlorination kits).

Assembled below is data of melting points taken of our pure isomers and taken from the literature. This list reveals interesting features of configuration/physical property corelation.

MELTING POINTS OF POLYCHLORINATED BIPHENYLS

Chlorine Position	*Melting Points*
Mono	
2-Cl	32.0-32.5°C
3-Cl	Oil
4-Cl	75.5-77.0°C
Di	
2, 3-Cl_2	Oil (Lit. 27.7-28.2°C)
2, 4-Cl_2	Oil (Lit. 24-25°C)
2, 5-Cl_2	Oil (Lit. 22-23°C)
2, 6-Cl_2	34-35°C
3, 4-Cl_2	47-48°C
3, 5-Cl_2	Oil (Lit. 31-32°C)
2, 2'-Cl_2	60-61°C
3, 3'-Cl_2	25-26°C
4, 4'-Cl_2	148-149°C
2, 3'-Cl_2	Lit. Oil
2, 4'-Cl_2	42.5-43.5°C
3, 4'-Cl_2	Lit. Oil
Tri	
2, 3, 4-Cl_3	101-102°C
2, 3, 5-Cl_3	Lit. 41°C
2, 3, 6-Cl_3	58-60°C
2, 4, 5-Cl_3	76-78°C
2, 4, 6-Cl_3	62.0-63.5°C
2, 3, 2'-Cl_3	Lit. 28-29°C
2, 3, 4'-Cl_3	Lit. 73°C
2, 4, 4'-Cl_3	57.0-57.5°C
2, 5, 2'Cl_3	43-44°C
2, 5, 3'-Cl_3	40.0-40.5°C
2, 5, 4'-Cl_3	63.5-64.5°C
3, 4, 2'-Cl_3	60.0-60.5°C
3, 4, 4'-Cl_3	Lit. 87-88°C
3, 5, 2'-Cl_3	Lit. 58°C
3, 5, 4'-Cl_3	Lit. 88°C

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MELTING POINTS OF POLYCHLORINATED BIPHENYLS

Chlorine Position	*Melting Points*
Tetra	
2, 3, 4, 5-Cl_4	91.5-92.5°C
2, 3, 5, 6-Cl_4	77.0-77.5°C
2, 3, 4, 4'-Cl_4	Lit. 141-142°C
2, 4, 5, 4'-Cl_4	Lit. 125°C
2, 3, 2' 3'-Cl_4	119.5-121.5°C
2, 3, 2' 5'-Cl_4	46.5-47.0°C
2, 4, 2' 4'-Cl_4	41-42°C
2, 4, 2' 5'-Cl_4	64-66°C
2, 4, 3' 4'-Cl_4	127-128°C
2, 5, 2' 5'-Cl_4	86-87°C
2, 5, 3' 4'-Cl_4	104-107°C
2, 6, 2', 6'-Cl_4	190-200°C (sublimes)
3, 4, 3', 4'-Cl_4	182-184°C
3, 5, 3', 5'-Cl_4	Lit. 164°C
Penta	
2, 3, 4, 5, 6,-Cl_5	123-125°C
2, 3, 4, 5, 4'-Cl_5	Lit. 98-99°C
2, 3, 4, 2', 5'-Cl_5	111.5-113.0°C
2, 3, 4, 3' 4'-Cl_5	Lit. 101-105°C
2, 3, 6, 2' 5'-Cl_5	97-98°C
2, 4, 5, 2' 3'-Cl_5	81-82°C
2, 4, 5, 2' 5'-Cl_5	76.5-77.5°C
2, 4, 5, 3' 4'-Cl_5	Lit. 105-107°C
Hexa	
2, 3, 4, 5, 6, 2'-Cl_6	Lit. 134-137°C
2, 3, 4, 5, 6, 3'-Cl_6	Lit. 97-100°C
2, 3, 4, 5, 6, 4'-Cl_6	Lit. 160-165°C
2, 3, 4, 5, 2' 4'-Cl_6	Lit. 77-78°C
2, 3, 4, 5, 2' 5'-Cl_6	89-91°C
2, 3, 5, 6, 2' 5'-Cl_6	100-101°C
2, 3, 4, 2' 3' 4'-Cl_6	155-8°C
2, 3, 4, 2' 4' 5'-Cl_6	78.5-80.0°C
2, 3, 5, 2' 3' 5'-Cl_6	Lit. 128-129°C
2, 3, 6, 2' 3' 6'-Cl_6	115-117°C
2, 3, 6, 2' 4' 5'-Cl_6	Lit. Oil
2, 4, 5, 2' 4' 5'-Cl_6	102-104°C
2, 4, 5, 2' 4' 6'-Cl_6	Lit. Oil
2, 4, 6, 2' 4' 6'-Cl_6	113.5-114.5°C
3, 4, 5, 3', 4' 5'-Cl_6	Lit. 198

MONS 067555

MELTING POINTS OF POLYCHLORINATED BIPHENYLS

Chlorine Position	*Melting Points*
Hepta	
2, 3, 4, 5, 6, 2' 5'-Cl_7	147-150°C
2, 3, 4, 5, 6, 3', 4'-Cl_7	Lit. 116-118°C
2, 3, 4, 5, 2', 3', 4'-Cl_7	Lit. 134.5-135.5°C
2, 3, 4, 5, 2' 3' 6'-Cl_7	Lit. 130.5-130.7°C
2, 3, 4, 5, 2' 4' 5'-Cl_7	Lit. 109-110°C
2, 3, 4, 5, 2' 4' 6'-Cl_7	Lit. 152-153°C
2, 3, 4, 5, 3' 4' 5'-Cl_7	Lit. 162-163°C
Octa	
2, 3, 4, 5, 2' 3' 4' 5'-Cl_8	158-159°C
2, 3, 4, 6, 2' 3' 4' 6'-Cl_8	Lit. 132°C
2, 3, 5, 6, 2' 3' 5' 6'-Cl_8	161-162°C
Nona	
2, 3, 4, 5, 6, 2' 3' 4' 5'-Cl_9	204.5-206.5°C
Deca	
2, 3, 4, 5, 6, 2' 3' 4' 5' 6'-Cl_{10}	300-310°C (sublimes)

All melting Points taken on a Fischer-Johns melting point stage.

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MONS 067556

99% Pure PCB Isomers

For clarity we have kept the position numbering separate for each ring. For Chemical Abstracts nomenclature transpose numbers listing lowest number first.

RCS-001	Biphenyl	$7.00/500mg
RCS-002	2-Chlorobiphenyl	7.00/100mg
RCS-003	3-Chlorobiphenyl	7.00/100mg
RCS-004	4-Chlorobiphenyl	7.00/100mg
RCS-005	2, 2'-Dichlorobiphenyl	18.00/100mg
RCS-006	3, 3'-Dichlorobiphenyl	18.00/100mg
RCS-007	4, 4'-Dichlorobiphenyl	18.00/100mg
RCS-008	2, 4'-Dichlorobiphenyl	32.00/50mg
RCS-009	2, 3-Dichlorobiphenyl	14.00/100mg
RCS-010	2, 4-Dichlorobiphenyl	14.00/100mg
RCS-011	2, 5-Dichlorobiphenyl	14.00/100mg
RCS-012	2, 6-Dichlorobiphenyl	14.00/100mg
RCS-013	3, 4-Dichlorobiphenyl	14.00/100mg
RCS-014	3, 5-Dichlorobiphenyl	14.00/100mg
RCS-015	2, 4, 4'-Trichlorobiphenyl	26.00/20mg
RCS-052	2, 4, 3', 4'-Tetrachlorobiphenyl	32.00/20mg
RCS-016	2, 5, 2'-Trichlorobiphenyl	28.00/50mg
RCS-017	2, 5, 3'-Trichlorobiphenyl	28.00/50mg
RCS-018	2, 5, 4'-Trichlorobiphenyl	28.00/50mg
RCS-019	3, 4, 2'-Trichlorobiphenyl	28.00/50mg
RCS-020	2, 3, 4-Trichlorobiphenyl	26.00/50mg
RCS-021	2, 3, 6-Trichlorobiphenyl	30.00/50mg
RCS-022	2, 4, 5-Trichlorobiphenyl	22.00/100mg
RCS-023	2, 4, 6-Trichlorobiphenyl	26.00/100mg
RCS-024	2, 3, 2', 3'-Tetrachlorobiphenyl	28.00/100mg
RCS-025	2, 4, 2', 4'-Tetrachlorobiphenyl	28.00/100mg
RCS-026	2, 5, 2', 5'-Tetrachlorobiphenyl	28.00/100mg
RCS-027	2, 6, 2', 6'-Tetrachlorobiphenyl	28.00/100mg
RCS-028	3, 4, 3', 4'-Tetrachlorobiphenyl	28.00/100mg
RCS-029	2, 3, 2', 5'-Tetrachlorobiphenyl	35.00/50mg
RCS-030	2, 4, 2', 5'-Tetrachlorobiphemyl	22.00/20mg
RCS-031	2, 5, 3', 4'-Tetrachlorobiphenyl	35.00/50mg
RCS-032	2, 3, 4, 5,-Tetrachlorobiphenyl	20.00/50mg
RCS-033	2, 3, 5, 6-Tetrachlorobiphenyl	20.00/50mg
RCS-034	2, 3, 4, 2', 5'-Pentachlorobiphenyl	25.00/20mg
RCS-035	2, 3, 6, 2', 5'-Pentachlorobiphenyl	22.00/10mg
RCS-036	2, 4, 5, 2', 3'-Pentachlorobiphenyl	22.00/10mg
RCS-038	2, 4, 5, 2', 5'-Pentachlorobiphenyl	35.00/50mg
RCS-039	2, 3, 4, 5, 6-Pentachlorobiphenyl	28.00/100mg
RCS-040	2, 3, 4, 2', 3', 4'-Hexachlorobiphenyl	32.00/20mg
RCS-041	2, 3, 4, 2', 4', 5'-Hexachlorobiphenyl	28.00/10mg
RCS-042	2, 3, 6, 2', 3', 6'-Hexachlorobiphenyl	36.00/20mg
RCS-043	2, 4, 5, 2', 4', 5'-Hexachlorobiphenyl	36.00/100mg
RCS-044	2, 4, 6, 2', 4', 6-Hexachlorobiphenyl	32.00/50mg
RCS-045	2, 3, 4, 5, 2', 5'-Hexachlorobiphenyl	28.00/10mg
RCS-046	2, 3, 5, 6, 2', 5'-Hexachlorobiphenyl	28.00/10mg
RCS-047	2, 3, 4, 5, 6, 2', 5'-Heptachlorobiphenyl	36.00/10mg
RCS-048	2, 3, 4, 5, 2', 3', 4', 5'-Octachlorobiphenyl	26.00/20mg
RCS-049	2, 3, 5, 6, 1', 3', 5', 6'-Octachlrobiphenyl	26.00/20mg
RCS-050	2, 3, 4, 5, 6, 2', 3', 4', 5'-Nonachlorobiphenyl	36.00/10mg
RCS-051	2, 3, 4, 5, 6, 2', 3', 4', 5', 6'-Decachlorobiphenyl	7.00/100mg

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Bibliography on PCB Literature available on request.

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For complete extraction of pesticides and PCB's from environmental water samples (for instance – river water).
References:

1. The extraction and recovery of polychlorinated biphenyls (PCB) using porous polyurethane foam. H. D. Gesser, A. Chow, F. C. Davis, J. F. Uthe, and J. Reinke. Anal. Lett., 4, 883-6 (1971).
2. Extraction of organochlorine pesticides from water by porous polyurethane. J. F. Uthe, J. Reinke and H. Gesser, Environmental Letters, 3, 117-135 (1972).

Written procedure for extraction of pesticides and PCB's from water samples will be supplied with each order or on request.

Polyurethane-foam plugs (22mm x 38mm)

RCS-083	Untreated	$10.00/50
RCS-084	Washed	12.00/12
RCS-085	Treated with 0.5% DC-200	12.00/12

Chromatographic Tubes (20mm ID, 400mm long)

RCS-086	Tube without fritted disc	$13.00/2 tubes
RCS-087	Tube with fritted disc	11.00/each

Perchlorination Kits for Analysis of Polychlorinated Aromatics

References:

1. Analysis of chlorinated aromatic hydrocarbons by exhaustive chlorination: Qualitative and structural aspects of the perchloro derivatives of biphenyl, naphthalene, terphenyl, dibenzofuran, dibenzodioxin and DDE. O. Hutzinger, S. Safe, and V. Zitko.
   International Journal of Environmental Analytical Chemistry, 2, 95 (1972).
2. Column chromatographic separation of polychlorinated biphenyls from chlorinated hydrocarbon pesticides, and subsequent gas chromatographic quantitation in terms of derivatives. O. W. Berg, P. L. Diosady and G. A. V. Rees Bulletin of Environmental Contamination and Toxicology, 7, #6, 338-347, (1972).
3. Screening method for the detection of chlorodibenzo-p-dioxins in the presence of chlorobiphenyls, chloronaphthalenes, and chlorodibenzofurans. D. T. Williams and B. J. Blanchfield, JAOAC. 55, 93-5 (1972).

RCS079	Perchlorination reagents A_1 and A_2 For PCB's, PCDD's, PCF's, and p,p'-DDE (in equal volumes).	$10.00
RCS080	Perchlorination reagent B For PCB, PCT and p,p'-DDE	6.00
RCS081	Perchlorination reagent C For PCN's	6.00
RCS082	Perchlorination kit (A_1, A_2, B, C)	16.00

Detailed perchlorination procedures will be supplied on request and with each order.

MONS 067558

POLYCHLORINATED BIPHENYL MIXTURES

RCS066 ..... PCB-Kit (1 gm each of Aroclor 1232, 1242, 1248, 1254, 1260 and 1268) 9.00/kit

99% POLYCHLORINATED NAPHTHALENES

RCS072 ..... Naphthalene ..... $ 7.00/500 mg
RCS073 ..... 1-Chloronaphthalene ..... 7.00/100 mg
RCS074 ..... 2-Chloronaphthalene ..... 7.00/100 mg
RCS075 ..... 1,2,3,4,5,6,7,8-Octachloronaphthalene ..... 15.00/50 mg
RCS076 ..... Halowax kit (1 gm each of 1031,1000, 1001, 1099, 1013, 1014, 1051) 10.00/kit

Halowax Number	1031	1000	1001	1099	1013	1014	1051
Approx. % Chlorine	22	26	50	52	56	62	70

Number of Chlorines	1	2	3	4	5	6	7	8
% of Chlorine	21.85	36.40	46.00	53.38	59.07	63.6	67.2	70.3

Reference: Behavior of chlorinated naphthalenes in analytical methods for organochlorinated pesticides and polychlorinated biphenyls. J. A. Armour and J. A. Burke, JAOAC, 54, 175-7 (1971).

99% POLYCHLORINATED DIBENZO-P-DIOXINS

RCS053 ... 1-Chlorodibenzo-p-dioxin ..... 20/50 mg
RCS054 ... 2-Chlorodibenzo-p-dioxin ..... 20/50 mg
RCS067 ... Dibenzo-p-dioxin ..... $15.00/50 mg
RCS055 ... 2, 3-Dichlorodibenzo-p-dioxin ..... 25/50 mg
RCS068 ... 2, 7-Dichlorodibenzo-p-dioxin ..... 25.00/50 mg
RCS069 ... 1, 2, 3, 4, 6, 7, 8, 9-Octachlorodibenzo-p-dioxin ..... 20.00/50 mg
RCS056 ... 1, 2, 4-Trichlorodibenzo-p-dioxin ..... 25/50 mg
RCS057 ... 1, 2, 3, 4-Tetrachlorodibenzo-p-dioxin ..... 25/50 mg

References:

1. Thin-layer chromatographic separation of two chlorodibenzo-p-dioxins from some polychlorinated biphenyls and organochlorine pesticides. D. T. Williams and B. J. Blanchfield, JAOAC, 54, 1429-31 (1971).
2. Determination of polychlorodibenzo-p-dioxins in chlorophenols and lipids. D. Firestone, Paper presented at the 162nd National ACS Meeting, Pesticide Div., Sept. 12-17, 1971.

99% POLYCHLORINATED DIBENZOFURANS

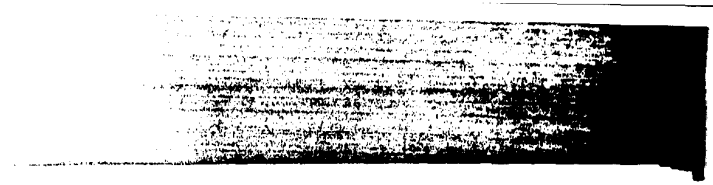
RCS070 ..... Dibenzofuran ..... $ 7.00/500 mg
RCS058 ..... 3, 6-Dichlorodibenzofuran ..... 36/20 mg
RCS071 ..... 1,2,3,4,5,6,7,8-Octachlorodibenzofuran ..... 15.00/50 mg

Reference: Identification and toxicological evaluation of chlorinated dibenzofuran and chlorinated naphthalene in two commercial polychlorinated biphenyls. J. G. Vos, J. H. Koeman, H. L. van der Maas, M. C. Ten Noever de Brauw and R. H. de Vos, Food Cosmet. Toxicol., 8, 625-633 (1970).

OTHER POLLUTION STANDARDS

RCS077 ..... Hexachlorophene [2,2'-Methylenebis-(3,4,6-trichlorophenol)] ..... $ 5.00/1 mg
RCS078 ..... Perchlorinated p,p'-DDE ..... 20.00/50 mg

MONS 067559



PESTICIDE STANDARDS

The list of pesticide standards that follows is possibly the most extensive compilation offered. For your convenience we have also listed the synonyms and a cross reference for different trade names. If the pesticide you need is not listed, please inquire. (*Available also in solution concentrations of .1 to 1000 PPM in powers of 10).

Catalog #	Product	Synonym	Active Ingredient	% A. I.	Price
———	AAT	See Parathion			
———	Acquinite	See Trichloronitromethane			
———	Acricide	See Binapacryl			
———	Acti-Dione	See Cycloheximide			
RSP050	Alanap	NPA	N-1-Naphthylphthalamic Acid	Tech	10.00/g
RSP051 *	Aldrin	Octalene	1, 2, 3, 4, 10, 10 Hexachloro-1, 4, 4, 5, 8, 8a-hexahydro-1, 4-endoexo-5, 8-dimethano naphthalene	90%	10.00/g
RSP057	Aldrin, tech.		1, 2, 3, 4, 10, 10-Hexachloro-1, 4, 4, 5, 8, 8a-hexahydro-1, 4-endoexo-5, 8-dimethano naphthalene	90%	8.00/g
———	Allron	See Parathion			
RSP089	Allyl Alcohol		Allyl Alcohol	97%	8.00/g
RSP058	Ametryne		2-Methyl mercapto-4-ethylamino-6-isopropylamino-S-triazine	98.5%	10.00/g
RSP059	Ametryne, tech.		2-Methyl mercapto-4-ethylamino-6-isopropylamino-S-triazine	Tech	8.00/g
———	Aminocarb	See Matacil			
RSP081	Amitrole		3-Amino-1, 2, 4,-triazole	90%	20.00/100mg
RSP082	Amitrole, tech.		3-Amino-1, 2, 4,-triazole		8.00/g
RSP083 *	Amobam		Diammonium ethylene bisdithiocarbamate	42%	12.00/g
———	Apracarb	See Baygon			
RSP084	Aramite		2-(p-tert-Butylphenoxy)-isopropyl-2'-chloroethyl sulfite	93%	20.00/100mg
———	Arathane	See Karathane			
RSP085 *	Atrazine	Gesaprim	2-chloro-4-ethylamino-6-isopropylamino-s-triazine	90%	10.00/mg
RSP085	Atrazine, tech.		2-chloro-4-ethylamino-6-isopropylamino-s-triazine		8.00/g
RSP088	Avadex	Di-allate	S-2, 3-Dichloroallyl-N, N-diisopropyl-thiol carbonate	Tech	12.00/g
RSP087	Azinphosmethyl	Guthion Gothion Methyl guthion	O, O-Dimethyl-S-[4-oxo-1, 2, 3-benzotriazin-3 (4H)-yl methyl] phosphorodithioate	96%	15.00/g
RSP088	Azinphosmethyl, tech.		O, O-Dimethyl-S-[4-oxo-1, 2, 3-benzotriazin-3 (4H)-yl methyl] phosphorodithioate		6.00/g
RSP089	Azobenzene		Diphenyldiimide	99%	15.00/100mg
RSP070	Bandane		Polychlorodicyclopentadiene isomers	Tech	12.00/100mg
RSP071	Banvel D	Dicamba	3, 6-Dichloro-o-anisic acid	99%	20.00/100mg
———	Baron	See Erbon			
———	Basudin	See Diazinon			
RSP078	Baygon	Apracarb Unden	o-Isopropoxyphenyl methylcarbamate	Tech	10.00/g
RSP073	Benzyl Benzoate		Benzyl Benzoate	99%	10.00/g
RSP063 *	BHC-mix		Hexachlorocyclohexane isomer mix	Tech	6.00/g
RSP049	α -BHC		Alpha-1, 2, 3, 4, 5, 6-Hexachlorocyclohexane	99%	20.00/100mg
RSP074	β -BHC		Beta-1, 2, 3, 4, 5, 6-Hexachlorocyclohexane	99%	20.00/100mg
———	γ -BHC	See Lindane			
RSP044	δ -BHC		Delta-1, 2, 3, 4, 5, 6 Hexachlorocyclohexane	99%	20.00/100mg
RSP075	Butacrycl	Acricide Miticide	2-sec-Butyl-4, 6-dinitrophenyl-3, 3-dimethylacrylate	98%	10.00/g
RSP076	Butran		2, 6-Dichloro-4-nitroaniline	Tech	10.00/g
———	Bromenil	See Bromoxynil			
RSP077	Bromoxynil	Bromenil Buctryl	3, 5-Dibromo-4-hydroxybenzonitrile	98%	10.00/100mg
———	Buctryl	See Bromoxynil			
RSP078	Butan		2-Nitro-1, 1-bis (p-chlorophenyl) butane	98%	10.00/100mg
———	Butoxide	See Piperonyl Butoxide			
———	Caparol	See Prometryne			

MONS 067560

PESTICIDE STANDARDS

Catalog #	Product	Synonym	Active Ingredient	% A. I.	Price
RSP079	Captan	Orthocide	N-Trichloromethylthio-4-cyclohexene 1, 2-dicarboximide	99%	10.00/g
———	Carbaryl	See Sevin			
———	Carbophenothion	See Trithion			
———	Carbophos	See Malathion			
———	Cardibe	See Ethyl Hexane Diol			
RSP080	Chlorbenside	Sulfide Chlorparacide Chlorsulphacide Mitox	p-chlorobenzyl-p-chlorophenyl	99%	12.00/100mg
RSP004 •	Chlordane	Octachlor	1, 2, 3, 4, 5, 6, 7, 8, 8-Octachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methano indene	Tech.	14.00/g
RSP081	Chloroacetic acid	Monochloroacetic Acid	Chloroacetic Acid	99%	8.00/g
RSP082	Chlorobenzilate		Ethyl-4, 4'-dichlorobenrilate	99%	10.00/g
RSP083	Chlorobenzilate, tech.		Ethyl-4, 4'-dichlorobenzilate	45%	4.00/g
———	Chlorophos	See Trichlorfon			
———	Chloropicrin	See Trichloronitromethane			
———	Chlorsulphacide	See Chlorbenside			
———	Chlorparacide	See Chlorbenside			
RSP084	Cinchrin		α -Methyl benzyl-3-(dimethoxyphosphinyloxy)-cis-crotonate	85%	10.00/g
RSP088 •	Co-Ral	Coumaphos	O, O-Diethyl-O-(3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl phosphoro thioate	99%	2.100/100mg
RSP085	Co-Ral, tech		O, O-Diethyl-O-(3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl phosphoro thioate		6.00/g
———	Coumafene	See Warfarin			
———	Coumaphos	See Co-Ral			
RSP086	Cyclohexamide	Acti-dione	3-[2-(3, 5 Dimethyl-2-oxycyclohexyl) -2-hydroxyethyl] glutarimide	Tech.	12.00/g
———	Cygon	See Dimethoate			
———	Cymen	See Ziraphos			
RSP087	Cypova	Dodine	n-dodecylguanidine acetate	95%	20.00/100mg
RSP088	Cypova, tech.		n-dodecylguanidine acetate		6.00/g
RSP009 •	2, 4-D Acid		2-(2, 4-Dichlorophenoxy) acetic acid	99%	12.00/100mg
RSP007 •	2, 4-D Acid-Methyl Ester		2-(2, 4-Dichlorophenoxy) acetic acid methyl ester	99%	10.00/100mg
RSP089	Dacthal	DCPA	Dimethyl-2, 3, 5, 6-tetrachloroterephthalate	99%	10.00/g
RSP090	Dalapon		2, 2-Dichloropropionic Acid	90%	20.00/100mg
———	Dall	See Methyl Parathion			
RSP091	Dasanet	Mylone	3, 5-Dimethyl-1, 3, 5, 3H-tetrahydrothiadiazin-2-thone	98%	12.00/g
———	DCPA	See Dacthal			
RSP008	DDD mix	TDE mix	1, 1-Dichloro-2, 2-(chlorophenyl) ethane	Tech. (3 isomer mix)	3.00/g
RSP098 •	, p-DDD	o, p-TDE	1, 1-Dichloro-2-(o-chlorophenyl)-2-(p-chlorophenyl) ethane	99%	12.00/100mg
RSP009 •	p, p'-DDD	p, p'-TDE	1, 1-Dichloro-2, 2-bis (p-chlorophenyl) ethane	99%	20.00/100mg
RSP047	o, p-DDE	o, p-DDX	1, 1-Dichloro-2-(o-chlorophenyl)-2-(p-chlorophenyl) ethylene	99%	20.00/100mg
RSP010 •	p, p'-DDE	p, p'-DDX	1, 1-Dichloro-2, 2'-bis (p-chlorophenyl) ethylene	99%	25.00/g
RSP011 •	DDT mix		1, 1, 1-Trichloro-2, 2-bis (chlorophenyl) ethylene	Tech (3 isomer mix)	2.00/g
RSP018 •	o, p-DDT		1, 1, 1-Trichloro-2-(o-chlorophenyl) -2-(p-chlorophenyl) ethane	99%	25.00/g
RSP013 •	p, p'-DDT		1, 1, 1-Trichloro-2, 2-bis (p-chlorophenyl) ethane	99%	12.00/g
——— •	DDVP	See Dichlorvos			
———	o, p-DDX	See o, p-DDE			
———	p, p'-DDX	See p, p'-DDE			
RSP093	DEET	Delphene Detamide	N, N-Diethyl-m-toluamide	95%	12.00/g

MONS 067561

PESTICIDE STANDARDS

Catalog #	Product	Synonym	Active Ingredient	% A. I.	Price
RSP015 ●	DEF		S, S, S-Tributyl phosphorotrithioate	94%	22.00/100mg
———	Delphene	See DEET			
RSP016 ●	Demeton	Syston	Mix of 0 (0, 0-Diethyl-0-2-(ethyl thio) ethyl phosphorothioate) and 0 (0, 0-Diethyl-2-2-(ethylthio) ethyl phosphothioate)	Tech.	20.00/100mg
———	Detamide	See DEET			
RSP004	Dexon		p-Dimethylaminobenzenediazo sodium sulfonate	84%	12.00/100mg
———	DFA	See Diphenylamine			
———	Di-Allate	See Avadex			
RSP017 ●	Diazinon	Basudin	0, 0-Diethyl-0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate	99%	12.00/100mg
RSP005	Diazinon, tech.		0, 0-Diethyl-0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate	40%	6.00/g
RSP018 ●	Dibrom	Naled	1, 2-Dibromo-2, 2-dichloroethyl dimethyl phosphate	93%	12.00/100mg
RSP006	Dibutylphthalate		Dibutylphthalate	99%	12.00/g
———	Dicumba	See Bonvel D			
———	Dicaptan	See Dicapthon			
RSP007	Dicapthon	Dicaptan	0-(2-Chloro-4-nitrophenyl)-0, 0-dimethyl phosphorothioate	99.8%	12.00/100mg
———	Dichlone	See Phygon			
RSP008	o-Dichlorobenzene		o-Dichlorobenzene	99%	6.00/g
RSP009	p-Dichlorobenzene		p-Dichlorobenzene	99%	6.00/g
RSP100	2, 4-Dichlorophenol		2, 4-Dichlorophenol	99%	6.00/g
———	Dichloroprop	See 2, 4-DP-Acid			
RSP014	Dichlorvos	DDVP Herkol Vapona	0, 0-Dimethyl-0-(2, 2-dichlorovinyl) phosphate	99%	12.00/100mg
———	Dicofol	See Kelthane			
RSP019 ●	Dieldrin	Heod	1, 2, 3, 4, 10, 10-Hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endoexo-5,8-dimethanonaphthalene	85%	16.00/g
RSP101	Difolatan		N-(1, 1, 2, 2-Tetrachloroethylsulfenyl) cis-Δ-4-cyclohexene-1, 2-dicarboximide	99%	12.00/100mg
———	Dimecron	See Phosphamidon			
RSP102	Dimethoate	Rogor Cygon Fostion	O, O-Dimethyl-S-(N-Methyl carbamoyl-methyl) phosphorodithioate	99%	22.00/g
RSP103	Dimethyl Phthalate		Dimethyl Phthalate	99%	12.00/g
———	Dinocap	See Karathane			
RSP104	Dinoseb	DNBP	2, 4-Dinitro-6-sec-butyl phenol	99%	12.00/100mg
RSP105	Diphacin	Diphacinone	2-Diphenyl-acetyl-1, 3-indandione	Tech	12.00/100mg
———	Diphacinone	See Diphacin			
RSP106	Diphenamid	Dymid Enid	N, N-Dimethyl 2, 2-diphenylacetamide	Tech	12.00/g
RSP107	Diphenyl-Amine	DFA	Diphenylamine	99%	18.00/g
———	Diptarex	See Trichlorfon			
———	Diptotox	See Trichlorfon			
———	Disulfoton	See Di-Syston			
RSP108	Di-Syston	Disulfoton	O, O-Diethyl-S-2-(ethylthio) ethyl phosphorodithioate	97%	16.00/g
———	Dithane-Manganese	See Maneb			
———	Dithane-Zinc	See Zineb			
———	DMPA	See Zyton			
———	DNBP	See Dinoseb			
———	DNTP	See Parathion			
———	Dodine	See Cypera			
———	Dowen 132	See Ruelene			
RSP109	2, 4-DP-Acid	Dichloroprop	2-(2, 4-Dichlorophenoxy) propionic acid	99%	12.00/100mg
———	DTMC	See Kelthane			
———	Duphar	See Tedion			
RSP110	Dursban		O, O-Diethyl-O-(3, 5, 6-trichloro-2-pyridyl) phosphorothioate	99%	12.00/100mg

MONS 067562

PESTICIDE STANDARDS

Catalog #	Product	Synonym	Active Ingredient	% A.I.	Price
------	Dylox	See Trichlorfon			
------	Dymid	See Diphenamid			
------	Endosulfan	See Thiodan			
RSP020 •	Endrin		1, 2, 3, 4, 10, 10-Hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo, endo-5,8-dimethanonaphthalene	99%	16.00/g
RSP111	Endrin, tech.		1, 2, 3, 4, 10, 10-Hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo, endo-5,8-dimethanonaphthalene	97%	6.00/g
------	Enid	See Diphenamid			
RSP021 •	EPN		O-Ethyl-O-p-nitrophenyl phenylphosphorothioate	97%	12.00/100mg
RSP112	Erbon	Baron	2-(2, 4, 5-Trichlorophenoxy) ethyl-2, 2-dichloropropionate	Tech.	6.00/g
------	Eximanite	See Ovex			
RSP082 •	Ethion	Nialate	O, O, O', O'-Tetraethyl-S, S'-methylene-biphosphorodithioate	95%	22.00/100mg
RSP113	Ethyl Hexanediol	Cardite	2-Ethyl-1, 3-Hexanediol	Tech.	12.00/g
------	Etilon	See Parathion			
RSP115	Eugenol		Eugenol	80%	12.00/g
RSP114	Fenitrothion	Folithion Sumithion	O, O-Dimethyl-O-(4-nitro-m-tolyl) phosphorothioate	99%	20.00/100mg
RSP053	Fenitrothion, tech.		O, O-Dimethyl-O-(4-nitro-m-tolyl) phosphorothioate	95%	12.00/g
RSP110	Fenthion		O, O-Dimethyl-O-(4-(methylthio)-m-tolyl) phosphorothioate	Tech.	16.00/100mg
------	Fenoprop	See Silvex			
------	Folidol	See Parathion			
------	Folithion	See Fenitrothion			
------	Folpet	See Phaltan			
------	Forstan	See Morestan			
------	Fostion	See Dimethoate			
RSP117	Fumazone		1, 2-Dibromo-3-chloropropane	Tech.	6.00/g
------	Gesafram	See Prometone			
------	Gemasil	See Propazine			
------	Gesaprim	See Atrazine			
------	Gesagard	See Prometryne			
------	Gesatop	See Simazine			
------	Gusathion	See Azinphosmethyl			
------	Guthion	See Azinphosmethyl			
------	HCB	See Hexachlorobenzene			
------	HEOD	See Dieldrin			
RSP024 •	Heptachlor	Methanoindene	1, 4, 5, 6, 7, 8, 8-Heptachloro-3a, 4, 7, 7a-tetrahydro-4, 7-endomethanoindene	97.4%	16.00/g
RSP025 •	Heptachlor		1, 4, 5, 6, 7, 8, 8-Heptachloro-2, 3-epoxy-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindan	99%	35.00/100mg
------	Herbol	See Dichloroxo			
RSP051	Hexachlorobenzene	HCB	Hexachlorobenzene	99%	16.00/g
RSP118	Imidan		O, O-Dimethyl-S-phthalimidomethyl phosphorodithioate	95%	16.00/g
RSP119	IPC		Isopropyl N-phenylcarbamate	Tech.	6.00/g
------	Isoenthane	See Karathane			
RSP120	Karathane	Arathane Dinocap Isorothane Mildex	2-(1-Methyl-n-heptyl)-4, 6-dinitrophenyl crotonate	85%	20.00/g
------	Karbofos	See Malathion			
RSP026 •	Kelthane	Dicofol DTMC	1, 1-bis (4-Chlorophenyl)-2, 2, 2-trichloroethanol	99%	17.00/g
RSP121	Kelthane, tech.		1, 1-bis (4-Chlorophenyl)-2, 2, 2-trichloroethanol		8.00/g
RSP045	Lannate	Methomyl	S-Methyl-N-((Methylcarbamoyl) oxy) thioacetimidate	99%	16.00/g
RSP122	Lethane 384		2-(2-Butoxyethoxy) ethyl thiocyanate	53%	12.00/g

MONS 067563

PESTICIDE STANDARDS

Catalog #	Product	Synonym	Active Ingredient	% A. I.	Price
RSP027 •	Lindane	Gamma-BHC (γ-BHC)	Gamma-1, 2, 3, 4, 5, 6-Hexachlorocyclohexane	99%	20.00/g
RSP028 •	Malathion	Carbophos Karbofos	S-(1, 2-bis (Ethoxycarbonyl) ethyl)-O, O-dimethyl phosphorodithioate	99%	20.00/g
RSP183	Malathion, tech.		S-(1, 2-bis (Ethoxycarbonyl) ethyl)-O, O-dimethyl phosphorodithioate	95%	8.00/g
———	Malix	See Thiodan			
RSP124	Maneb	Dithane-manganese Manzate	Ethylenebisdithiocarbamate manganese	80%	12.00/100mg
———	Manzate	See Maneb			
RSP125	Matacil	Aminocarb	4-Dimethylamino-3-tolyl N-methyl carbamate	98%	12.00/100mg
RSP126	Mesmin		(N-Methylmercuri)-1, 4, 5, 6, 7, 7-hexachlorobicyclo (2.2.1) hept-5-ene-2, 3-dicarboximide	99.7%	20.00/100mg
RSP127	Metasystox-R	Oxydemeton-methyl	O, O-Dimethyl-S-(2-(ethylsulfinyl) ethyl) phosphorothioate	50%	12.00/g
———	Methomyl	See Lannate			
RSP029 •	Methoxychlor	Methoxy DDT DMDT	1, 1, 1-Trichloro-2, 2-bis (p-methoxyphenyl) ethane	98%	17.00/g
RSP128	Methoxychlor, tech.		1, 1, 1-Trichloro-2, 2-bis (p-methoxyphenyl) ethane	80.5%	6.00/g
———	Methoxy Propazine	See Prometone			
———	Methyl Guthion	See Azinphosmethyl			
RSP129	Methyl Parathion		O, O-Dimethyl-O-p-nitrophenyl phosphate	98%	12.00/g
RSP068	Methyl Parathion	Dalf Nitrox	O, O-Dimethyl-O-p-nitrophenyl phosphorothioate	98%	12.00/100mg
RSP130	Methyl Parathion, tech.		O, O-Dimethyl-O-p-nitrophenyl phosphorothioate	85%	8.00/g
———	Mevinphos	See Phosdrin			
———	Mildex	See Karathane			
———	Mintacol	See Para-zeon			
RSP050	Mirex		Dodecachloroctahydro-1, 3, 4-metheno-2H-cyclobuta (cd) pentalene	99%	16.00/g
———	Mitox	See Chlorbenside			
———	Monochloroacetic Acid	See Chloroacetic Acid			
RSP131	Morestan, tech.	Fortan	6-Methyl-2-oxo-1, 3-dithio (4, 5-b) quinoxaline	87%	12.00/g
———	Morocide	See Binapacryl			
———	Naled	See Dibrom			
———	Negaweon	See Trichlorfon			
———	Nemafos	See Zinophos			
———	Nialate	See Ethion			
———	Niran	See Parathion			
———	Nitrostigmine	See Parathion			
———	Nitox	See Methyl Parathion			
———	NPA	See Alanap			
———	Octachlor	See Chlordane			
———	Octalene	See Aldrin			
———	OMPA	See Schradan			
———	Orthocide	See Captan			
RSP132	Ovex	Estonate Ovochlor Ovotran	p-Chlorophenyl p-chlorobenzenesulfonate	98%	12.00/g
RSP133	Ovex, tech.		p-Chlorophenyl p-chlorobenzenesulfonate		4.00/g
———	Ovochlor	See Ovex			
———	Ovotran	See Ovex			
———	Oxydemetonmethyl	See Metasystox-R			
RSP134	Panogen		Methylmercuric dicyanodiamide	min. 90%	12.00/g
RSP030 •	Para-zeon	Mintacol	O, O-Diethyl-o-p-nitrophenyl phosphate (oxygen analog of parathion)	99%	12.00/100mg
RSP135	Paraquat Dichloride		1, 1'-Dimethyl-4, 4'-dipyridinium dihydrochloride	99%	12.00/100mg

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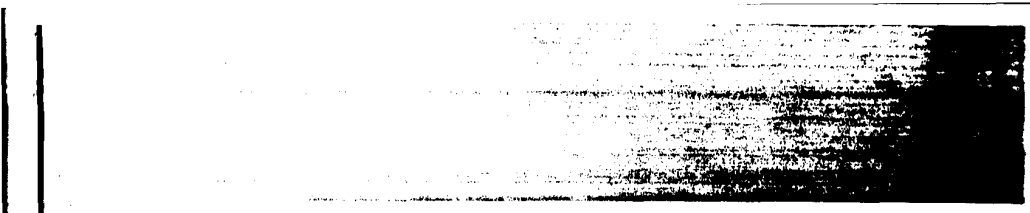
PESTICIDE STANDARDS

Catalog #	Product	Synonym	Active Ingredient	% A. I.	Price
RSP031	Parathion	Folidol Niran Etilon Rhodiatox Thiophos Nitrostigmine Alkron AAT; SNP; DNTP;	O, O-Diethyl-o-p-nitrophenyl phosphorothioate	99.7%	15.00/100mg
RSP136	Parathion, tech.		O, O-Diethyl-o-p-nitrophenyl phosphorothioate	Tech.	12.00/g
RSP137	Paris Green		Copper acetoarsenite	91.7%	6.00/g
RSP138	Parnon		Bis (p-chlorophenyl)-3-pyridine methanol	Tech.	12.00/100mg
------	Parsate	See Zinab			
RSP139	PCNB		Pentachloronitrobenzene	99%	6.00/g
------	PCP	See Pentachlorophenol			
RSP140	Pentachlorophenol	PCP Santobrite	Pentachlorophenol	99%	20.00/g
RSP141	Perthane		1, 1-dichloro-2, 2-bis (p-ethylphenyl) ethane	95%	12.00/g
------	Pestox	See Schradan			
RSP142	Phaltan	Folpet Thiophol	N-Trichloromethylthiophthalimide	99%	12.00/100mg
RSP143	Phaltan, tech.		N-Trichloromethylthiophthalimide	93.3%	6.00/g
------	Phenacide	See Toxaphene			
------	Phenatox	See Toxaphene			
RSP032 ●	Phenothiazine		Phenothiazine	Pract.	12.00/g
------	Phenate	See Thiuset			
RSP033 ●	Phosdrin	Mevinphos	2-Carbomethoxy-1-propen-2yl dimethyl phosphate	60%	18.00/g
RSP144	Phosphamidon	Dimecron	1-chloroethyl carbamoyl-1-propen-2-yl-dimethyl phosphate	99%	15.00/g
RSP145	Phosphamidon		1-chlorodiethyl carbamoyl-1-propen-2-yl-dimethyl phosphate	87.8%	6.00/g
RSP146	Phygon	Dichlone	2, 3-Dichloro-1, 4-naphthoquinone	Tech.	12.00/g
RSP147	Piperonyl Butoxide	Butoxide	12-(2-n-Butoxyethoxy)-ethoxy) 4, 5-methylene dioxy-2-propylbenzene	90%	10.00/g
RSP148	Plantvax		2, 3-Dihydro-5-carboxanilide-6-methyl-1, 4-oxathiin-4, 4-dioxide	97%	22.00/g
RSP149	Promex		N, N-Di-n-butyl-p-chlorobenzene sulfonamide	Tech.	6.00/g
------	Preventol I	See 2, 4, 5-Trichlorophenol			
RSP150	Prolan		2-Nitro-1, 1-bis (p-chlorophenyl) propane	99%	16.00/100mg
RSP155	Prometone	Methoxypropazine Gesafram	2, 4-Bis-(isopropylamino)-6-methoxy-S-triazine	99%	14.00/g
RSP034 ●	Prometryne	Caparol Gesagard	2-Methyl-mercapto-4, 6-bis (isopropyl amino)-S-triazine	99%	15.00/100mg
RSP035 ●	Propazine	Gesamil	2-Chloro-4, 6-bis (isopropyl amino) -S-triazine	98.7%	14.00/100mg
RSP151	Propylisome		Di-n-propyl-3-methyl-6, 7-methylenelinoxy-1, 2, 3, 4-tetrahydronaphthalene-1, 2-dicarboxylate	Tech.	18.00/g
RSP152	Randox	CDAA	2-Chloro-N, N-diallyl acetamide	Tech.	6.00/g
------	Rhodiatox	See Parathion			
------	Rogor	See Dimethoate			
RSP036 ●	Ronnel		Dimethyl 2, 4, 5-trichlorophenyl phosphorothionate	99%	14.00/g
RSP152	Ronnel, tech.		Dimethyl 2, 4, 5-trichlorophenyl phosphorothionate	Tech.	6.00/g
RSP034	Roelene	Dowco 132	4-tert-Butyl-2-chlorophenyl methylmethyl phosphoramidite	99%	12.00/100mg
RSP154	Roelene, tech.		4-tert-Butyl-2-chlorophenyl methylmethyl phosphoramidite		6.00/g
------	Santobrite	See Pentachlorophenol			

MONS 067565



PESTICIDE STANDARD

Catalog #		Product	Synonym	Active Ingredient	% A.I.	Price
RSP038	•	Schradan	OMPA Pestan hytess	Octamethylpyrophosphoramide	99.8%	14.00/g
RSP173		Schradan, tech.		Octamethylpyrophosphoramide	95%	8.00/g
RSP170	•	Sevin	Carbaryl	1-Naphthyl N-methyl carbamate	99%	21.00/100mg
RSP171		Silvex	Fenoprop	2-(2, 4, 5-Trichlorophenoxy) propionic Acid	99%	10.00/100mg
RSP172		Silvex, tech.		2-(2, 4, 5-Trichlorophenoxy) propionic Acid		8.00/g
RSP039	•	Simazine	Gesatop	2-chloro-4, 6-bis (ethylamino)-S-triazine	99.3%	11.00/100mg
------		SNP	See Parathion			
RSP174		Spergon	Chloranil	Tetrachloro-p-benzoquinone	Tech	6.00/g
RSP175		Strobane		Terpene polychlorinates	95% Chlorene	10.00/g
------		Sulfo-Clde	See Sulfoxide			
RSP176		Sulfoxide	Sulfonyl Sulfo-cide	1, 2-Methylmedioxy-4-12-(octyl sulfinyl) propyl] benzene	88%	12.00/g
------		Sulfonyl	See Sulfoxide			
------		Sumithion	See Fenitrothion			
------		Systox	See Demeton			
------		Sytam	See Schradan			
RSP177		2, 4, 5 T-acid		2, 4, 5-Trichlorophenoxyacetic Acid	98%	10.00/100mg
RSP178		2, 4, 5 T-acid		2, 4, 5-Trichlorophenoxyacetic Acid	Tech.	8.00/g
------		TCTS	See Tedion			
------		TDE mix	See DDD-mix			
------		o, p-TDE	See o, p-DDD			
------		p, p' TDE	See p, p'-DDD			
RSP158		Tedion	Duphar Tetradifon TCTS	p-Chlorophenyl 2, 4, 5-trichlorophenyl sulfone	98%	10.00/g
RSP187		2, 3, 4, 6 Tetrachlorophenol		2, 3, 4, 6 Tetrachlorophenol	98%	12.00/100mg
------		Tetradifon	See Tedion			
RSP156		Thimet	Phorate	O, O Diethyl S-(ethylthio) methyl phosphorodithioate	98.8%	15.00/g
RSP159		Thimet, tech.		O, O Diethyl S-(ethylthio) methyl phosphorodithioate	91%	8.00/g
RSP040	•	Thiodan	Endosulfan Malix	6, 7, 8, 9, 10, 10-Hexachloro-1, 5, 5a, 6, 9, 9a-hexahydro-6, 9-methano 2, 4, 3-benzodioxathiepin 3-oxide	98%	23.00/100mg
------		Thiometon	See Zinephos			
------		Thiophal	See Phaltan			
------		Thiophos	See Parathion			
RSP041	•	Tenaphene	Phenacide Phenator	Polychlorinated camphene	Tech.	17.00/g
RSP042	•	Trichlorfon	Tugon Chlorophos Dipterex Dylox Neguvon Dipterex	O, O Dimethyl (1-hydroxy-2, 2, 2-trichloroethyl) phosphonate	98%	12.00/g
RSP180		Trichloronitromethane	Chloropicrin Acquisite	Trichloronitromethane	95%	12.00/g
RSP181		2, 4, 5 Trichlorophenol	Preweted I	2, 4, 5 Trichlorophenol	99%	10.00/100mg
RSP182		2, 4, 6 Trichlorophenol		2, 4, 6 Trichlorophenol	99%	10.00/100mg
RSP055		Trithion	Carbaphenothion	S-[[p-Chlorophenyl) thiol methyl] O, O diethyl phosphorodithioate	95%	10.00/g
------		Tugon	See Trichlorfon			
------		Undex	See Baygon			
------		Vapona	See Dichlorvos			
RSP183		Vorlex		Methylisothiocyanate	20%	12.00/g
RSP043	•	Warfarin	Coumafene	3-(α'-Acetonylbenzyl)-4-hydroxy coumarin	Tech	10.00/100mg

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PESTICIDE STANDARDS

Catalog #	Product	Synonym	Active Ingredient	% A.I.	Price
RSP104	Zectran		4-dimethyl amino-3, 5 xylyl-N-Methyl carbamate	99%	10.00/g
RSP105	Zectran, tech.		4-dimethyl amino-3, 5 xylyl-N-Methyl carbamate	95%	6.00/g
RSP106	Zineb	Dithane-zinc Famate	Zinc ethylene bisdithiocarbamate	75%	20.00/g
RSP107	Ziosphos	Thermorin Cyren Nemafos	O, O-Diethyl-O-2-pyrazinyl phosphorothioate	98%	10.00/100mg
RSP108	Zytron	DMPA	O-(2, 4-Dichlorophenyl)-O-methyl isopropyl phosphoramidothioate	98%	12.00/100mg
RSP109	Zytron, tech.		O-(2, 4-Dichlorophenyl)-O-methyl isopropyl phosphoramidothioate	Tech.	8.00/g

PRECOATED TLC PLATES from ANALABS

Analabs TLC plates are of precision quality. They are precoated using procedures developed by leading chromatographic investigators.

The prescored 20 x 20 cm plate can be snapped in sections for two 10 x 20 cm, or four 5 x 20 cm plates. Scoring on the uncoated side makes snapping the plates easy. A clear edge on the plate allows the plate to be grasped without disturbing the coating. Separation information can be marked in this area.

ORDERING INFORMATION
20 x 20 cm PRECOATED PLATES 250 μ thick. 25 PLATES/BOX

NUMBER CATALOG	*TLC PLATE TYPE*	*PRESCORED PRICE*		*UNSCORED PRICE*
		5 x 20 cm	10 x 20 cm	20 x 20 cm
TLP-001	Anasil G	$30	$26	$22
TLP-002	Anasil GF (254)	$30	$26	$22
TLP-003	Anasil H	$30	$26	$22
TLP-004	Anasil HF (254)	$30	$26	$22
TLP-005	Silica Gel G	$30	$26	$22
TLP-006	Silica Gel GF (254)	$30	$26	$22
TLP-007	Microcrystalline Cellulose (Avicel)	$31	$27	$23
TLP-008	Microcrystalline Cellulose, F (254) (Avicel)	$31	$27	$23

Analabs precoated plates are guaranteed to arrive at your laboratory in condition for immediate use. Any plates that arrive damaged will be replaced at no cost to you and no troublesome paperwork.

MONS 067567

PESTICIDEGRADE SOLVENTS

Pesticidegrade Solvents are certified to contain no interfering substance greater than that equivalent to 10 parts per trillion of a chlorinated pesticide.

Catalog #	*Solvent*		*Unit*	*Price*
SSP001	Acetone, Presticidgrade			
	Water	0.05% max.	1 Liter	$14.00
SSP002	Acetonitrile, Pesticidegrade			
	Water	0.05% max.	1 Liter	15.00
SSP003	Benzene, Pesticidegrade			
	Water	0.03% max.	1 Liter	12.00
SSP004	2-Butanone, Pesticidegrade			
	Water	0.05% max.	1 Liter	13.00
SSP005	Butyl Alcohol, Pesticidegrade			
	Water	0.05% max.	1 Liter	12.00
SSP006	iso-Butyl Alcohol, Pesticidegrade			
	Water	0.05% max.	1 Liter	15.00
SSP007	Carbon Tetrachloride, Pesticidegrade			
	Water	0.02% max.	1 Liter	16.00
SSP008	Chloroform, Pesticidegrade			
	Water	0.02% max.	1 Liter	17.00
SSP009	Cyelohexane, Pesticidegrade			
	Water	0.02% max.	1 Liter	16.00
SSP010	Dichloromethane, Pesticidegrade			
	Water	0.02% max.	1 Liter	16.00
SSP011	N, N-Dimethylformamide, Pesticidegrade			
	Water	0.05% max.	1 Liter	19.00
SSP012	p-Dioxane, Pesticidegrade			
	Water	0.05% max.	1 Liter	17.00
SSP013	Ether, Pesticidegrade			
	Water	0.05% max.	1 Liter	12.00
SSP014	Ethyl Acetate, Pesticidegrade			
	Water	0.05% max.	1 Liter	13.00
SSP015	Ethyl Alcohol, Pesticidegrade Completely Denatured			
	Water	0.05% max.	1 Liter	12.00
SSP016	Heptane, Pesticidegrade			
	Water	0.03% max.	1 Liter	13.00
SSP017	Hexane, Pesticidegrade			
	Water	0.02% max.	1 Liter	12.00
SSP018	Methanol, Pesticidegrade			
	Water	0.05% max.	1 Liter	11.00
SSP019	Methylsulfoxide, Pesticidegrade			
	Water	0.05% max.	1 Liter	21.00
SSP020	Pentane, Pesticidegrade			
	Water	0.03% max.	1 Liter	15.00
SSP021	Petroleum Ether, Pesticidegrade			
	Water	0.03% max.	1 Liter	12.00
SSP022	iso-propyl Alcohol, Pesticidegrade			
	Water	0.05% max.	1 Liter	15.00
SSP023	Toluene, Pesticidegrade			
	Water	0.02% max.	1 Liter	11.00
SSP024	2, 2, 4-Trimethylpentane, Pesticidegrade			
	Water	0.02% max.	1 Liter	16.00

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Analabs ANNOUNCES for 1974
A POLLUTION CHEMICAL STANDARD CATALOG

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