

Monsanto

FROM (NAME & LOCATION) Industrial Chemicals Co. - St. Louis

DATE December 17, 1971

FILE

REFERENCE

TO Directors of Marketing
Field Sales Directors
Field Sales Managers
District Sales Directors

CONFIDENTIAL

At their Board meeting on December 9, 1971, Monsanto's Board of Directors approved corporate Monsanto decisions previously taken as follows:

1. Terminate all sales of PCB fluids for use in heat transfer applications by formal notice to all customers.
2. Immediately implement a plan to terminate all sales of polychlorinated terphenyls by March 31, 1972 for plasticizers.
3. Sales of PCB fluids for transformer or capacitor use will be dependent upon the receipt of agreements acceptable to Monsanto, holding Monsanto harmless from legal liability associated with the use of PCBs in transformers and capacitors from customers whose financial responsibility makes such agreements meaningful in Monsanto's opinion.

Since Monsanto Industrial Chemicals Company sells these products to many key corporate Monsanto customers, we want you to be aware of these decisions and their implementation so that customer visits don't lead to surprises.

What MICC products are involved?

1. Specialty Products Business Group
Functional Products Group
MICC

Heat Transfer Fluids:

Therminol® FR-Lo Temp
Therminol® FR-O
Therminol® FR-1

TNGS 004838

PLAINTIFF'S
EXHIBIT

219
10-26-95

WATER_PCB-SD0000076719

Capacitor Dielectric Fluids:	Capacitor 21
	Aroclor [®] 1016
	Aroclor [®] 1242
	Aroclor [®] 1248
	Aroclor [®] 1254
Transformer Askarel Fluids:	Inerteen 100-42
	Inerteen 70-30
	Inerteen PPO
	Pyranol A13B3B

2. Plasticizer Business Group
Rubber & Process Chemicals Division
WICC

Plasticizers	Aroclor [®] 1221B	Montar 5
	Aroclor [®] 5432	Santicizer 301
	Aroclor [®] 5442	Santicizer 311
	Aroclor [®] 5460	Santicizer 326
	Aroclor [®] 6000 Series	Santicizer 327
		Santicizer 335
		Santicizer 336
		Santicizer 337
		MXP 101

What effect will this have on our customers?

While everyone wishes these decisions did not have to be taken, and while they will cause some inconvenience to customers, the picture is not so gloomy as might be supposed.

1. These decisions should not come as a complete surprise to any customer. We have been alerting customers by letter periodically since February, 1970 of the problems associated with PCBs.
2. We phased out PCBs from certain applications (plasticizers, hydraulic fluids, and process fluids) from mid-1970 to early 1971.
3. We discontinued sales of PCBs to new heat transfer fluid systems several months ago.
4. Since August, 1971, many existing PCB heat transfer fluid users have effected conversions to non-PCB fluids. (To date over 150 of such systems have converted. We have retained 90% of these conversions for Monsanto with our non-PCB heat transfer fluids Thermanol 55 and 66.)

TNGS 004839

What help are we offering our customers?

1. Heat Transfer Fluids

As explained in our customer notification letter, we have assembled an experienced engineering team to give help to customers as they decide on conversions. We also offer the services of a high temperature incinerator to dispose of used PCB heat transfer fluids, and will accept return of originally packaged PCB fluids.

2. Dielectrics

The decision on dielectric fluids will probably not affect most of you since transformer and capacitor manufacturers are a reasonably small and separate group. We emphasize that we are not discontinuing dielectric PCBs since their usage is important to the national interest. Monsanto is conditioning such sales, however, on obtaining certain financial safeguards, while acting responsibly in the interest of the electrical industry, its consumers, and thus the country. We are also active in ANSI G107, a committee set up to develop guidelines and policies for handling PCB in the electrical industry.

3. Plasticizers

Monsanto is working to develop a list of suggested replacement products and suppliers to be used as a guide in replacing our Aroclor[®] products in existing formulations.

Questions from customers

Customers are going to ask questions about these decisions. We would suggest that your salesmen not try to answer these questions but to refer the customer to St. Louis:

Heat Transfer Fluids

Telephone:	(314) 694-2514
Mail:	Cumming Paton Monsanto Company P. O. Box 14617 St. Louis, Missouri 63178

Dielectrics

T. L. Gossage	(314) 694-2545
P. G. Benignus	(314) 694-2513
C. Paton	(314) 694-2520

TNGS 004840

Plasticizers

W. S. Clark (314) 694-2518

Direct inquiries from customers to Monsanto district offices should be handled in the same way. If you wish to pass on questions or statements from customers, please feel free to do so through the same channels.

Key Monsanto customers

Attached you will find a list of key corporate Monsanto customers who will be given special notification of Monsanto's decisions. Separate lists are given for Heat Transfer Fluids and chlorinated terphenyl plasticizers. No list is given for dielectric customers since discontinuation of sales will not result unless our terms are rejected. Customers not included in these lists will receive the formal notification letters by mail (copies attached). Key customers will be notified as follows:

Heat Transfer

1. By mail: Formal letter plus cover letter indicating that conversions are already underway or (in the case of multi-plant locations) have actually taken place at some locations.
2. By phone: Formal letter will then be mailed.
3. By phone plus personal visit (letter hand-carried): In this category we may ask assistance from Regional Vice Presidents or Directors of Sales/Marketing to introduce us to the "right" people. The personnel primarily involved from Specialty Products Group in notifying key customers will be;

H. S. Bergen, Jr.	- Business Group Director
T. L. Gossage	- Director of Marketing
N. T. Johnson	- Field Sales Manager
C. Paton	- Product Manager

Plasticizers

1. By mail: Formal notification by letter addressed to the Office of the President to be mailed on 12/31/71.
2. By phone: By regional managers and salesmen during period from 12/20/71 to 12/31/71. This will cover all important accounts.

TNGS 004841

3. Personal calls: By regional managers and salesmen from 12/20/71 to 12/31/71 with follow-up visits by St. Louis management personnel from 1/1/72 to 1/14/72 at key accounts as appropriate.

Customer Notification

U. S. Domestic Customers

Heat Transfer Fluids: December 15-20, 1971
Plasticizer Aroclor: December 20-31, 1971

Canada

Notification will follow the U. S. pattern as quickly thereafter as practical.

International

Action will be taken through World Area Marketing management in the first quarter of 1972.

It is very important that you do not make this subject a deliberate topic of conversation in your dealings with your customers. Please do not preempt the business groups involved in notifying customers. We have alerted you so that you are not caught unaware should delicate negotiations concerning your products be going on. We would ask in return that you treat this information in confidence so that we can implement these corporate decisions as effectively as possible for both Monsanto and our customers.

Competition

Be particularly careful in how you handle this information at the following accounts:

Dow
Dow Corning
All oil companies

Dow is Monsanto's major competitor in synthetic heat transfer fluid. They have never had fire-resistant fluids like Therminol FR fluid. However, they will be out to obtain refills of fluid with Dowtherm against our Therminol 66. If the customer operates at temperatures below 550°F. or so, he may elect to go to lower cost fluid such as Therminol 55. In these cases, our competition will be petroleum-based fractions from Humble, Mobil, Shell, etc.

TNGS 004842

Finally, may we ask that this memo be furnished only to those with a need to know.

C. Paton

C. Paton
Product Manager
Dielectric, Heat Transfer &
Process Fluids
Specialty Products Business Group

W. S. Clark

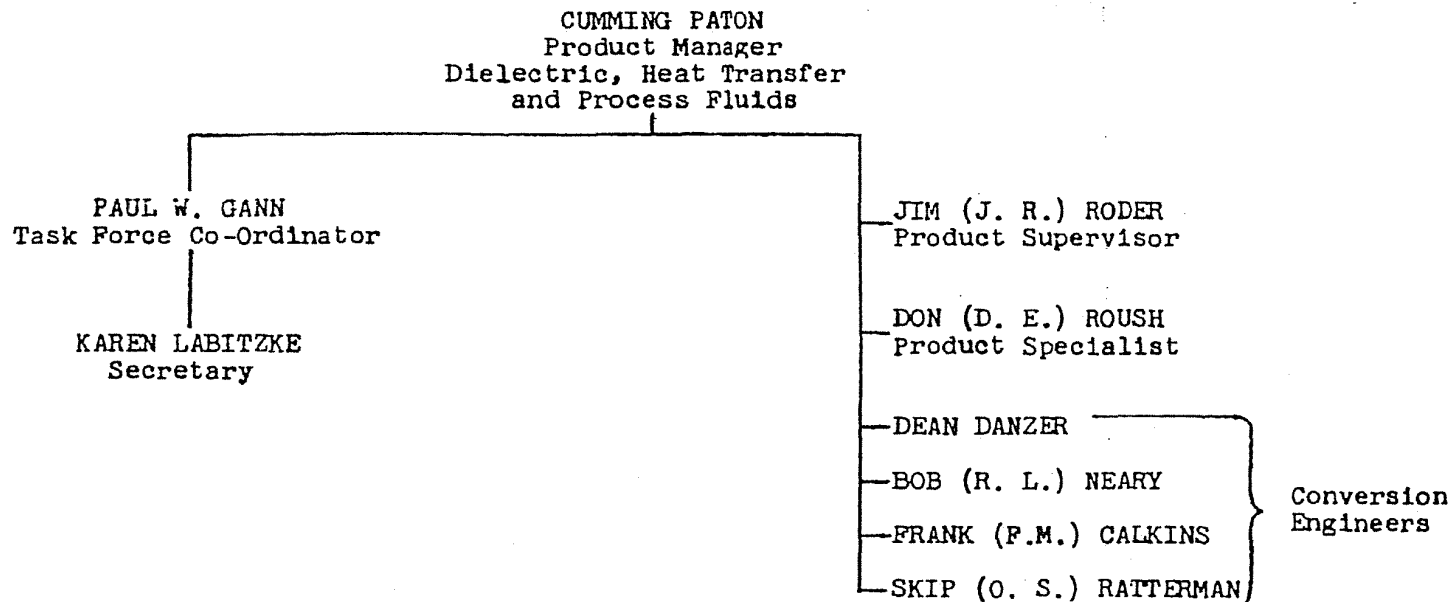
W. S. Clark
Product Supervisor
Plasticizer Business Group

Enc. (H. T. Fluid Letter)
(Plasticizer Aroclor Letter)
(Key H. T. Fluid Accounts)
(Key Plasticizer Aroclor Accounts)

TNGS 004843

SPECIALTY PRODUCTS BUSINESS GROUP
MONSANTO INDUSTRIAL CHEMICALS COMPANY

PCB TASK FORCE - HEAT TRANSFER FLUIDS



TASK FORCE TELEPHONE NUMBER: (314) 694-2514

TASK FORCE MAIL ADDRESS: Cumming Paton
Monsanto Company
P. O. Box 14617
St. Louis, Missouri 63178

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Monsanto

MONSANTO INDUSTRIAL CHEMICALS CO.
800 N. Lindbergh Boulevard
St. Louis, Missouri 63186
Phone (314) 894-1000

December 31, 1971

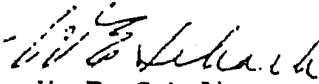
Dear Sir:

We are writing to advise you that Monsanto has made the decision to cease the sale of polychlorinated terphenyls for use as plasticizers and for use in other open system applications effective March 31, 1972. These products have been sold by Monsanto under the trade name Aroclor®.

Normal volumes of our existing Aroclor product line may be purchased between now and March 31, 1972, however, no shipments will be made after that date. Sales during the last six months of 1971 will determine normal order quantities.

Monsanto is working to develop a list of suggested replacement products and suppliers to be used as a guide in replacing our Aroclor® products in existing formulations. This list may be obtained by contacting any of our regional offices whose addresses and telephone numbers are shown on the attached sheet.

Very truly yours,



W. E. Schalk
Sales Director
Plasticizers

/dbw

a unit of Monsanto Company

TNGS 004845

Monsanto

MONSANTO INDUSTRIAL CHEMICALS CO.
800 N. Lindbergh Boulevard
St. Louis, Missouri 63185
Phone: (314) 684-1000

December 15, 1971

Dear Sir:

We are writing to advise you that, effective this date, Monsanto will no longer sell the Therminol® FR series of heat transfer fluids. This important decision by Monsanto's management has been carefully considered.

The Therminol® FR series of fluids contain polychlorinated biphenyls (PCBs). As we have previously advised you, studies indicate PCBs may be accumulating in the environment. In some instances, PCBs have been found in food or in the food chain. An article by Carl G. Gustafson of the Federal Water Quality Administration appearing in "Environmental Science & Technology" and dealing with this subject is attached for your information.

Because of Monsanto's concern over this problem, we have discontinued sales of PCBs where the usage was in so-called "open systems." We have discontinued sales of Therminol® FR materials where the usage would be in food processing applications. In addition, we have encouraged Therminol® FR fluid customers to switch to other materials.

As a result of these efforts, many of our heat transfer fluid customers have switched from Therminol® FR series fluids to other materials or systems.

Our action in discontinuing sales for use in heat transfer systems has been taken because of the problems which may arise should there occur accidental leakage of PCBs from such systems. We believe this action is in the best interest of all our customers who have continued using these materials in heat transfer applications.

A unit of Monsanto Company

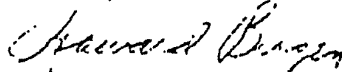
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In order to help you accomplish a change-over from Therminol® FR to another heat transfer fluid with the least difficulty, Monsanto will offer you the following special services:

- 1) We have assembled a team of experienced engineers who will be available to visit your plant on request to consult with you on available alternatives. Of course, the decision is and will be yours as to how you elect to proceed. If you consider such a service would be of assistance to you, please telephone (314) 694-2514, or write directly to Dr. Cumming Paton, Monsanto Company, P. O. Box 14617, St. Louis, Missouri 63178.
- 2) We will pay freight costs incurred in returning the Therminol® FR to us and will properly dispose of the material (by high temperature incineration) at our cost. We will contact you concerning instructions about drainage, drumming and shipping of material to our facility in St. Louis.
- 3) We will accept return of any unopened drums of Therminol® FR series products which may be in your possession and credit you for this material at full purchase price if returned to us prior to March 1, 1972.

We sincerely regret any hardship that this decision may cause you, but feel you will agree Monsanto has made the correct decision.

Yours sincerely,



Howard Bergen, Director
Specialty Products Group
Monsanto Industrial Chemicals Company

Attachments

TNGS 004847

feature

PCB's—prevalent and persistent

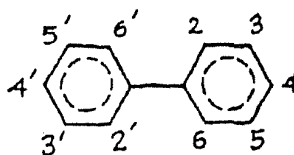
Intensified research is needed to minimize their dangers

Carl G. Gustafson, Federal Water Quality Administration, Athens, Ga.

During the past three years, a special class of compounds, called polychlorinated biphenyls (PCB's), has claimed the attention of ecologists and pesticide analysts in this country. These compounds were not discovered in the environment until 1966 in Sweden and 1967 in the U.S., despite the fact that they have been available commercially for 40 years. Interest in PCB's has arisen because they are frequently found in fish, bird, water, sediment, and other environmental samples when such samples are examined for chlorinated pesticide residues. That a wide variety of samples containing PCB's has been collected from England, Scandinavia, The Netherlands, Antarctica, Central America, and many different parts of the U.S. makes them truly ubiquitous pollutants.

Polychlorobiphenyls are made by substituting chlorine atoms for one or more of the hydrogen atoms at the

numbered positions of the biphenyl structure.



In the process of replacing hydrogen atoms with chlorine atoms, a large number of substitution combinations arise. For example, three monochlorobiphenyl isomers are possible, 12 dichlorobiphenyl isomers, 21 trichlorobiphenyl isomers, and so on. Theoretically, 210 compounds can be prepared by this substitution process; a typical example would be 2,4,6,2',4'-pentachlorobiphenyl.

Whenever aromatic hydrocarbons such as biphenyls are chlorinated, the product is a mixture of compounds, including isomers. It is quite difficult to synthesize single, specific chlorobiphenyl compounds in the laboratory unless involved procedures are employed. Consequently few of the individual compounds have been prepared in the pure form for study.

In the commercial process for PCB manufacture, biphenyl is chlorinated with anhydrous chlorine in tall cylindrical towers with either iron filings or ferric chloride as the catalyst. The by-product is hydrogen chloride; the product is a mixture of several PCB's. The degree of chlorination is determined by measuring the specific gravity of the mixture or, when the product is more viscous, the ball-and-ring softening-point test is used. The whole process takes from 12 to 36 hours.

In the U.S., the sole manufacturer of PCB's is the Monsanto Co., which markets them under the trade name

Aroclor. PCB's are also manufactured in Europe and Japan, under trade names such as Phenochlor and Clophen. The various Aroclors are differentiated by a four-digit number, with the last two digits indicating the percentage of chlorine in the mixture.

Properties

The three most important physical properties of the PCB's are low vapor pressures (they have high boiling points), low water solubility, and high dielectric constants. They are miscible with most organic solvents and compatible with many types of polymers. Although some individual polychlorobiphenyl compounds are crystalline, the Aroclor mixtures are either liquids or resins.

The chemical properties that make PCB's desirable industrial materials are their excellent thermal stability, their strong resistance to both acidic and basic hydrolysis, and their general inertness. They are quite resistant to oxidation. Monsanto reports, in a technical bulletin on PCB's, that they can be heated to 140° C. under 260 p.s.i. of oxygen pressure "without showing any evidence of oxidation as judged by development of acidity or formation of sludge."

The physiological properties of the PCB's make them potentially significant contaminants of the environment. For any pollutant, two factors are involved: acute toxicity, which is immediately evident because of a high death rate or other maiming effect; and chronic toxicity, which is the result of a slow accumulation of the poison in the body and is a sublethal effect. Whenever acute toxicity is high, a pollutant will be readily recognized and appropriate remedial actions will be introduced. If, on the other hand, acute toxicity is low,

The Monsanto Co. stated recently in a letter to Congressman William F. Ryan of New York that as of August 30, it would no longer sell PCB's to customers for use in general plasticizer operations where disposal of the end-products cannot be controlled. After some lag period—the time it takes to eventually dispose of the products made from PCB's and currently in processor's inventories—the quantity of PCB's getting into the environment may be substantially reduced. If Monsanto's former customers look for PCB substitutes, rather than purchasing PCB's from manufacturers in Japan and Europe, the projected decrease could become a reality.

Carl G. Gustafson

the physiological effects will go unnoticed until the chronic effects make themselves evident. When this happens, the problem may have advanced beyond immediate or easy correction.

Acute toxicity

All studies of PCB's in animals indicate that acute toxicity is not a significant factor. Their acute toxicities are on the order of those of other chlorinated aromatic compounds. Monsanto has sponsored two investigations of the acute toxicities of Aroclor mixtures. In the first, at the Kettering Laboratory at the University of Cincinnati, Dr. J. F. Treon and his co-workers investigated the toxicity of Aroclor vapors for guinea pigs, mice, rabbits, and rats. All animals survived a 24-day exposure to 0.83 p.p.m. of Aroclor 1242 for 7 hours per day on 17 of those days. Even after more prolonged tests, there were no severe effects from Aroclor 1242. In the second investigation, still in process, three groups of beagles are fed Aroclor 1242, 1254, and 1260, respectively, at a rate of 100 p.p.m. in their diets. After three months no significant abnormalities have been noted.

Similar studies on fish have been performed in several laboratories. Dr. Richard Schoettger of the Sport Fisheries and Wildlife Fish-Pesticide Research Laboratory in Columbia, Mo., reports that 96 hour- TL_{50} toxicities of the Aroclors to trout range from 1.17 to 60 p.p.m. Compared to DDT, whose 96 hour- TL_{50} toxicity is 0.002 to 0.009 p.p.m. for trout, the PCB's have a relatively low acute toxicity. With the more sensitive bluegill, the 96 hour- TL_{50} for Aroclor 1248 is 0.278 p.p.m., while that of DDT is 0.008 p.p.m. Aroclor toxicities appear to be inversely proportional to the chlorine content of the mixture.

Shellfish, oysters, and shrimp are more sensitive to PCB's. Dr. Tom Duke, at the Bureau of Commercial Fisheries Pesticide Field Station, reports 100% mortality of juvenile pink shrimp exposed to 0.10 p.p.m. of Aroclor 1254 in water for 48 hours. This concentration of Aroclor 1254 will cause a 100% decrease in shell growth of oysters after 96 hours. To achieve the same effects with DDT in these experiments, only 0.0006 p.p.m. and 0.01 p.p.m., respectively, were required.

There is very little evidence that PCB's are toxic to insects. Studies to date show that they are less toxic than

dieldrin or DDT. As with fish, their toxicity appears to be inversely proportional to the chlorine content of the mixture.

Based on the above data, it is understandable why the polychlorobiphenyls, commercially available for 40 years, have only recently attracted attention as toxic environmental contaminants.

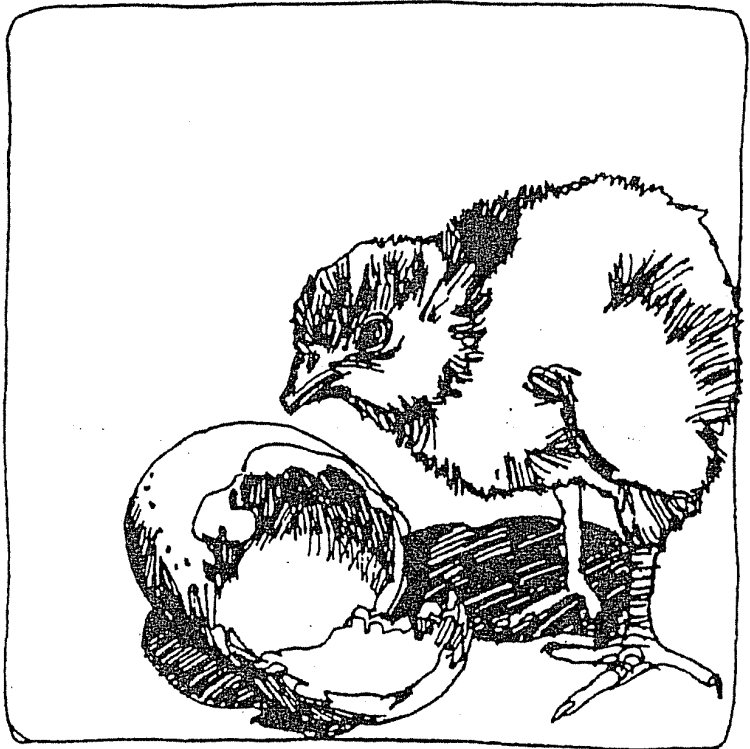
Chronic toxicity

The chronic toxicities of PCB's present a more disturbing situation; several chronic effects have been observed. It was discovered, quite by accident, that PCB's have a toxic effect on chickens. Professor E. I. McCune and his co-workers at the University of Missouri found their chickens dying after they were placed in a feeding house, parts of which had been freshly painted with an epoxy paint. Careful investigation revealed that the toxic factor was Aroclor 1242, a binder in the paint. When Aroclor 1242 was fed to the chicks it produced the same characteristic effects as chick edema factor. McCune reported: "Gross pathology included hydropericardium, hydroperitonium, enlarged heart, liver, and kidneys, and hemorrhage of internal organs. Mi-

croscopically the kidneys showed marked tubular dilation and numerous casts."

Another chronic effect of PCB's is related in wildfowl. The accumulation of high concentrations of chlorinated hydrocarbons in birds resulted in disruption of normal breeding behavior and in the formation of thin-shelled eggs. A dramatic example of this effect has been observed in the case of the brown pelican. On the Anacapa Islands off the California coast, no young were hatched last year from 300 pairs of nesting birds. The shells of most eggs laid were so thin that a dent occurred when the egg was picked up.

There are two possible causes for the laying of thin-shelled eggs by wildfowl. One is a low calcium reserve in the bird; the other is the inability of the bird to deliver the needed calcium to its oviduct, where the eggshell is forming. The calcium level in the avian biosystem and the calcium reserve in the secondary bone structure or medullary bone, found only in female birds when they are breeding, are controlled by the hormone estrogen. A high estrogen level is associated with the formation of this calcium reserve. Chlorinated hydrocarbons, such as DDT,

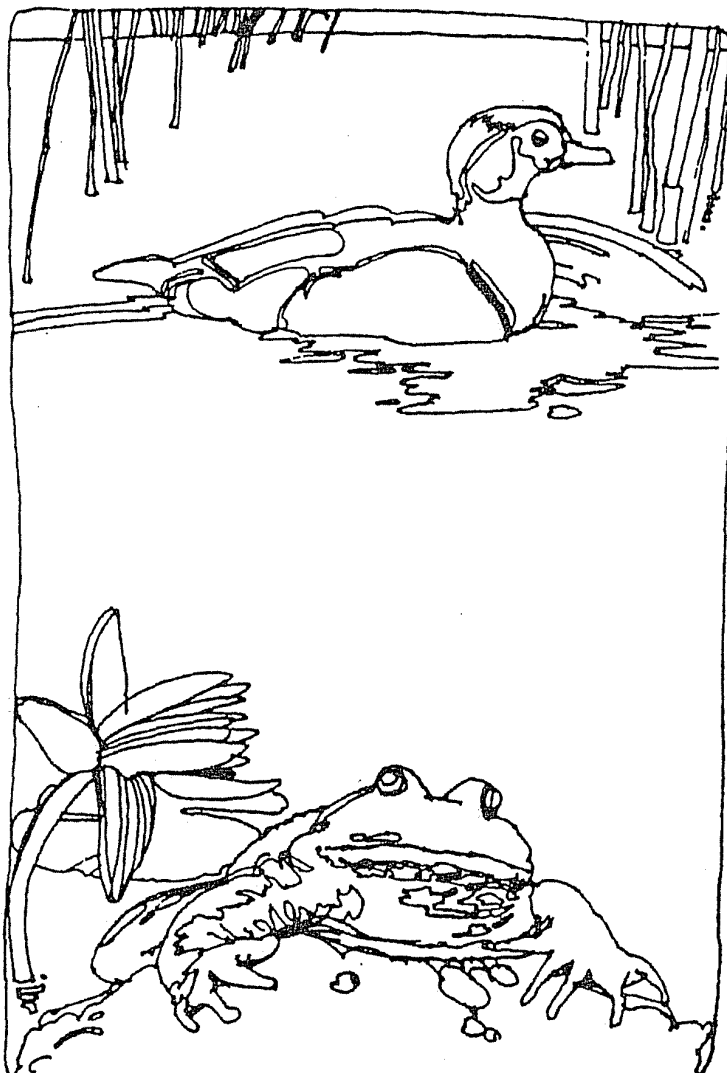


chlordane, dieldrin, and PCB's, activate enzymes in the liver which transform estrogen into a more water-soluble compound that is readily eliminated from the bird's body. This means that when estrogen levels are low, calcium reserves will also be low, and therefore very little calcium will be available for strong eggshell production. Dieldrin and PCB's are more effective than DDT in this type of enzyme-induction activity. Aroclor 1262 has an estradiol degrading potential four to five times that of *p,p'*-DDE or technical grade DDT.

The ability of the female bird to deliver calcium to her oviduct during the last 20 hours, when the eggshell is being formed, is related to the functioning of the enzyme carbonic anhydrase. When birds that have exhibited the ability to lay normal eggs are injected with a metabolite of DDT (DDT) just prior to the formation of the eggshell, they will lay thin-shelled eggs. This indicates that DDT also inhibits the activity of carbonic anhydrase, the enzyme that controls the flow of calcium from the blood stream of the bird into its oviduct.

Since dieldrin seems to have no effect on carbonic anhydrase, we may assume that neither do the PCB's. However, these compounds delay breeding time significantly. Many ornithologists feel that late breeding has a stronger influence on the reduction of bird populations than does the laying of thin-shelled eggs. If this is true, PCB's are a more potent threat than DDT to our declining bird populations, especially for predatory birds that accumulate fairly high levels of PCB's because they eat smaller animals that already have concentrated PCB's in their own tissues.

Other investigators have produced evidence to show that PCB's are similar to DDT in their activity. Dr. Joseph Street at Utah State University has shown that when PCB's accumulate in the liver, they induce microsomal enzyme activity by bringing about more rapid metabolism of drugs, insecticides, and other foreign compounds. He fed rats a diet containing 50 p.p.m. of Aroclor 1254 or Aroclor 1260. After 10 days on this diet, the test animals were administered hexobarbital at a dose of 100 p.p.m. to induce sleep. In comparison with a control group, the sleeping time for these rats was reduced by 65 to 80%. Street also found that Aroclor, when fed at the



same level, will reduce dieldrin storage in adipose tissue by 90 to 95%; increase aniline oxidation by 200 to 300%; and increase EPN detoxication by 430 to 470%. In addition, the PCB's cause activation of organothiophosphate compounds, which adversely affect the system. This latter effect counterbalances the detoxification of dieldrin.

Normally, when a substrate activates an enzyme, it is converted to a water-soluble form that will be eliminated from the system; however, this is not the case with PCB's. Because they remain in the system for prolonged periods of time, their enzyme induction activity is always present. In this way the normal concentration of important body chemicals may be lowered to the

point of bringing about malfunctions in the system. For example, Street believes that the PCB's bring about steroid degradation, which can lead to altered endocrine relationships.

The chronic toxicity to man is as follows:

Like the chlorinated naphthalenes, the chlorinated diphenyls have two distinct actions on the body, namely, a skin effect and a toxic action on the liver. The lesion produced in the liver is an acute yellow atrophy. This hepato-toxic action of the chlorinated diphenyls appears to be increased if there is exposure to carbon tetrachloride at the same time. The higher the chlorine content of the diphenyl compound, the more toxic it is liable to be. Oxides of chlorinated diphenyls are more

toxic than the unoxidized materials.

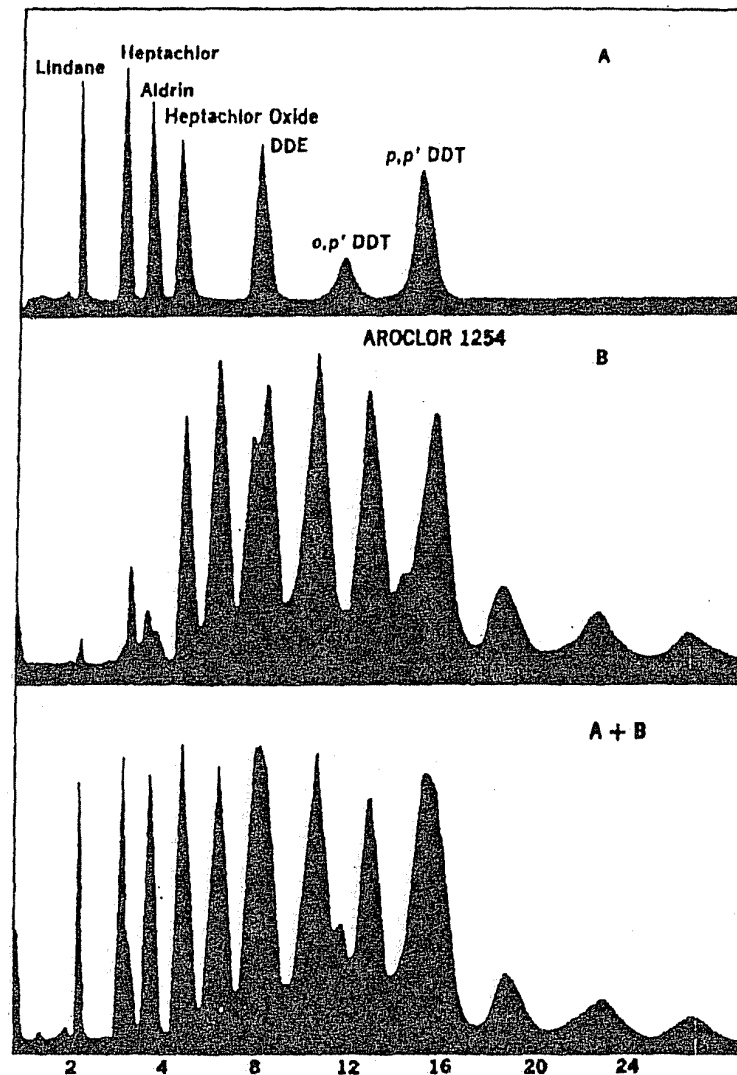
The skin lesion is known as chloracne, and consists of small pimples and dark pigmentation of the exposed areas, initially. Later, comedones and pustules develop. In persons who have suffered systemic intoxication, the usual signs and symptoms are nausea, vomiting, loss of weight, jaundice, edema, and abdominal pain. Where the liver damage has been severe, the patient may pass into coma and die.

Sax, N. Irving, "Dangerous Properties of Industrial Materials," 3rd ed., Van Nostrand-Reinhold, New York, 1968.

The ubiquity of pcn's is related to the wide spectrum of applications that have been found for them. The largest single use of pcn's is related to their electrical properties—as coolant-insulation fluids in transformers. For this purpose the Aroclors are also sold under such trade names as Chlorextyl (Allis-Chalmers Mfg. Co.), Dykanol (Federal Pacific Electric Co.), Inerleen (Westinghouse Electric Co.), No-flumol (Wagner Electric Co.), Pyranol (General Electric Co.), and Thermol (Monsanto Co.).

Other uses of pcn's include formulation into ballasts for fluorescent fixtures; impregnation of cotton and asbestos for braided insulation of electrical wiring; a plasticizer in wire and cable coatings; capacitors and askarel-type transformers; and plasticizers of vinyl chloride polymer films. Because of their thermal stability and fire resistance, the pcn's also find application in high-pressure hydraulic fluids, specialized lubricants and gasket sealers, heat transfer agents, and machine tool cutting oils. Miscellaneous uses include: formulation into some epoxy paints; protective coatings for wood, metal, and concrete; adhesives; and in carbonless reproducing paper. One of the primary manufacturers of carbonless reproducing paper also sells Aroclors in an encapsulated form.

Generally the kinds of applications described above mean that the pcn's will be in many types of products that eventually find their way to the domestic market. When used in manufacture of ballasts for fluorescent fixtures they will be found in kitchens, bathrooms, stores, and offices throughout the country. Wherever office forms are used that do not use carbon paper, one may find pcn's formulated into the microcapsules of dye that comprise the re-



Gas chromatogram A is of a standard pesticide mixture, B is typical of Aroclor 1254, and A + B is the chromatogram of a 50 : 50 mixture of both. The concentration of Aroclor 1254 is approximately 10 times those of the pesticides in A, hence it is understandable why PCB's were not readily recognized in pesticide chromatograms. Gas chromatograph (Packard 7620) conditions: gas flow 80 ml./min. nitrogen; temperatures—oven, 210° C., Inlet, 230° C., detector, 218° C.; Ni^{63} electron capture detector; 5' $\times$ $\frac{1}{8}$ " glass column packed with 8% SE-30 on Chromosorb Q 80-90 mesh.

producing layer of the business form. pcn's have also been found on the transparent receipts used in credit card charge forms. As plasticizers they can be expected to appear in many consumer plastics.

Since the chronic toxicities are so significant, it becomes important to know just how extensively the pcn's are distributed in the ecosystem, and just how they find their way into

the environment. Rainwater in England, brown seals off the coast of Scotland, white-tailed eagles in Sweden, cod in the Baltic Sea, mussels in The Netherlands, adelic penguin eggs in the Antarctica, brown pelican eggs in Panama, Arctic terns, shrimp in Florida, river water in Japan, waters in the Great Lakes, human hair, and human adipose tissue—samples of all these have been found to contain pcn's,

thus making them a class of widely dispersed pollutants.

Readily absorbed

The properties of PCB's that make them industrially useful are the same properties that cause them to persist in the environment. These include thermal stability, resistance to oxidation and hydrolysis, solubility in a wide range of organic solvents, water insolubility, high dielectric constant, and compatibility with many types of macromolecules. Their resistance to oxidation and hydrolysis also makes PCB's more stable and persistent than DDT. Consequently, they could eventually accumulate to a higher concentration than DDT, especially if the use of DDT is sharply curtailed in the U.S.

The solubility of PCB's in nonpolar solvents explains why they are readily absorbed into fatty tissue and into the liver. Their resistance to oxidation or other types of chemical degradation explains their persistence in the environment and accumulation in animal tissue. The latter effect is enhanced both by their insolubility in water and solubility in organic solvents. Their chemical inertness and resistance to metabolism account for their low acute toxicity. But as they slowly build up in a living system their concentration approaches toxicity levels, at which point chronic effects make themselves evident.

It has been established that fish-eating birds will accumulate large concentrations of PCB's, as in the case of the white-tailed eagle, which has been found to have as much as 14,000 p.p.m. of PCB's. Peregrine falcons, taken off the coast of California, were found to have as much as 2000 p.p.m. in their lipid tissue. When shrimp were exposed to 10 p.p.b. of Aroclor 1254 for 48 hours, they accumulated 1300 p.p.b. of PCB's, which represents a 130-fold concentration in a very short time. Oysters, exposed to an identical concentration of Aroclor 1254 for 96 hours and then placed in PCB-free water for four days, still had a concentration of 33,000 p.p.b. of PCB's, which constitutes a 3300-fold concentration. This means that even though the concentrations of PCB's are in the parts-per-billion range in the environment, their high lipid solubility causes them to collect in fatty tissues of lower animals and marine life. Therefore, species at the top of a food chain will also accumulate PCB's in their bodies, particularly in their lipid tissue and liver, in much the same



way as they accumulate DDT and other chlorinated pesticides.

Because of the low solubility of PCB's in water, when a solution or dispersion of them is discharged into a river or lake, they will accumulate on the sediment in relatively high concentrations. Subsequently, they will redissolve very slowly in the water as conditions change. Therefore, it will usually take a long time to flush out a contaminated area.

Accidental occurrence

The reason that PCB's have not been found in the ecosystem as extensively as DDT, and are not present in environmental samples at as high a concentration as DDT, is that PCB's find their way into the environment accidentally. DDT is deliberately spread because this is the only way its insecticidal properties can be utilized. PCB's are not intended to get into the environment, but they do because their unique chemical properties prevent them from being destroyed by our usual waste disposal methods. Thus, they inadvertently escape and become widely dispersed.

In Sweden, where the use of DDT has been banned, and where the main power source is hydroelectric, investi-

gators find that the concentration of PCB's in the environment is as high as that of DDT.

There are several ways by which PCB's get into the ecosystem. One of these is by incineration. Products containing PCB's, such as carbonless reproducing paper in business forms, plastics (especially polymer film and sheeting that contain PCB's as plasticizers), spent ballasts from fluorescent light fixtures, and objects coated with PCB-formulated coatings, all find their way to the city dump or incinerator for burning. The PCB's do not burn but are vaporized. They are then carried into the atmosphere, where they collect on particulate matter and are subsequently returned to the surface of the earth, into the rivers, lakes, and oceans. In this way they become widely distributed throughout the global environment. Another source is probably land run-off from industrial wastes and dumps. A third source is the point of manufacture and the plants where PCB's are processed into other products. They can escape through the plant ventilation and exhaust systems into the atmosphere and through its waste treatment system into sewers or directly into waterways.

It is interesting to note that the incidence of PCB's in environmental samples is highest in industrialized and urbanized areas. Birds whose primary habitat is the San Francisco Bay area have a larger concentration of PCB's per unit of body weight than those located in Baja, Calif., which is completely rural. Aquatic life in the Archipelago of Stockholm, the most industrialized area of Sweden, were found to have a higher concentration of PCB's than fish samples taken from the western coast of Sweden, a less developed area. Sediment samples taken from southern portions of Lake Michigan have a higher concentration of PCB's than those from other parts of the lake.

Monsanto states that until a recent change in marketing policy (see inset, page 814), sales of Aroclors were increasing at the rate of 8% per year. While this increase does not seem significant, it may be important if the increased consumption was in consumer products and thus would find their way into our normal solid waste disposal systems. Such an occurrence would mean a definite increase of PCB residues in the environment, and therefore a marked increase in their chronic toxicity effects.

Detection

PCB's were not discovered in environmental samples until very recently for several reasons. First, as indicated above, they have not been deliberately distributed about the ecosystem. Secondly, because of their relatively low acute toxicities, their presence was not immediately evident. Finally, they are difficult to detect analytically.

The PCB's were first detected as interfering peaks in the gas chromatographic analysis (GC) of environmental samples being analyzed for chlorinated pesticide residues. When PCB's are present in a sample they give a pattern of several GC peaks, whose retention times are similar to those of dieldrin, DDT, DDE, aldrin, and heptachlor oxide. Because the peaks were not large or sharp, investigators tended to ignore them until S. Jensen, in Sweden, and R. Risebrough, at the University of California at Berkeley, identified them as corresponding to common constituents of environmental samples being analyzed for persistent pesticides.

The problem of the interferences of PCB's with the analysis of other chlorinated pesticides has been largely overcome by prior treatment of the sample. Several investigators have used

column chromatography to separate PCB's from chlorinated pesticides. At a recent meeting, sponsored by the RWQA's National Water Quality Laboratory, Duluth, Minn., a general procedure was recommended for separation of PCB's from pesticides. In this procedure for biosamples, the sample is extracted with hexane as in regular pesticide analysis. It is then partitioned with acetonitrile to remove fats, the cleaned-up extract is passed through a Fluoril column and then through a silicic acid column. Finally, the sample is analyzed by gas chromatography, with a chloride-specific detector. In this way the pesticides are retained on the silicic acid column for later elution and identification.

Research needs

To assess fully the significance of PCB's as environmental pollutants, additional research is needed. No one really knows the extent of the chronic effects of these chlorinated hydrocarbons. Some problems that need to be considered are:

- Although PCB's are known to accumulate in human organs we do not know at what concentration they will begin to exhibit toxic effects. Will these chronic effects be similar to those shown in animals—microsomal enzyme activity, calcium metabolism inhibition, and so on? What are other possible chronic effects?

- Which of the many PCB compounds in the commercially available mixtures are responsible for their toxicity? Can commercial PCB mixtures be modified to eliminate the toxic components? Pure samples are required to answer these questions. At the present time work is continuing at the RWQA's Southeast Water Laboratory to separate each of the Aroclor mixtures into its many components, and to identify each component.

- We need to know all the uses for the PCB's. What is the annual production of PCB's? Our knowledge of these facts is limited and needs to be expanded. These facts should be known if we are to accurately determine how they get into the environment, and take steps to prevent further environmental contamination by them.

- In view of the complexity of the isolation and accurate quantitative analysis of PCB's in chlorinated residues, a straightforward, unambiguous measurement of them needs to be developed.

- What is the fate of PCB's in natural waters? More needs to be known of their partition coefficients between bottom sediments and water. This is vital if we are to estimate how long it will take for a river bed to clean itself of contamination. It will also be useful when assessing the effects of PCB's on marine life that feed on the bottoms of lakes, rivers, and estuaries. We should also learn more about PCB solubility in water of various ionic strengths.

- Are present waste treatment systems adequate to handle PCB's? Do special measures need to be taken when PCB's are part of the waste effluent being treated?

By trying to get some of these answers now, we may find that we are in a position to control the escape of PCB's into the environment before additional damage is done. So frequently, action is taken only after it is evident that massive damage has resulted from a particular pollutant. In the case of the PCB's we may have an opportunity to resolve the situation before that happens.

Additional Reading

Hubbard, H. L., "Chlorinated Biphenyl and Related Compounds," *Encyclopedia of Chemical Technology*, 2nd ed., 3, Interscience Publ., New York, N.Y., 1964, pp. 289-298.
Reynolds, L. M., *Bull. Environ. Contam. Toxicol.* 4, 128 (1969).
Risebrough, R. N., et al., *Nature* 220 (1968).



Carl G. Gustafson, chairman of the Department of Chemistry of King's College, Briarcliff Manor, N.Y., received a Ph.D. in organic chemistry from the University of Delaware in 1957. During the 1969-70 academic year, he was on leave at the RWQA Southeast Water Laboratory in Athens, Ga., where he studied trace organic analysis in waste effluents. As a member of the National Water Contaminants Characterization Research Program, he worked with PCB's and pulp and paper mill effluents.

KEY PLASTICIZER ACCOUNTS

American Mineral Spirits Co. (Div. of Union Oil)
Borden
Central Solvents
Chrysler
Colonial Press
Continental Can
Dreyfus
H. B. Fuller
General Electric
W. R. Grace
Inmont
Minnesota Mining & Manufacturing Company
Nashua
National Starch
Products Research Company
Swift
Uniroyal
United Resins
Valspar
Yates Manufacturing

TNGS 004854

HEAT TRANSFER ACCOUNTS

(Key to Monsanto or because of Therminol FR
Fluid volumes)

We selected only those key customers who bought Therminol FR fluid in 1970 and 1971. We are, however, sending letters to customers (some of whom are key accounts to Corporate Monsanto) who show up in 1968 and 1969 Therminol FR IBM runs. However, since these key accounts have not bought any fluid in 1970 and 1971, we believe the Therminol FR systems are very small (under 50 gallons). Consequently, we would not expect our formal notification letter to cause a major upset in Monsanto-customer relations.

1. Key Accounts where the formal notification letter was accompanied by a cover letter.

<u>Parent</u>	<u>Subsidiaries (if any)</u>
Alcoa	-
Atlantic Richfield	Arco Chemical Company
Cargill	-
Celanese	-
Cities Service Oil Co.	-
Chemetron	-
Continental Can	-
Crown Zellerbach	Gaylord Containers
B. F. Goodrich	-
(100 gallons only)	
Koppers	Morrison Molded Fiberglass Div.
Marcor	Standard T. Chemical
"	Container Corp.
Libby, Owens Ford	Aeroquip
Mead	-
Minnesota, Mining & Mfg.	-
National Starch	Proctor Chemical
Olin	-
Phelps Dodge	-
Sherwin Williams	-
Standard Oil of Indiana	Amoco Chemicals
Teledyne	Teledyne Read Co.
Union Camp	Harshaw Chemical
Union Oil	American Mineral Spirits Co.
Westvaco	-

Letters will be addressed to the Director of Purchases
at the Head Office of the parent company.

TNGS 004855

2. Key Accounts notified by phone (December 17 to 20, 1971) with follow-up formal notification letter.

<u>Parent</u>	<u>Subsidiaries (if any)</u>
Airco	Airco Speers
American Cyanamid	-
Armco Steel	-
Athol Manufacturing	-
Betz Laboratories	-
Boise Cascade	-
Borden Company	-
DuPont	-
Duval Sierrita	-
East Alco Aluminum	-
Ethyl Corp.	-
FMC Corporation	-
GAF	-
General Electric	-
General Motors	-
Gilman Brothers	-
W. R. Grace	-
Grumman	-
Gulf Coast Aluminum	-
Interplastic Corp.	-
Kaiser Aluminum	-
Litton Industries	Hewitt Robbins
Malden Mills	-
Martin Marietta	Harvey Aluminum
Motorola	-
N L Industries	-
Nalco	-
New England Petroleum	-
North American Rockwell	-
Norton	-
National Southwire	-
Northwest Industries	Velsicol
National Distillers	US Industrial Chemicals
Owens Corning	-
Owens Illinois	-
Pennwalt	-
Pioneer Plastics	-
P&G	-
Quaker Oats	-
RCA	-
Republic Steel	-
Reynolds Metal	-
Riegel Paper	-
Schenectady Chemical	-
Soo Valley	-
Topco Associates	-

TN6S 004856

<u>Parent</u>	<u>Subsidiaries (if any)</u>
U. S. Gypsum	-
U. S. Steel	-
Uniroyal	-
Universal Oil Products	-
Upjohn	-
Westinghouse	-
Sears Roebuck & Co.	DeSoto Chemicals
Revere Copper & Brass	-

3. Phone Calls (December 17 to 20, 1971) with personal visits by St. Louis Specialty Products Group management December 21, 1971 to January 7, 1972.

(Formal notification letter will be hand carried)

<u>Parent</u>	<u>Subsidiaries (if any)</u>
Allied Chemical	-
Armstrong Cork	-
Bendix	-
Burlington Industries	Pee Dee Fabrics
Continental Oil	-
Deering-Milliken	Sylvan Chemical
Diamond Shamrock	-
Enjay Chemical	Humble Oil
Firestone	-
Ford Motor	-
General Tire	Aerojet General
P. D. George	-
Goodyear	-
Inmont	-
Kentile	-
Lever Brothers	-
Lubrizol	-
Occidental Petroleum	Hooker
PPG	-
Purex	Lanson Chemical
Reichhold	-
Rohm & Haas	-
Shell	-
Standard Oil of California	Chevron
Stauffer	-
Sun Oil	-
Tenneco	-
Texaco	-
Union Carbide	-
U. S. Plywood-Champion	-
Witco	Argus

TNGS 004857

Visits will be made to the parent company only by St. Louis personnel except in the case of Hooker. We plant to visit Hooker in Niagara Falls not Occidental Petroleum.

4. Key Customers who will be sent formal notification letters only (for competitive reasons).

Dow
Dow Corning
ICI America

TNGS 004858