PRESENTATION

To The

INTERDEPARTMENTAL TASK FORCE ON PCBs

WASHINGTON, D. C.

May 15, 1972

by

MONSANTO COMPANY

Introduction

By

W. B. Papageorge

Considerable interest has been and continues to be expressed by many involved in studies of PCBs and the environment concerning their degradability. Monsanto has received many inquiries relating to results of our studies. We now have accumulated some meaningful data which we believe would be appropriate to present in a status report to the Interdepartmental PCB Task Force. We sincerely appreciate this opportunity to share this information with you this afternoon.

Slide #1 - We plan to discuss current results of laboratory biodegration studies of PCBs and the levels of PCB residues observed in the tissues of laboratory animals which were used in our toxicity studies. We will review briefly actions Monsanto has taken to reduce PCB usage and environmental losses. We will also discuss the application of our laboratory findings to the development of a modified more readily degradable PCB mixture for use by the capacitor industry as a dielectric fluid. As many of you are aware, we have designated this material as Aroclor 1016.

Slide #2 - Our presentation will begin with Dr. Tucker discussing primary bacterial degradation and PCB residues in fish, fowl and mammal tissues. Dr. Munch will review evidence that demonstrates disappearance of PCBs from the environment and Dr. Paton will discuss Monsanto's PCB sales and use actions and the impact these actions will have on the environment.

Because of the limited time available, may I suggest that questions be held until all the speakers have completed their reports. Following the presentations there will be opportunity for further discussion of information which may be of particular interest to you.

Dr. Tucker, Research Group Leader, will now present a status report of his laboratory results.

OBJECTIVES

- PROGRESS REPORT ON LABORATORY BIODEGRADATION OF PCB'S
- RESIDUE ACCUMULATION STUDIES IN FISH, BIRDS AND MAMMALS
- TO SHOW REDUCTION IN LESS BIODEGRADABLE PCB'S AS A RESULT OF MONSANTO ACTIONS ON SALES AND PRODUCTS

MONS 043808

AGENDA

- INTRODUCTION — W. B. PAPAGEORGE
- PCB STUDIES — E. S. TUCKER
  - PRIMARY BACTERIAL DEGRADATION
  - RESIDUES IN FISH, FOWL AND MAMMALS
- EVIDENCE FOR LOSS OF PCB FROM THE ENVIRONMENT — R. H. MUNCH
- MONSANTO PCB ACTIONS — C. PATON
- DISCUSSION

MONS 043809

ASSESSMENT OF THE BIOLOGICAL PERSISTENCE OF POLYCHLORINATED BIPHENYLS

By

Dr. E. S. Tucker

The research I will review today will focus upon one aspect of Monsanto's efforts to understand the environmental impact and behavior of our polychlorinated biphenyl or PCB products.

This research was initiated early in 1969 after development of the necessary PCB analytical methodology and subsequent confirmation of Dr. Soren Jensen's identification of PCB residues in fish and birds in Sweden.

At this point in time, PCB residue data from Monsanto and external environmental monitoring programs indicated that at the previous rate of use and release of these products that some PCB homologs were beginning to reach detectable levels in fish, birds and mammals. Conversely, these data indicated to us that with the exception of localized, controllable contamination, PCB homologs with less than five chlorine atoms per molecule had not accumulated to detectable levels; even though it was known that significantly greater amounts of the PCB homologs with less than 5 chlorine atoms per molecule had been manufactured and used over the years.

Now, before discussing our biological studies, I would like to review for you the gross homolog composition of our Aroclor products and then in a very brief fashion, try and illustrate to you the complexity of these materials and hence the complexity of the problem.

In the first slide (#1), is shown the most recent data on the weight % composition of four of our Aroclor products as a function of each detectable PCB homolog. The first column on the left lists the homolog in question and the subsequent columns under each product show the weight % distribution of each PCB homolog in each product.

As most of you probably know, with the exception of Aroclor 1016, the last two digits of each product number refer to the degree of chlorination. For example, Aroclor 1221 contains 21% chlorine by weight, and so on.

Aroclor 1016 is a special case in that while it contains about 41% chlorine by weight, its penta, hexa, and heptachloro biphenyl content has been significantly reduced with respect to Aroclor 1242, a product produced by direct chlorination, containing 42% by weight chlorine. Please note that the penta, hexa, and heptachloro biphenyl homologs in Aroclor 1016 have been reduced by factors of about 8, 10, and 10, respectively, with reference to Aroclor 1242.

As you can also see, the chief constituents of Aroclor 1221 are the mono- and dichloro biphenyls, while Aroclor 1016 and Aroclor 1242 contain predominantly di-, tri-, and tetrachloro biphenyls, and Aroclor 1254, tetra, penta, and hexachloro biphenyls.

As I indicated earlier, this table represents our most recent efforts at determining the homolog distribution of our PCB products and as such a number of you may have seen estimations of the homolog content of these products which are significantly different. The analytical methodology used is currently in a very dynamic state and our understanding of the contents of these products increases as the methodology is improved. At this point in time, we regard these numbers as the most accurate ones currently available.

In the next slide (#2) are shown examples of low resolution - packed column electron capture chromatograms of Aroclor 1221, Aroclor 1242, Aroclor 1254, and Aroclor 1260. This is what these products look like to a residue analyst using the most commonly employed detection system.

From these chromatograms, it can be readily seen that we are dealing with multi-component products, which of course, increases the complexity of assessing every aspect of this problem - relative to a well defined single component system such as DDT.

I should mention at this point, that the PCB residues generally found in wildlife are most similar to Aroclor 1254 and Aroclor 1260 chromatograms.

The next slide (#3) demonstrates that in reality, these materials are even more complex than is generally realized. In the upper right portion of this slide is again shown a low resolution electron capture gas chromatogram of Aroclor 1242 under the optimum conditions normally employed by residue analysts. Under these conditions, Aroclor 1242 would appear to be a 15 component system.

In the lower portion of this slide is a flame ionization gas chromatogram of the same material using a high resolution S.C.O.T. column. If one carefully inspects this chromatogram, our simple 15 component product has now been resolved into 55 different components.

These facts simply indicate that all PCB products cannot be lumped together in terms of either their environmental impact or persistence.

The type of biological studies which we have carried out to date are shown in the next slide (#5). For discussion purposes, they can be conveniently divided into two categories: "Primary Bacterial Degradation Studies", an area in which research on PCBs is just beginning, and "Residue Accumulation Studies". Most of our bacterial degradation work has been centered around the fairly well known semi-continuous activated sludge degradation test.

Our residue accumulation studies have been fairly extensive and have involved the exposure of better than 2100 fish, chickens, rats and dogs to the various Aroclor products; resulting in the collection of over 1200 samples of which approximately 500 pooled samples were eventually analyzed for PCB residues.

The prime objective of these studies is given on Slide #6.

Slide #7. The semi-continuous activated sludge test procedure we used to evaluate the primary bacterial degradation rates of the Aroclor products is the test method recommended by the Soap and Detergents Association for the evaluation of the biodegradability of linear alkyl benzene sulfonate type surfactants [JAOCS 42, 986 (1965) & 46, 432 (1969)].

> Primary Biodegradation - Minimum alternation of the chemical structure of the material in question to an extent that characteristic properties of the original material are no longer evident.

This procedure employs sludge from a sewage treatment plant as the source of microorganisms to which a specific amount of the material being evaluated and a synthetic sewage mixture are fed on a periodic basis in a specially designed aeration chamber. The next slide (#8) graphically illustrates what the aeration chamber looks like. It is simply a large glass cylinder with provisions for aeration, auxiliary stirring, a siphon for periodic removal of the supernatant and a septum for introduction of the test material.

The mixed liquor (sludge + water) obtained from the sewage treatment plant is initially adjusted with tap water to a suspended solids concentration of about 2500 mg/l, and 1500 ml of this mixture is then charged to the aeration chamber.

The mechanical cycle employed is shown in the next slide (#9). Each cycle is initiated by the addition of the synthetic sewage and 1 mg of the PCB product being tested.

Since the PCBs are quite water insoluble, they are fed to the unit via injection of 200 µls of a concentrated ethanol solution. In this manner, homogenous dispersion of the PCBs on the bacterial sludge is obtained.

After about one hour of aeration an aliquot of the mixed liquor is withdrawn from the chamber and analyzed for PCBs via UV spectrophotometry and/or electron capture gas chromatography. Aeration is continued for about 48 hours and a second sample is withdrawn for analysis. At this point, the aeration is stopped and the sludge allowed to settle, the sludge volume and pH are then checked to insure that the unit is operating satisfactorily. Two-thirds of the supernatant is withdrawn and replaced with tap water; aeration is then resumed. The cycle is re-initiated by the addition of the synthetic sewage and Aroclor in question. This cycle is continuously repeated until a steady state and consistent degradation rates are obtained.

The per cent degradation rate is calculated as shown in the equation on the slide from the amounts found in the samples analyzed during each cycle.

Degradation testing of the Aroclor products shown in the next slide (#10) have been carried out over an eight month period in our laboratories. In this slide, we have shown graphically the results observed to date. Here we have plotted the mean per cent degradation

rates for biphenyl, Aroclor 1221, MCS 1043, a research material containing 30% by weight chlorine, Aroclor 1016 (41% chlorine), Aroclor 1242, and Aroclor 1254 versus the weight per cent chlorine present in each. The actual mean per cent degradation rates and 95% confidence limits for each material are shown in the lower left portion of the slide. These data were all obtained by UV spectrophotometry which in essence follows the decrease in the aromatic ring content and is indicative of bacterial ring cleavage. The important point to note here is that as the degree of chlorination decreases the degradation rate increases.

In order to give you a feeling for the degradation rates observed with other materials, Aroclor 1221 degrades at about the same rate as a non-linear ABS surfactant.

We have also used this technique to study p,p'-DDT and have at this point in time noted no significant primary degradation.

The next slide (#11) shows the changes in homolog distribution observed for Aroclor 1242 via electron capture gas chromatographic analyses. The upper chromatogram shows the character of the residue one hour after addition. The numbers above each peak indicate the dominant homolog or homologs present in each. The lower chromatogram is of the residue after 72 hours of exposure to the bacterial sludge. It can be readily seen by comparing the two chromatograms that all the dichloro biphenyls, most of the trichloro biphenyls, and a significant portion of the tetrachloro biphenyls are degraded in 48 hours under these test conditions.

The conclusions which we draw from this preliminary data are shown in the next slide (#12).

Next, I will discuss our "Aroclor Residue Studies" (Slide #13).

Our white leghorn chicken studies (Slide #14) have consisted of a 90 day oral exposure of Aroclor 1242, Aroclor 1254, and Aroclor 1260 at 1, 10, and 100 ppm feed levels and a repeat 90 day study of Aroclor 1242 at the 2, 4, and 8 ppm feed levels. 336 Chickens were employed from which a total of 521 tissue, chick, and egg samples were collected. Of these 112 pooled samples were analyzed for PCB residues.

In the next slide (#15) are shown the results of the 90 day oral exposure of white leghorn chickens to Aroclor 1242. On the left side, we have shown the oral exposure levels which were 1, 10, and 100 ppm, the theoretical residue in ppm, which would have been found in the lipid if the chickens had retained all of the Aroclor 1242 which they orally injested. As you can see, these levels are ~125, 1250, and 12,500 ppm. Next is shown the actual average level in ppm found in the lipid of the muscle, fat, and liver samples and then the levels found after 30 days on a PCB free diet. The important points to note are that ~90% of all the Aroclor 1242 consumed is directly excreted and/or metabolized and that after 30 days on a PCB free diet 35%, 44%, and 57% of the PCBs retained after 90 days of continuous exposure at the 1, 10, and 100 ppm levels was excreted and/or metabolized.

On the right hand side of this slide is shown the homolog distribution of the product fed and that of the residues isolated from the tissues after 90 days of exposure and 30 days on a PCB free diet. The numbers across the top simply refer to the number of chlorine atoms per biphenyl molecule. As you can see, Aroclor 1242 contains dominant amounts of the di- through pentachlorobiphenyls and a minor amount of hexachlorobiphenyl. After 90 days of exposure the dichlorobiphenyl was no longer observable and the dominant components were the tri- through pentachloro biphenyl homologs. After 30 days on a PCB free recovery diet, the hexachloro biphenyl is now a dominant component because of continued excretion and/or metabolism of the lower chlorinated homologs.

In the next slide (#16) are shown the results for the 90 day oral exposure of Aroclor 1254 in white leghorn chickens at the 1, 10, and 100 ppm exposure levels. The theoretical residues are the same as before and we have again shown the actual levels found in the tissues after 90 days of continuous exposure and 30 days on a PCB free diet. In this instance, ∿70-72% of the Aroclor 1254 ingested was directly excreted and/or metabolized and after 30 days on a PCB free diet, ∿45% of the residues retained were excreted and/or metabolized.

The homolog distribution of the product and residues is shown on the right of the slide, the product Aroclor 1254 contains minor amounts of the tri- and heptachloro homologs and dominant amounts of the tetra-, penta-, and hexachloro biphenyls. The residue after 90 days of exposure did not contain detectable amounts of the trichloro biphenyls and the tetrachloro biphenyls were no longer a dominant component. The dominant homologs were penta- and hexachloro biphenyls. After 30 days on a PCB free diet, the tetrachloro biphenyls were now not detectable, the pentachloro biphenyls were a minor component, and the hexachloro biphenyls the dominant component.

In the next slide (#17) are the results for Aroclor 1260. Again, the oral exposure level and theoretical residue levels are the same and the PCB residues found in the tissues after 90 days of continuous exposure and 30 days on a PCB free recovery diet are shown. After 90 days of exposure, 57-52% of all Aroclor 1260 consumed was directly excreted and/or metabolized and after 30 days on a PCB free diet ∿40% of the residues retained were excreted and/or metabolized.

As shown on the right, Aroclor 1260 contains dominant amounts of penta-, hexa-, and heptachloro biphenyls and a minor amount of octachloro biphenyl. The residues after 90 days of exposure and 30 days on a PCB free recovery diet contain minor amounts of the penta- and octachloro homologs. In both cases, the dominant homologs were the hexa- and heptachloro biphenyls.

Our albino rat work (Slide #18) has consisted of 30 day oral, 2 year chronic oral and a 3 generation rat reproduction exposure study with Aroclor 1242, Aroclor 1254, and Aroclor 1260 and a 90 day subacute

oral exposure of Aroclor 1221. Approximately 1400 animals were used in these exposure studies from which about 400 muscle, liver, and fat samples were collected. Two hundred of these samples were analyzed for PCB residues.

In the next slide (#19) are shown the results of our two year chronic oral exposure study of Aroclor 1242 in albino rats. The oral exposure levels were 1, 10, and 100 ppm and the theoretical residues were ~800, 8000, 80,000 ppm, respectively. The actual residues found in the tissue lipid are shown after 3, 12, and 24 months of exposure. Comparison of the residues found after 24 months to the theoretical residue levels indicates that 99% of the Aroclor 1242 fed was directly excreted and/or metabolized at all exposure levels.

As is shown on the right, Aroclor 1242 contains dominant amounts of the di- through pentachloro biphenyl homologs and a minor amount of the hexa-. The residues after two years did not contain a significant amount of the dichloro biphenyls and the dominant components were the tri-, tetra-, and pentachloro biphenyl homologs.

In the next slide (#20) are shown the results of the two year chronic oral exposure of albino rats to Aroclor 1254. The exposure and theoretical residue levels are the same as with Aroclor 1242. The residues found after 3, 12, and 24 months of exposure are also shown. Comparison of the residues after two years to the amount ingested demonstrates that 95-98% of the Aroclor 1254 consumed is directly excreted and/or metabolized.

The homolog distribution of Aroclor 1254 and the residues are shown on the right. Aroclor 1254 contains minor amounts of the tri- and heptachloro biphenyl homologs and dominant amounts of the tetra-, penta-, and hexachloro biphenyl homologs. The residues did not contain detectable levels of the trichloro homologs and the tetrachloro biphenyls were no longer a dominant component. The dominant homologs were the penta- and hexachloro biphenyls.

The next slide (#21) shows the the results for the two year exposure of Aroclor 1260 in albino rats. Again, the exposure and theoretical residue levels are the same and the residues found in the tissues after 3, 12, and 24 months of exposure are shown. In this case 93-95% of all Aroclor 1260 ingested was directly excreted and/or metabolized.

The dominant homologs in Aroclor 1260 and the residues isolated from the tissues were similar in all cases.

In order to demonstrate the relationship between residue storage levels and the degree of chlorination of the product fed (slide #22). I have plotted the average ppm PCB found in the lipid vs the weight per cent chlorine in the product fed. These data were taken from our 90 day subacute albino rat studies with Aroclor 1221, Aroclor 1242, Aroclor 1254, and Aroclor 1260 at an exposure level of 100 ppm. As you can see, the residue storage levels decrease exponentially as the weight per cent chlorine decreases, simply demonstrating the relationship between the higher homolog content of an Aroclor product and the tissue storage level.

Our beagle dog studies (Slide #23) have consisted of a two year chronic exposure of Aroclor 1242, Aroclor 1254, and Aroclor 1260 and a 90 day subacute study of Aroclor 1221. In these studies, 108 beagle dogs were used, resulting in the collection of 263 samples, and the analyses of 146 for PCB residues.

The next slide (#24) shows the results of one two year study of Aroclor 1242 at exposure levels of 1, 10, and 100 ppm. In this study, the theoretical residue levels are ~500, 5000, and 50,000 ppm respectively. We have also shown on this slide the residue levels found after two years of exposure and after 30 and 60 day periods on PCB free recovery diets. The beagle dogs directly excreted and/or metabolized 99.6% of the Aroclor 1242 consumed and after 60 days on PCB free diets, 50-60% of PCB residue retained after two years of exposure was excreted and/or metabolized.

Aroclor 1242 contains dominant amounts of the di-, tri-, tetra-, and pentachloro homologs and a minor amount of the hexa- homolog. The residue found after two years of exposure contained no detectable levels of the dichloro homologs and dominant levels of the tri-, tetra-, hepta-, and octachloro biphenyls. The pentachloro homolog, although dominant in the product fed, was not a dominant component of the residue. After 30 days on a PCB free recovery diet, the di-, tri-, and tetrachloro biphenyls were not detectable components of the residue. At this point, the dominant components were the hexa-, hepta-, and octachloro biphenyls. The trend toward excretion and/or metabolism of the lower chlorinated homologs continued to the extent that after 60 days on the recovery diet the hexachloro biphenyl was no longer a dominant component, and the hepta- and octachloro biphenyls became the dominant constituents in the residue.

In the next slide (#25) are the results for the two year exposure of beagle dogs to Aroclor 1254. The oral exposure and theoretical residue levels are the same and the PCB residue levels found in the tissues after two years of exposure and after 30 and 60 day periods on PCB free recovery diets are again shown.

In this instance, the dogs excreted and/or metabolized 98-99% of all Aroclor 1254 consumed over a two year period. After 60 days on a PCB free recovery diet, 30-40% of the residues retained were excreted and/or metabolized. The product fed, Aroclor 1254, contains minor amounts of the tri- and heptachloro biphenyls and dominant amounts of the tetra-, penta-, and hexachloro homologs. After two years of exposure, the residue retained from the product did not contain detectable levels of the tri- or tetrachloro biphenyls, the penta-, and hexachloro biphenyls remained dominant components, and the heptachloro biphenyls became dominant constituents.

After 30 days on the PCB free recovery diet, the pentachloro homologs became a minor component of the residue, the hexa- and heptachloro biphenyls remained dominant components and the octachloro homologs became a minor component. After 60 days on the PCB free recovery diet, the pentachloro biphenyls were excreted and/or metabolized to the extent that the octachloro homologs became a dominant constituent of the residue.

The next slide (#26) shows the results for the two year oral exposure residue study of Aroclor 1260 in beagle dogs. The exposure and theoretical residue levels are the same as those for the Aroclor 1242 and Aroclor 1254 studies. Next is shown the residues which accumulated after two years of continuous exposure and the residues retained after 30 and 60 day recovery periods on PCB free diets. With this Aroclor 98-99% of the amount consumed over two years was directly excreted and/or metabolized. After 60 days on the recovery diet ~13% of the retained residues were excreted and/or metabolized.

The homolog distribution of Aroclor 1260 is as shown, dominant amounts of the penta-, hexa-, and heptachloro biphenyls with a minor amount of the octachloro homologs. After two years, the PCB residue contains no detectable level of the pentachloro homologs, a minor amount of the heptachloro biphenyls, and dominant amounts of the hexachloro and octachloro homologs. After 30 days on the recovery diet, the dominant homologs are now the hexa-, hepta-, and octachloro biphenyls becoming a dominant component of the residue via loss of some of the hexachloro biphenyls. After 60 days on the recovery diet, the hexachloro biphenyls are no longer dominant components of the residue and it is now mainly the hepta- and octachloro biphenyls.

The next slide (#27) illustrates the residue fall off as a function of Aroclor and recovery period. These data are from the two year beagle dog studies and the exposure level is 1 ppm. In this graph, I have plotted the average ppm PCB found in the lipid for Aroclor 1260, Aroclor 1254, and Aroclor 1242 after two years of continuous oral exposure and then after 1 month and 2 month recovery periods on PCB free diets. This plot simply demonstrates that the PCB residues retained from Aroclor 1242 fall off more quickly than those retained from Aroclor 1254 and Aroclor 1260.

The table in the next slide (#28) shows the relative ability of fowl, small mammals, and large mammals to retain orally ingested PCBs. These data are for Aroclor 1242 at the exposure levels and periods shown. The concentration factor is calculated by dividing the maximum PCB level found in the lipid by the exposure level. As you can see from the factors, chickens retain PCBs to a greater extent than do rats or dogs.

Our fish residue work is not very extensive at this point - primarily because we have had problems in finding consulting laboratories capable of carrying out dynamic low level fish exposure studies, and secondly, because government laboratories such as those in Duluth, Minnesota, Columbia, Missouri, and Gulf Breeze, Florida were, and are, still in better positions to carry out and evaluate these types of studies.

We have done some very preliminary 21 day dynamic exposures of catfish and bluegill fingerlings to some of our Aroclor products and it generally supports the conclusions which can be drawn from literature data.

The general conclusions which we draw from these residue studies are shown in the next three slides.

Slide #29 - Build-Up - Conclusions

Slide #30 - Fall-Off - Conclusions

Slide #31 - Alteration of Homolog Distribution - Conclusions

In summary, we feel that the results of our preliminary research support, what has and is being observed via residue analysis of environmental samples; that is to say, from a residue viewpoint, that the bulk of the PCB homologs released to the environment (PCBs with less than 5 chlorines) are subject to environmental degradation of one sort or another at measurable rates and as such have not accumulated.

E. S. Tucker

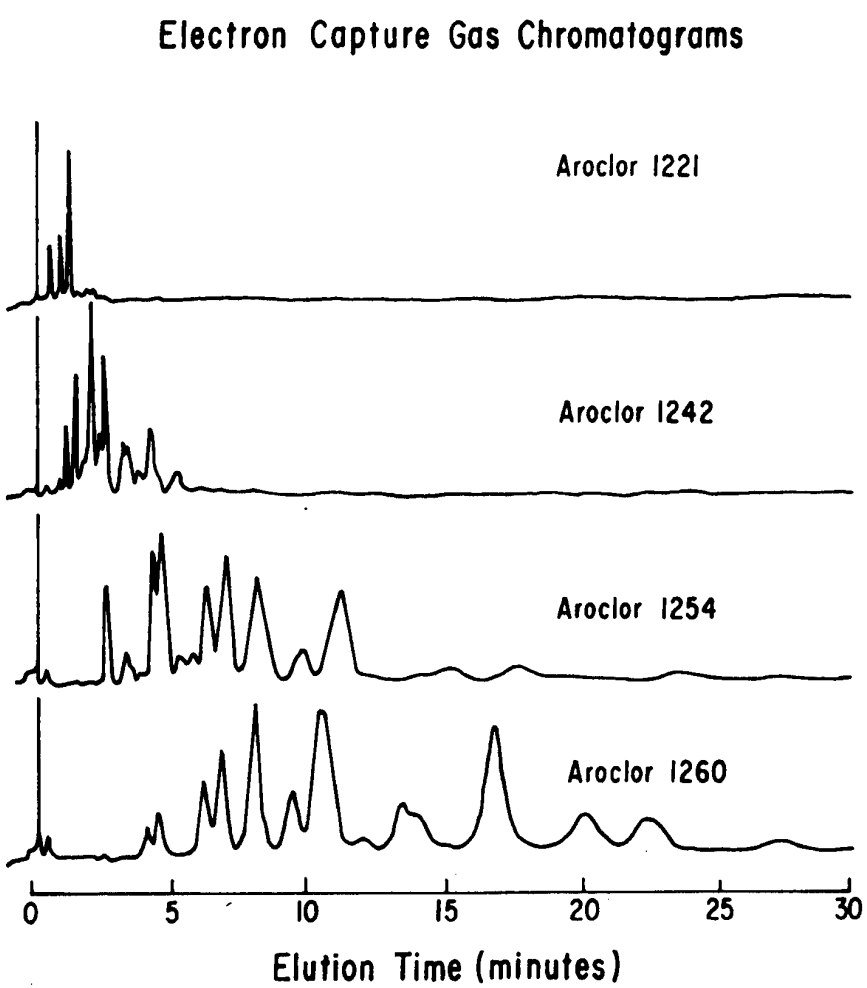
TYPICAL % COMPOSITION OF POLYCHLORINATED BIPHENYL PRODUCTS *

HOMOLOG # Cl/BIPHENYL	AROCLOR 1221	AROCLOR 1016	AROCLOR 1242	AROCLOR 1254
0	11	<0.1	<0.1	<0.1
1	51	1	1	<0.1
2	32	20	16	<0.5
3	4	57	49	1
4	2	21	25	21
5	<0.5	1	8	48
6	ND	<0.1	1	23
7	ND	ND	<0.1	6
8	ND	ND	ND	ND

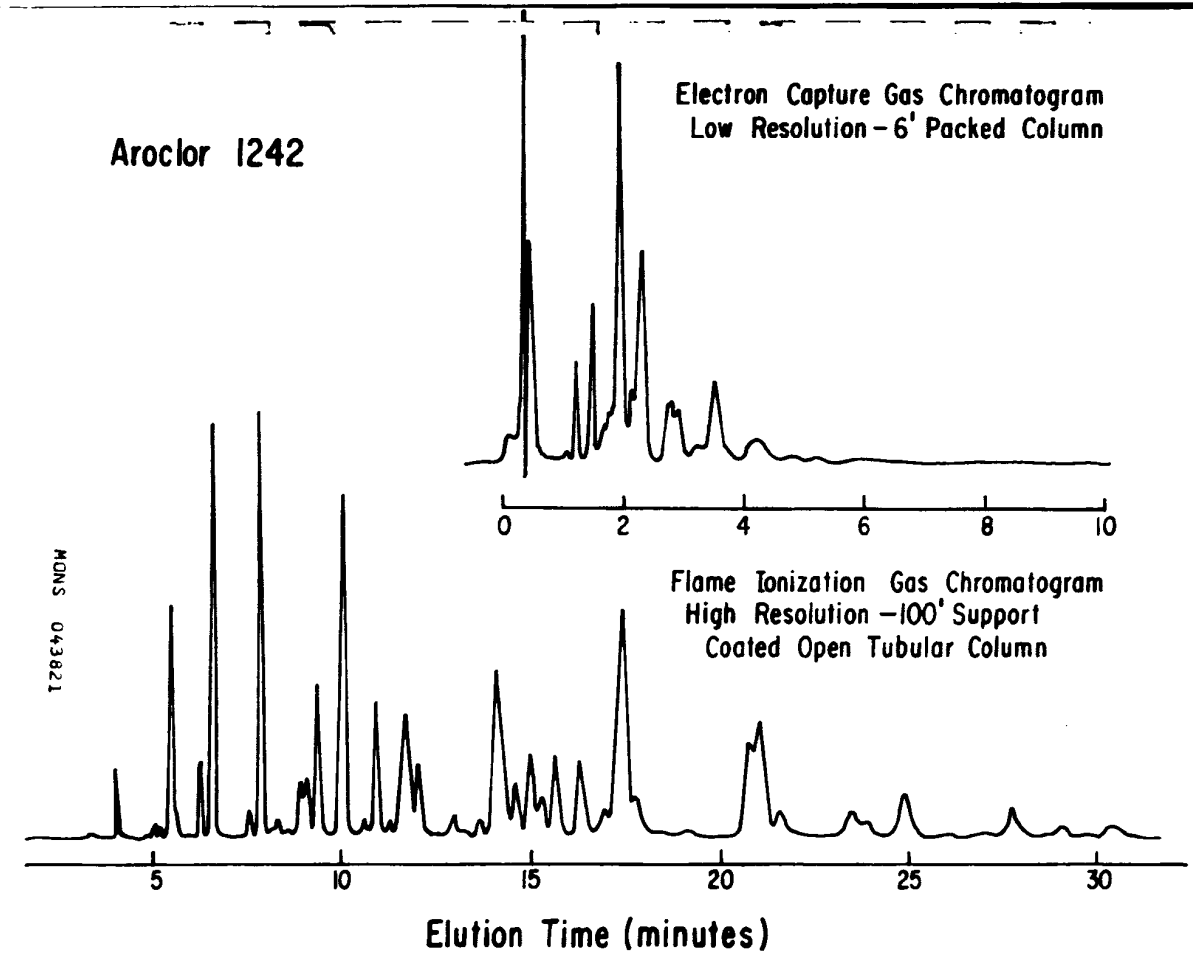
*PER CENT (W/W) BY GC/MASS USING AREA CORRECTION FACTORS BY HOMOLOG RESPONSE

NONE DETECTED, <0.01% = ND

MONS 043819


Electron Capture Gas Chromatograms
Aroclor 1221
Aroclor 1242
Aroclor 1254
Aroclor 1260
0
5
10
15
20
25
30
Elution Time (minutes)

MONS 043820


Aroclor 1242
Electron Capture Gas Chromatogram
Low Resolution – 6' Packed Column
0
2
4
6
8
10
Flame Ionization Gas Chromatogram
High Resolution – 100' Support
Coated Open Tubular Column
MONS 043621
5
10
15
20
25
30
Elution Time (minutes)

- PCB PRODUCTS ARE NOT A SINGLE ENTITY, BUT COMPLEX MULTI-COMPONENT MIXTURES

- PCB RESIDUES FOUND IN WILD LIFE ARE DOMINANTLY PENTA-, HEXA-, HEPTA-, AND OCTA-CHLORO BIPHENYLS

- PCB RESIDUE ARE MOST SIMILAR TO AROCLOR 1254 AND AROCLOR 1260 PRODUCTS

PRIMARY BACTERIAL DEGRADATION STUDIES

- SEMI-CONTINUOUS ACTIVATED SLUDGE DEGRADATION

RESIDUE ACCUMULATION STUDIES

- FISH - CATFISH AND BLUEGILLS
- BIRDS - WHITE LEGHORN CHICKENS
- MAMMALS - ALBINO RATS AND BEAGLE DOGS

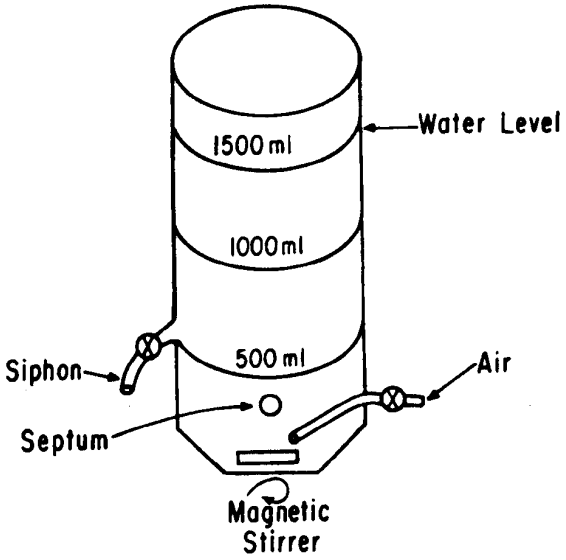
ASSESSMENT OF THE PERSISTENCE OF POLYCHLORINATED BIPHENYLS IN BIOLOGICAL SYSTEMS

MONS 043824

AROCLOR SEMI-CONTINUOUS ACTIVATED SLUDGE PRIMARY DEGRADATION STUDIES

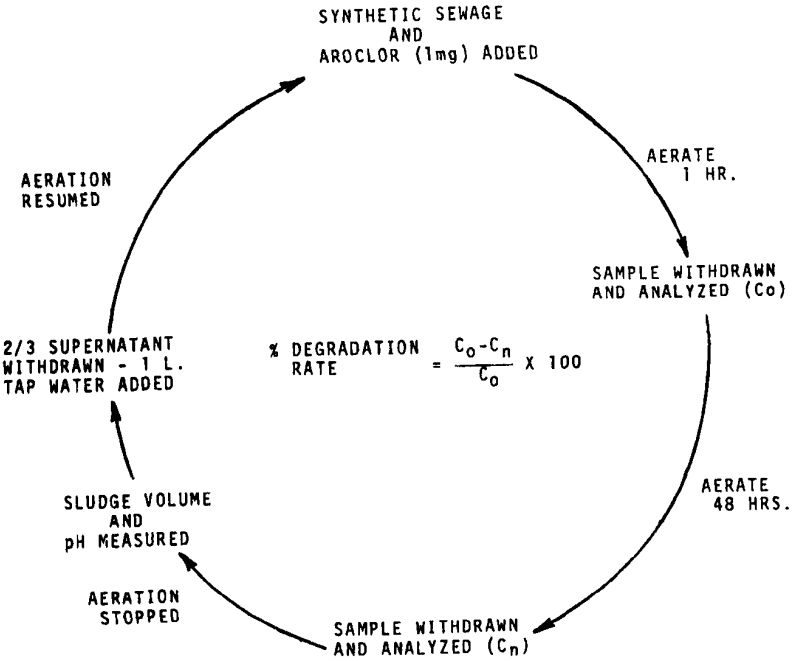
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Semi-Continuous Activated Sludge Test Unit



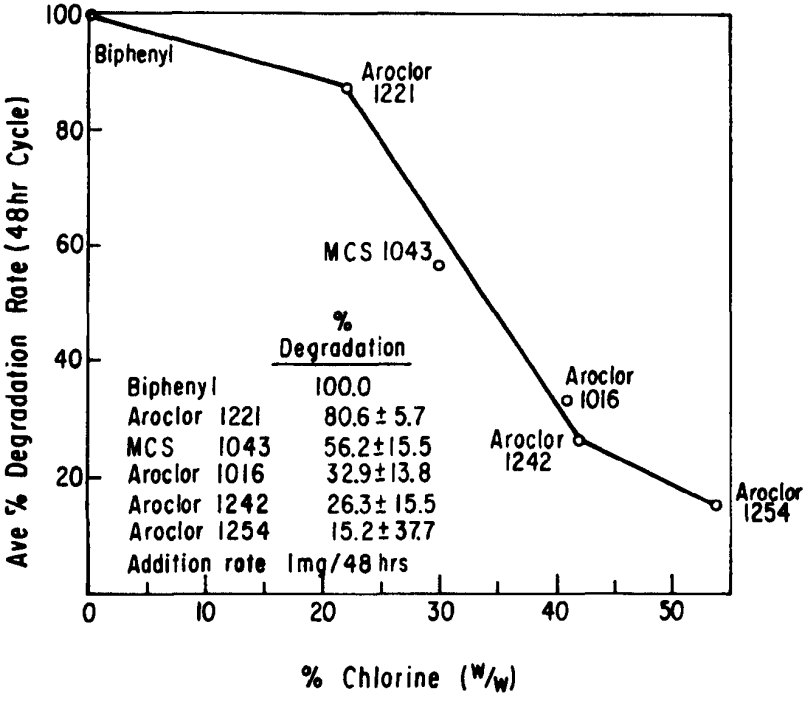
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MECHANICAL CYCLE



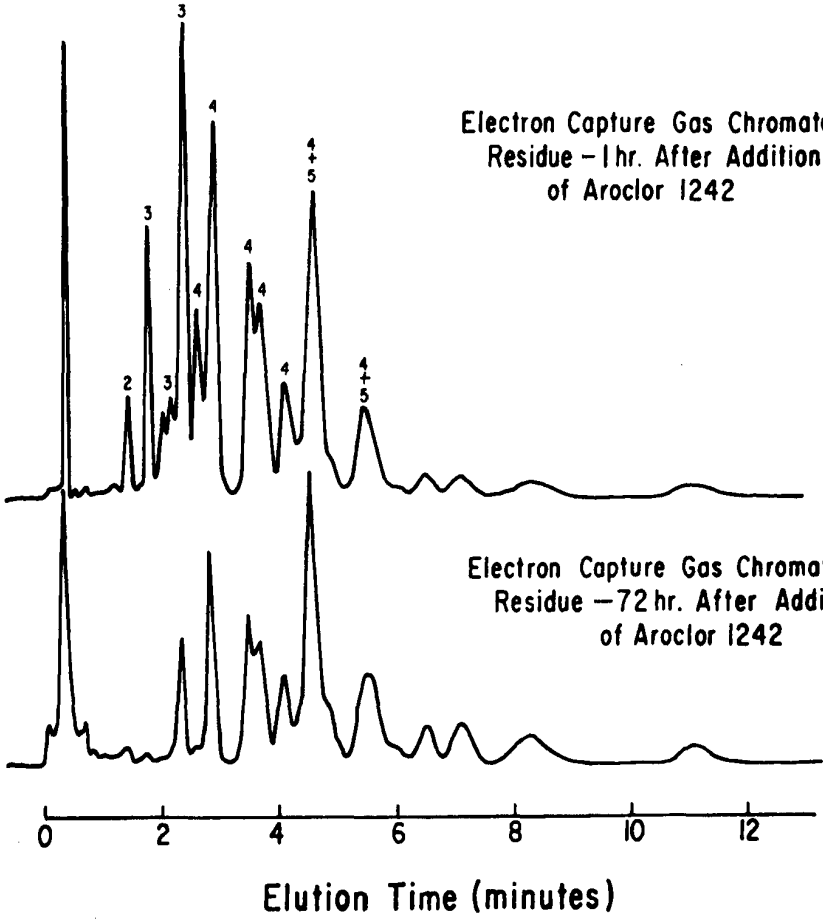
MONS 043827

Semi-Continuous Activated Sludge Degradation of Polychlorinated Biphenyls



MONS 043828

Semi-Continuous Activated Sludge Degradation of Aroclor 1242



MONS 043829

BACTERIAL DEGRADATION STUDIES

CONCLUSIONS

- RATE OF PRIMARY DEGRADATION INCREASES AS THE DEGREE OF CHLORINATION OF THE AROCLOR PRODUCT DECREASES

BIPHENYL>AROCLOR 1221>MCS 1043
>AROCLOR 1016>AROCLOR 1242>AROCLOR 1254

- BIPHENYL, MONO-, DI-, TRI-, AND TETRACHLORO BIPHENYL HOMOLOGS UNDERGO PRIMARY BACTERIAL DEGRADATION

AROCLOR RESIDUE STUDIES

MONS 043831

WHITE LEGHORN CHICKEN STUDIES

PRODUCTS STUDIED		90 DAY ORAL	
		AROCLOR 1242 AROCLOR 1254 AROCLOR 1260	AROCLOR 1242
NUMBER OF CHICKENS	FEMALE	200	80
	MALE	40	16
NUMBER OF SAMPLES	MUSCLE	40	8
	LIVER	40	8
	FAT	40	8
	EGGS	~250	~60
	CHICKS	30	10
NUMBER OF SAMPLES ANALYZED	MUSCLE	14	5
	LIVER	12	4
	FAT	18	5
	EGGS	25	8
	CHICKS	11	10
TOTAL SAMPLES COLLECTED		400	121
TOTAL ANALYZED		80	32

ORAL EXPOSURE CARRIED OUT BY
INDUSTRIAL BIO-TEST LABORATORIES, INC.
NORTHBROOK, ILLINOIS

RESIDUE STUDY OF AROCLOR 1242 IN WHITE LEGHORN CHICKENS

90 DAY ORAL

	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	126	1260	12602	-	(2)	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 12 WEEK EXPOSURE	14	136	1312	-	-	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 30 DAY RECOVERY	9	77	749	-	-	(3)	(4)	(5)	(6)	-	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043833

RESIDUE STUDY OF AROCLOR 1254 IN WHITE LEGHORN CHICKENS

90 DAY ORAL

	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	126	1260	12602	-	-	3	(4)	(5)	(6)	7	-	-	-
*RESIDUE, 12 WEEK EXPOSURE	38	362	3506	-	-	-	4	(5)	(6)	7	-	-	-
*RESIDUE, 30 DAY RECOVERY	17	164	1580	-	-	-	-	5	(6)	7	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043834

RESIDUE STUDY OF AROCLOR 1260 IN WHITE LEGHORN CHICKENS

90 DAY ORAL

	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	126	1260	12602	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 12 WEEK EXPOSURE	65	607	5909	-	-	-	-	5	(6)	(7)	8	-	-
*RESIDUE, 30 DAY RECOVERY	26	232	2363	-	-	-	-	5	(6)	(7)	8	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043835

ALBINO RAT STUDIES

		30 DAY ORAL	2 YEAR CHRONIC ORAL	3 GENERATION RAT REPRODUCTION	90 DAY SUBACUTE ORAL
PRODUCTS STUDIED		AROCLOR 1242 AROCLOR 1254 AROCLOR 1260	AROCLOR 1242 AROCLOR 1254 AROCLOR 1260	AROCLOR 1242 AROCLOR 1254 AROCLOR 1260	AROCLOR 1221
NUMBER OF RATS	FEMALE	115	500	~20	60
	MALE	115	500	~20	60
NUMBER OF SAMPLES	MUSCLE	18	33	-	7
	KIDNEY	18	-	-	-
	LIVER	18	33	-	7
	FAT	18	33	-	7
	PUPS	-	-	10	-
NUMBER OF SAMPLES ANALYZED	MUSCLE	18	33	-	7
	KIDNEY	18	-	-	-
	LIVER	18	33	-	7
	FAT	18	33	-	7
	PUPS	-	-	10	-
TOTAL SAMPLES COLLECTED		144	198	20	42
TOTAL ANALYZED		72	99	10	21

ORAL EXPOSURE CARRIED OUT BY
INDUSTRIAL BIO-TEST LABORATORIES, INC.
NORTHBROOK, ILLINOIS

RESIDUE STUDY OF AROCLOR 1242 IN ALBINO RATS

TWO YEAR CHRONIC ORAL EXPOSURE

ORAL EXPOSURE LEVEL	PPM PCBs 1	10	100	HOMOLOG DISTRIBUTION 1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	803	8037	80373	-	(2)	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 3 MONTH EXPOSURE	6	23	90	-	-	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 12 MONTH EXPOSURE	9	37	155	-	-	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 24 MONTH EXPOSURE	12	53	240	-	-	(3)	(4)	(5)	6	-	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043837

RESIDUE STUDY OF AROCLOR 1254 IN ALBINO RATS

TWO YEAR CHRONIC ORAL EXPOSURE

ORAL EXPOSURE LEVEL	PPM PCBs 1	10	100	HOMOLOG DISTRIBUTION 1	2	3	4	5	6	7	8	9	10
†THEORETICAL RESIDUE	803	8037	80373	-	-	3	(4)	(5)	(6)	7	-	-	-
*RESIDUE, 3 MONTH EXPOSURE	13	94	679	-	-	-	4	(5)	(6)	7	-	-	-
*RESIDUE, 12 MONTH EXPOSURE	24	189	1471	-	-	-	4	(5)	(6)	7	-	-	-
*RESIDUE, 24 MONTH EXPOSURE	42	355	3038	-	-	-	4	(5)	(6)	7	-	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043838

RESIDUE STUDY OF AROCLOR 1260 IN ALBINO RATS

TWO YEAR CHRONIC ORAL EXPOSURE

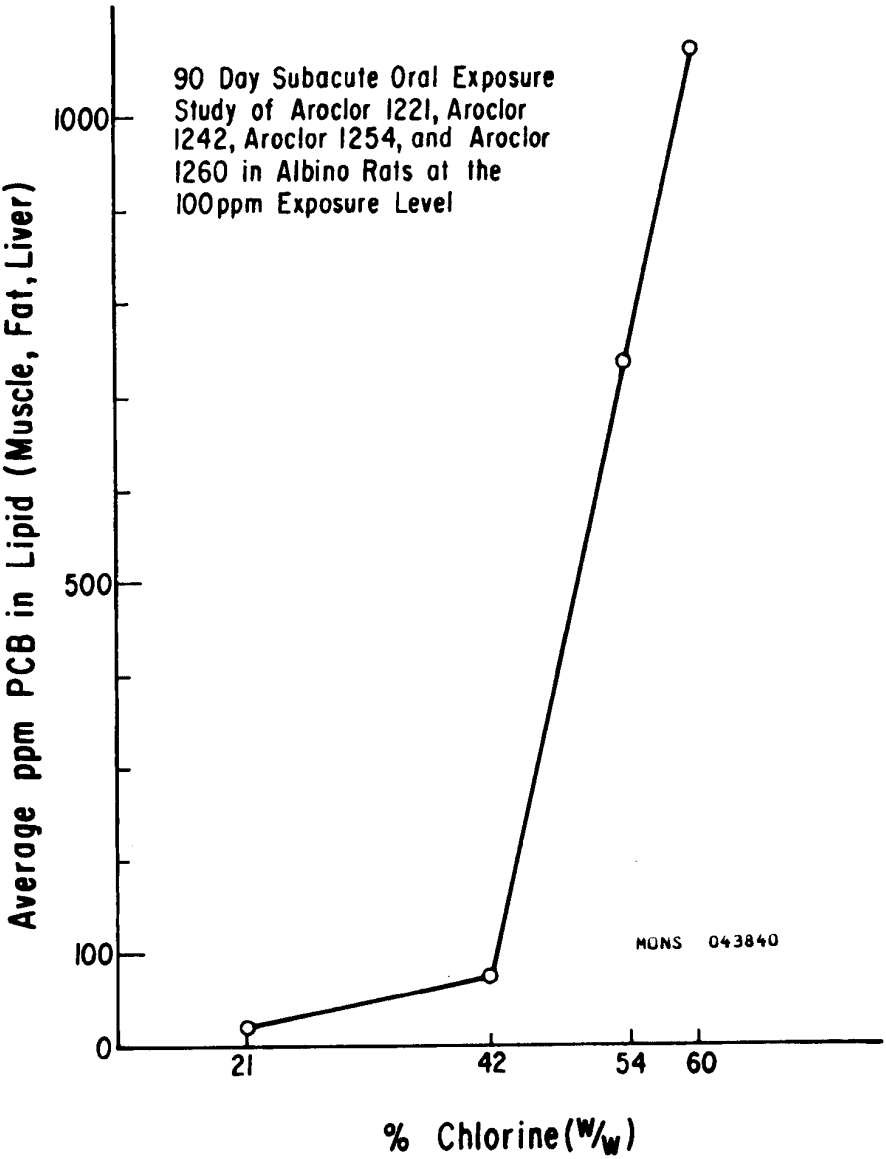
	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	803	8037	80373	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 3 MONTH EXPOSURE	18	134	970	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 12 MONTH EXPOSURE	35	270	2099	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 24 MONTH EXPOSURE	59	507	4338	-	-	-	-	(5)	(6)	(7)	8	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043839


90 Day Subacute Oral Exposure Study of Aroclor 1221, Aroclor 1242, Aroclor 1254, and Aroclor 1260 in Albino Rats at the 100ppm Exposure Level
Average ppm PCB in Lipid (Muscle, Fat, Liver)
1000
500
100
0
21
42
54
60
% Chlorine (W/W)
MONS 043840

BEAGLE DOG STUDIES

PRODUCTS STUDIED		2 YEAR CHRONIC ORAL AROCLOR 1242 AROCLOR 1254 AROCLOR 1260	90 DAY SUBACUTE ORAL AROCLOR 1221
NUMBER OF DOGS	FEMALE	40	14
	MALE	40	14
NUMBER OF SAMPLES	MUSCLE	54	7
	LIVER	54	7
	FAT	54	7
TOTAL SAMPLES COLLECTED		242	21
NUMBER OF SAMPLES ANALYZED	MUSCLE	42	7
	LIVER	40	7
	FAT	43	7
TOTAL ANALYZED		125	21

ORAL EXPOSURE CARRIED OUT BY
INDUSTRIAL BIO-TEST LABORATORIES, INC.
NORTHBROOK, ILLINOIS

RESIDUE STUDY OF AROCLOR 1242 IN BEAGLE DOGS

TWO YEAR CHRONIC ORAL EXPOSURE

	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	519	5186	51865	-	(2)	(3)	(4)	(5)	6	-	-	-	-
*RESIDUE, 2 YEAR EXPOSURE	2	6	12	-	-	(3)	(4)	5	6	(7)	(8)	-	-
*RESIDUE, 30 DAY RECOVERY	1	4	10	-	-	-	-	5	(6)	(7)	(8)	-	-
*RESIDUE, 60 DAY RECOVERY	0.8	3	6	-	-	-	-	5	6	(7)	(8)	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043842

RESIDUE STUDY OF AROCLOR 1254 IN BEAGLE DOGS

TWO YEAR CHRONIC ORAL EXPOSURE

	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	519	5186	51865	-	-	3	(4)	(5)	(6)	7	-	-	-
*RESIDUE, 2 YEAR EXPOSURE	7	30	132	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 30 DAY RECOVERY	5	24	109	-	-	-	-	5	(6)	(7)	8	-	-
*RESIDUE, 60 DAY RECOVERY	4	20	88	-	-	-	-	5	(6)	(7)	(8)	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MDNS 043843

RESIDUE STUDY OF AROCLOR 1260 IN BEAGLE DOGS

TWO YEAR CHRONIC ORAL EXPOSURE

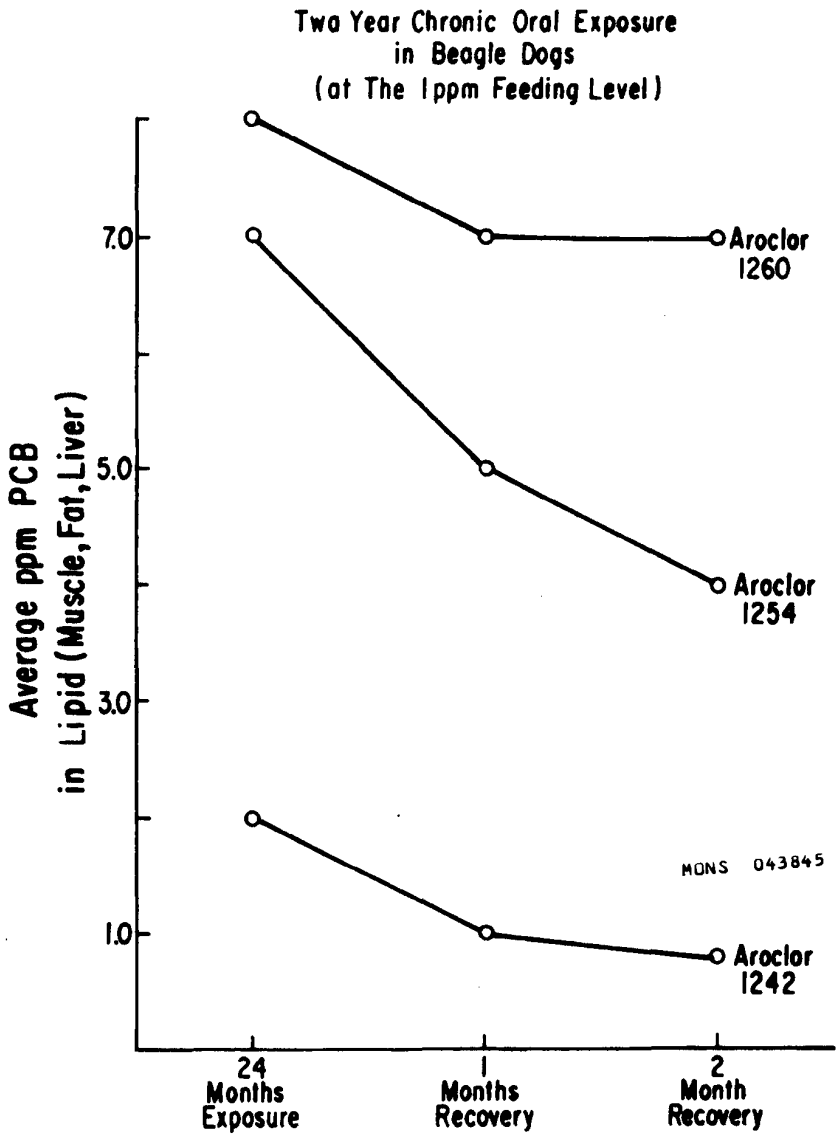
	PPM PCBs			HOMOLOG DISTRIBUTION									
				1	2	3	4	5	6	7	8	9	10
ORAL EXPOSURE LEVEL	1	10	100										
†THEORETICAL RESIDUE	519	5186	51865	-	-	-	-	(5)	(6)	(7)	8	-	-
*RESIDUE, 2 YEAR EXPOSURE	8	63	388	-	-	-	-	-	(6)	7	(8)	-	-
*RESIDUE, 30 DAY RECOVERY	7	60	363	-	-	-	-	-	(6)	(7)	(8)	-	-
*RESIDUE, 60 DAY RECOVERY	7	55	337	-	-	-	-	-	6	(7)	(8)	-	-

†IF TOTAL PCB CONSUMED WERE RETAINED

*AVERAGE PPM IN LIPID - ALL TISSUES

( )ELECTRON CAPTURE PEAKS GREATER THAN 5% OF TOTAL

MONS 043844


Two Year Chronic Oral Exposure
in Beagle Dogs
(at The 1ppm Feeding Level)
Average ppm PCB
in Lipid (Muscle, Fat, Liver)
7.0
5.0
3.0
1.0
Aroclor
1260
Aroclor
1254
Aroclor
1242
MONS 043845
24
Months
Exposure
1
Months
Recovery
2
Month
Recovery

	EXPOSURE LEVEL (PPM)	EXPOSURE PERIOD	CONCENTRATION FACTOR*
WHITE LEGHORN CHICKENS	1.0 (FEED)	12 WEEKS	20
ALBINO RATS	1.0 (FEED)	2 YEARS	9
BEAGLE DOGS	1.0 (FEED)	2 YEARS	2

*CONCENTRATION FACTORS DO NOT TAKE INTO ACCOUNT EXPOSURE PERIODS

CONCLUSIONS

RESIDUE BUILDUP STUDIES

- FOR ALL PRODUCTS THE PCB RESIDUE LEVEL INCREASED AS THE EXPOSURE LEVEL AND PERIOD INCREASED

- RELATIVE TO AROCLOR 1260, THE HIGHEST CHLORINATED PRODUCT STUDIED, THE PCB RESIDUE LEVEL DECREASED EXPONENTIALLY AS AS THE WEIGHT % CHLORINE OF THE PRODUCT DECREASED

- RELATIVE LEVELS OF PCB RESIDUES FOUND WERE -

  FISH>>>>>CHICKENS>RATS>DOGS

- RELATIVE PCB RESIDUE LEVELS IN TISSUES WERE -

CHICKENS	FAT = MUSCLE>LIVER
RATS	LIVER>FAT = MUSCLE>KIDNEY
DOGS	LIVER>FAT = MUSCLE

- FOR ALL PRODUCTS THE DOGS AND RATS EXCRETED AND/OR METABOLIZED 93 TO 99% OF THE TOTAL AROCLOR ORALLY INGESTED

- CHICKENS EXCRETED AND/OR METABOLIZED PRODUCTS INJESTED ORALLY AS FOLLOWS -

  90% OF AROCLOR 1242
  70% OF AROCLOR 1254
  50% OF AROCLOR 1260

MONS 043847

CONCLUSIONS

RESIDUE FALL-OFF

- DOGS AND CHICKENS CONTINUED TO EXCRETE AND/OR METABOLIZE PCB RESIDUES, INCLUDING PENTA AND HEXA HOMOLOGS, RETAINED WHEN PLACED ON PCB FREE RECOVERY DIETS

  DOGS > CHICKENS

- RELATIVE RESIDUE FALL-OFF RATES SHOWED -

  DOGS: AROCLOR 1242>AROCLOR 1254 >AROCLOR 1260

  CHICKENS: AROCLOR 1242>AROCLOR 1254>AROCLOR 1260

CONCLUSIONS

RESIDUE STUDIES

ALTERATIONS OF AROCLOR HOMOLOG DISTRIBUTION

- ALTERATION OF THE HOMOLOG DISTRIBUTION OF ALL PRODUCTS WAS OBSERVED IN ALL STUDIES EXCEPT FISH

- LOWER CHLORINATED HOMOLOGS PRESENT IN ALL PRODUCTS WERE PREFERENTIALLY EXCRETED AND/OR METABOLIZED

- ALTERATION OF THE HOMOLOG DISTRIBUTION INCREASED AS THE WEIGHT % CHLORINE OF THE PRODUCTS DECREASED (INCLUDING PENTA AND HEXA HOMOLOGS)

  AROCLOR 1221>>AROCLOR 1242>AROCLOR 1254 >AROCLOR 1260

  DOGS>RATS>CHICKENS>>>>>FISH

WHAT HAPPENS TO PCBs IN THE ENVIRONMENT?

By

Dr. R. H. Munch

Because they can be detected by the same analytical methods, and because some suspect that they may have similar biological effects to DDT, polychlorinated biphenyls in the environment (PCBs) have become a cause of concern. It is, therefore, important to present data to show that PCBs do disappear from the environment.

Probably the most effective way to do this is to compare what has been put into the environment with what is found there now. This can be done in the following way:

The commercial PCB products are mixture of chlorinated biphenyl homologs containing from one to ten atoms of chlorine per biphenyl molecule. If there were no degradation in the environment, or if all homologs degraded at the same rate, the ratio of homologs in "aged environmental samples" (samples taken at a distance from a known source) should be the same as that in the products introduced into the environment. On the other hand, if the homolog ratio in "aged environment samples" differs from that of material produced, some process must be operating in the environment to remove different homologs at different rates. Monsanto, the sole U. S. producer, recently released data on its sales of the various commercial grades of PCB for the years 1957-72. Rest-of-world sales by other producers and production before 1957 probably represent a similar product mix. Using the Monsanto data and known homolog analyses of each of the commercial grades, the percentage of each homolog in the total U. S. production can be calculated.

The other required datum is an estimate of the homolog distribution in "environmentally aged samples." Analysts experienced in this field generally agree that material recovered from such samples is similar to Aroclor 1254 or 1260, the Monsanto trade name for mixtures of PCBs with chlorine contents corresponding to an average of five and six chlorine atoms per biphenyl molecule respectively (1-8). In order to present a conservative comparison and because most analysts cite Aroclor 1254, we shall use the homolog content of that material in our comparison.

The homolog contents of the material produced in the U. S. from 1957 to 1971 and that of Aroclor 1254 are tabulated below:

	Homolog							
0	1	2	3	4	5	6	7	8
U. S. Sales 1957 - 1971								
0.1	1.3	14.8	29.9	21.9	16.1	10.5	4.2	1.1
Aroclor 1254								
<.1	<.1	<.5	1	21	48	23	6	ND

It is apparent that the homolog ratio of the material sold is quite different from that of Aroclor 1254. There must, therefore, be one or more processes in the environment which remove the lower homologs at much greater rates than the higher ones. The precision of the data is too low to permit accurate calculations of the relative rates of loss. However, it would appear that the homologs containing less than four chlorine atoms may be degraded at rates approximately thirty times those for the five and six chlorine homologs. Laboratory data which we hope to publish later show that the rate of bacterial degradation is an inverse function of the chlorine content for PCBs and might, therefore, be one of the degradative processes responsible for the relative decrease in the lower homologs.

1) L. M. Reynolds, Pesticide Residue Analysis in the Presence of Polychlorinated Biphenyls Residue Reviews 34, 27, 32, 41, 42, 44 (1971).

2) R. W. Risebrough, P. Reiche and H. S. Scott - Current Progress in the Determination of the Polychlorinated Biphenyls - Bulletin of Environmental Contamination & Toxicology 4, 192, 199 (197).

3) G. E. Bagley, W. L. Reichel and E. Cromartie - Identification of Polychlorinated Biphenyls in Two Bald Eagles by Combined Gas-Liquid Chromatography-Mass Spectrometry - Journal of the AOAC 53, 251, 252, 257 (1970).

4) Albert C. Tas and Rudolf H. deVos - Characterization of Four Major Components in a Technical Polychlorinated Biphenyl Mixture - Environmental Science & Technology 5, 1216 (1971).

5) Judith A. Armour and Jerry A. Burke - Method for Separating Polychlorinated Biphenyls from DDT and Its Analogs - Journal of the AOAC 53, 763, 765 (1970).

6) Ian Prestt, D. J. Jeffreries and N. W. Moore - Polychlorinated Biphenyls in Wild Birds in Britain and Their Arian Toxicity - Environmental Pollution 1, 3, 15 (1970).

7) V. Zitko - Polychlorinated Biphenyls and Organochlorine Pesticides in Some Freshwater and Marine Fishes - Bulletin of Environmental Contamination & Toxicology 6, 464, 467 (1971).

8) PCBs & The Environment - Interdepartmental Task Force on PCBs - Washington May, 1972 - COM-72-10419 - Table 6, P. 93.

HOW DO WE GET THE DATA NEEDED?

1. PRODUCTION FIGURES FOR ALL MONSANTO PCB PRODUCTS AND HOMOLOG CONTENT OF EACH PRODUCT ARE AVAILABLE FOR 1957-71. WE USE THESE DATA TO CALCULATE HOMOLOG RATIOS FOR 1957-71 PRODUCTION.

2. EUROPEAN PRODUCERS MAKE SIMILAR PRODUCTS IN ABOUT THE SAME RATIOS AS MONSANTO.

3. PRODUCTION BEFORE '57 WOULD NOT AFFECT THE FIGURES GREATLY SINCE PRODUCT RATIOS WERE SIMILAR AND PRODUCTION SMALLER.

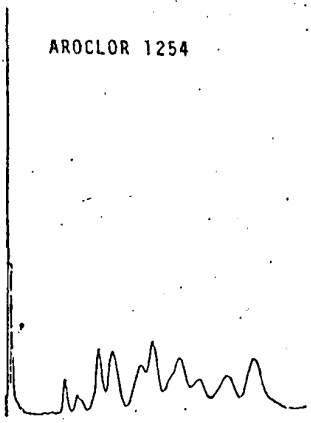
4. ANALYSTS GENERALLY AGREE THAT MATERIAL FOUND IN "AGED ENVIRONMENTAL SAMPLES" IS SIMILAR TO AROCLOR 1254 OR IN RARE CASES EVEN TO AROCLOR 1260.

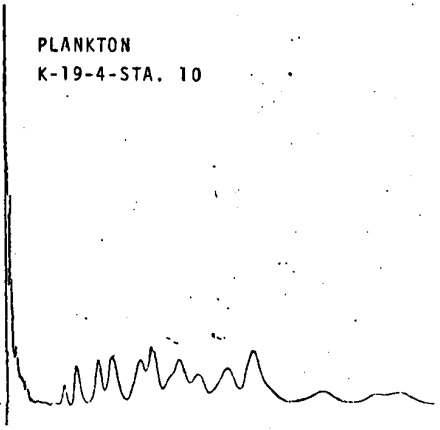
A COMPARISON OF THE HOMOLOG RATIOS FOR PCBs SOLD WITH THOSE FOUND IN AGED ENVIRONMENTAL SAMPLES

	HOMOLOG								
	0	1	2	3	4	5	6	7	8
U.S. SALES '57 - '71	0.1	1.3	14.8	29.9	21.9	16.1	10.5	4.2	1.1%
AROCLOR 1254	<.1	<.1	<.5	1	21	48	23	6	ND

MONS 043854

HARVEY, MIKLAS AND BOWEN OF
WOODS HOLE OCEANOGRAPHIC INSTITUTE
AROCLOR 1254 VS ENVIRONMENTAL MATERIAL CURVES





WHAT HAPPENS TO PCBs IN THE ENVIRONMENT?

1. PCBs ARE MAN MADE.

2. WE CANNOT DETERMINE IF THEY DEGRADE IN THE ENVIRONMENT FROM THE TOTAL CONCENTRATIONS FOUND THERE.

3. THE PCBs ARE MIXTURES OF HOMOLOGS.

4. THEREFORE, COMPARISON OF HOMOLOG RATIOS IN "ENVIRONMENTALLY AGED SAMPLES" WITH HOMOLOG RATIOS IN MATERIAL PRODUCED CAN BE USED TO GAIN INSIGHT AS TO WHAT IS HAPPENING IN THE ENVIRONMENT.

CONCLUSIONS

1. THERE ARE MARKED DIFFERENCES BETWEEN THE RATIOS OF HOMOLOGS IN PCBs FOUND IN "AGED ENVIRONMENTAL SAMPLES" AND THE RATIO OF HOMOLOGS FOR MATERIAL PRODUCED.

2. THESE DIFFERENCES CAN BEST BE EXPLAINED BY ASSUMING THAT THE PCBs WITH 3 OR LESS CHLORINE ATOMS PER MOLECULE DEGRADE MUCH MORE RAPIDLY THAN THE HIGHER HOMOLOGS.

3. THE HOMOLOG RATIO DATA DO NOT GIVE INFORMATION ON THE RATE OF DEGRADATION OF HIGHER HOMOLOGS. HOWEVER, SEMI-CONTINUOUS ACTIVATED SLUDGE TEST DATA SHOW THAT THESE TOO DEGRADE BUT AT A SLOWER RATE.

MONSANTO PCB ACTIONS

By

Dr. C. Paton

In this section I would like to present the voluntary changes that Monsanto has made in PCB sales with particular emphasis on the PCB product changes made in dielectrics. I also wish to show the significance of the data presented by Drs. Tucker and Munch.

Monsanto's sales actions can be divided into two categories (Slide 1: Monsanto's PCB Actions).

The first category is further described in:

Slide 2: Monsanto's PCB sales in U. S. A. and

Slide 3: Effect of phase-out policy

I respectfully submit we have achieved a significant reduction in PCB output by our actions. Turning to the second phase of our actions, viz, the product changes in PCBs for dielectric use I will first take a moment to explain the variation in biodegradability of PCBs.

Slide 4: Degree of Biodegradation of PCBs.

The product changes made dielectrics are shown on Slide 5: PCB Product Changes in Dielectrics.

Dealing first with capacitors:

Slide 6: PCBs used in Capacitors

Note: (a) Penta-chlorobiphenyl percentages include hexa- and higher homologs. Do not add both percentages together.

(b) This slide shows a substantial decrease in production of homologs of penta-chloro and higher over the years.

Slide 7: Why Convert to Aroclor 1016?

Reasons were:

(a) 9-fold reduction in penta-chloro and higher homologs.

(b) 10-fold reduction in hexa-chloro and higher homologs.

(c) Aroclor 1016 was the PCB product that could be introduced into the capacitor industry while still meeting Underwriter's Laboratory requirement on flammability.

(d) Aroclor 1016 was selected because its electrical properties and in-plant processing performance most closely met the capacitor industry's requirements.

Note: Our choice of Aroclor 1016 has since been borne-out by industry experience which to date has shown no problems.

Slide 8: Capacitor Fluids: What is Effect of Aroclor 1016?

We have tried to show amounts of penta-chloro and higher and hexa-chloro and higher homologs which would have been produced (Not entering the environment) for each of three possible capacitor fluids in 1972. Aroclor 1016 (used at 97% level in U.S.A. in 1972) is obviously the PCB involving least penta and higher chloro biphenyl production.

Of obvious interest is the possible amount of PCBs entering the environment from capacitor failures.

Slide 9:

Using the worst case (0.2% per year failure) we see that no more than 40 pounds of hexa-chloro and higher homologs of PCB are likely to enter the environment if Aroclor 1016 is used at a rate of 20M lb./year.

Turning now to Transformers.

MONS 043859

Slide 11:

Note: Higher chlorinated PCBs are needed in transformers than in capacitors because the correct Hydrogen/Chlorine ratio is vital in preventing formation of flammable, explosive arc-form gases.

Slide 12:

Slide 13:

In summary, Slide 14:

We will continue our voluntary policy of no more sales world-wide except to dielectric users. This means a 45% reduction in total PCB sales in the U.S.A. We will restrict over 97% capacitor fluid sales to Aroclor 1016 only. This means penta-chloro and higher production will be no more than 1.1% or 220 M lbs. in 1972. Hexa-chloro biphenyl and higher will be even lower 0.1% or 20,000 lbs. in 1972. We will eliminate Aroclor 1260 from transformer fluids and continue incineration facilities for scrap PCBs. We will encourage the dielectric industry through ANSI C-107, which represents both capacitor and transformer manufacturers and users, to enforce strict environmental control over PCBs. This is a committee on which several of the agencies represented here today are members.

MONSANTO PCB ACTIONS

- PHASE-OUT OF PCB SALES WORLDWIDE IN ALL APPLICATIONS EXCEPT DIELECTRICS
- CONVERSION OF DIELECTRIC FLUIDS TO MORE BIODEGRADABLE PCB'S

MONS 043861

MONSANTO PCB SALES IN U.S.A.

(MILLION POUNDS)

	DIELECTRICS	ALL OTHERS	TOTAL
1969	37.0	30.0	67.0
1970	40.5	33.5	74.0
1972 (EST.)	32.0	--	32.0

MDNS 043862

EFFECT OF PHASE-OUT POLICY

PCB SALES REDUCED IN U.S.A. BY

30 TO 33 MILLION POUNDS.

OR 45%

MONS 043863

DEGREE OF BIODEGRADATION OF PCB'S

BASED ON DATA PRESENTED

- TRANSITION IN BIODEGRADATION OCCURS AROUND PENTA-/HEXA-CHLOROBIPHENYL
- DISAPPEARANCE OF ALL HOMOLOGS BELOW HEXA-CHLOROBIPHENYL OBSERVED
- PENTA- AND HIGHER PCB DETERMINED BY SPECIFIC GLC/MS TEST METHOD

MONS 043864

PCB PRODUCT
CHANGES IN DIELECTRICS

CAPACITORS

97% CONVERSION TO AROCLOR 1016

TRANSFORMERS

ELIMINATION OF AROCLOR 1260

MDNS 043865

PCB'S USED IN CAPACITORS

PCB	MAJOR USE PERIOD	% PCB (PENTA-CHLORO- AND HIGHER	% PCB (HEXA-CHLORO- AND HIGHER
AROCLOR 1254	1930-1952	77.0	29.0
AROCLOR 1242	1952-SEPT. 1971	9.0	1.0
AROCLOR 1016	OCT. 1971	1.1	0.1

MDNS 043869

CAPACITOR FLUIDS
WHY CONVERT TO AROCLOR 1016 ?

- 9-FOLD REDUCTION IN PCB'S OF PENTACHLORO- AND HIGHER
- 10-FOLD REDUCTION IN PCB'S OF HEXACHLORO- AND HIGHER
- MINIMUM INDUSTRY TESTING REQUIRED

MONS 043867

CAPACITOR FLUIDS
WHAT IS THE EFFECT OF AROCLOR 1016?

U.S. CAPACITOR FLUID SALES (1972):~20 $\overline{M}$ LBS.

IF AROCLOR WAS	% PENTACHLORO- AND HIGHER PCBs WOULD BE*	% HEXA CHLORO- AND HIGHER PCBs WOULD BE*
1254	15,400,000 POUNDS	5,800,000 POUNDS
1242	1,800,000	200,000
1016	220,000	20,000

*THIS DOES NOT MEAN AMOUNTS OF PCB ENTERING THE ENVIRONMENT

MONS 043868

WHAT IS CAPACITOR FAILURE RATE ?

INDUSTRY SOURCES CITE : 0.02-0.2% PER YEAR

MDNS 043869

IF CAPACITOR FAILURE RATE IS 0.2% PER YEAR (WORST CASE)

PCB ESCAPE TO THE ENVIRONMENT* IS --

	AROCLOR 1242	AROCLOR 1016
ALL PCB HOMOLOGS	40,000 POUNDS	40,000 POUNDS
PENTA CHLORO- AND HIGHER	3,600	440
HEXA CHLORO- AND HIGHER	400	40

*ASSUMES U.S. FLUID SALES OF 20 M LB./YEAR

MDNS 043870

PCB CHANGES IN

TRANSFORMER FLUID APPLICATIONS

- AROCLOR 1260 BEING PHASED-OUT NOW
- INCINERATION OF SCRAP PCB'S - 1971

NOTE: ASKAREL (PCB) TRANSFORMERS ARE HERMETICALLY SEALED UNITS

MDNS 043871

WHAT IS FAILURE RATE IN LIQUID TRANSFORMERS?

INDUSTRY SOURCES CITE: UNDER 0.2% PER YEAR*

*ALL LIQUID TYPES - MINERAL OIL AND PCB.

MONS 043872

IF ASKAREL (PCB)

TRANSFORMERS FAIL AT 0.2%/YEAR

HOW MUCH PCB IS AFFECTED* ?

ALL PCB HOMOLOGS	24,000 LBS.

(ESTIMATED PCB TRANSFORMER FLUID SALES IN U.S. 12 M LBS./YEAR)

*WITH INCINERATION FACILITIES AVAILABLE, NOT ALL THESE AMOUNTS WILL ENTER ENVIRONMENT.

MONS 043873

MONSANTO'S PRESENT PROGRAM TO PREVENT ENVIRONMENTAL POLLUTION BY PCB'S

- NO MORE SALES WORLD-WIDE EXCEPT DIELECTRIC USERS
- RESTRICT OVER 97% CAPACITOR FLUID SALES TO AROCLOR 1016 ONLY
- ELIMINATE AROCLOR 1266 FROM TRANSFORMER FLUIDS
- CONTINUE INCINERATION FACILITIES FOR SCRAP PCB'S
- ENCOURAGE DIELECTRIC INDUSTRY THROUGH ANSI C-107 TO ENFORCE STRICT ENVIRONMENTAL CONTROL OVER PCB'S

MONS 043874

SUMMARY

By

W. B. Papageorge

In summary, our observations, admittedly limited, both from our laboratory data and from reports of other investigators lead us to believe with considerable confidence that PCBs do degrade in the environment. The complexity of the commercial mixtures has, however, hampered the determination of the varying rates of degradation of all the possible isomers.

Monsanto's sales actions have definitely reduced the amount of PCBs that could be introduced into the environment.

In those applications in which the use of PCBs is considered essential, namely transformers and capacitors, further actions will assure strict environmental control on PCBs.

In transformers the use of the lower chlorinated biphenyls along with proper handling during manufacture, use and repair and proper disposal of waste fluid by high temperature incineration should result in acceptable control.

For the capacitor application the development of Aroclor 1016, which satisfied all of the industry's requirements relating to dielectric characteristics and handling properties as well as having Underwriter Laboratory fire-resistance approval, permits the continued use of PCBs in this important hermetically sealed application but with a fluid that has a significantly lower content of the slower degrading isomers. The use of this material accompanied by proper handling and disposal of the scrap fluid by high temperature incineration represents in our considered opinion a significant step forward in our efforts to control the impact of PCBs on the environment.