Comparative Evaluation of Polychlorinated Biphenyl Solutions

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It is well established now that polychlorinated biphenyls (PCBs) are disturbingly widespread in the ecosystem, including human adipose tissue, human milk, and even brain and liver of small children. The analytical evidences for the presence of PCBs has been mostly based on the mass spectrometric analysis, gas chromatographic analysis, microcoulometric analysis, relative inertness to nitration and dehydrochlorination procedures and nuclear magnetic resonance analysis (BAGLEY et al. 1970, BIROS et al. 1970, KHAN et al. 1975 and ROTE and MURPHY 1971). Gas chromatographic patterns of PCB residues found in the environmental samples generally resemble Aroclors 1254 and 1260, products manufactured by Monsanto Co. However, there is a possibility of finding a multi-component residue that resembles a combination of various types of Aroclors. Also, from the analytical and toxicological viewpoints, there is a need to think of PCBs on an individual basis rather than as complex mixtures, which in turn will facilitate better understanding of the problems and significance of PCBs.

Although various methods have been developed for PCBs, their quantitation is very complicated owing to the fact that they are not single compounds, but complex mixtures of isomers having varying degrees of chlorination. The different Aroclors are designated by numbers, the first two digits give the molecular type and the last two represent the weight percent of chlorine. Thus Aroclor 1254 is a mixture of chlorinated biphenyls having an average chlorine content of 54%. Since it is extremely tedious to compare individual samples with all different types of Aroclors, the present investigation involves a comparative evaluation of different Aroclors.

EXPERIMENTAL

Standard 10 ppm solutions of Aroclor 1232; Aroclor 1242; Aroclor 1248; Aroclor 1254 and Aroclor 1260 were prepared using hexane as solvent. One milliliter each of these solutions were mixed thoroughly to form a uniform mixture. Two microliter of this mixture was analysed by gas chromatography followed by 2 µl each of the individual above mentioned Aroclors. Gas chromatographic analyses were carried out using a Varian Aerograph (Model 1200) equipped with an electron-capture detector fitted with 5 ft by 1/8 in coiled pyrex glass column packed with 10% DC-200 on Chromosorb W and operated at inlet, column and detector temperatures of 225, 185 (isothermal), and 210°C respectively. Nitrogen flow rate was adjusted at 55 ml per minute with

Bulletin of Environmental Contamination & Toxicology,
Vol. 16, No. 3 © 1976 by Springer-Verlag New York Inc.

the chart speed of 1/4 in per minute. The chromatograms obtained were comparatively studied based on their peak heights.

RESULTS AND DISCUSSION

The individual chromatograms of the 5 Aroclors are represented separately (Figures 1,2,&3) and their peak heights are given in Table 1. The excellant resolution obtained under the operating conditions used, revealed a total of 25 peaks for the mixture of these 5 Aroclors (Figure 4) and the retention times indicated a definite interval between the different peaks. Mass spectrometric evaluation of the Aroclors 1254 and 1260 (SISSONS and WELTI 1971) exhibited that the lower chlorinated biphenyls appear first followed by higher chlorinated biphenyls, a finding apparent in this study also. It was evident that Aroclors with low chlorine percentage such as Aroclor 1232 had comparatively more lower chlorinated biphenyls and less higher ones. As the percentage of chlorine increased, a prominent increase in the concentration of the higher chlorinated biphenyls was observed.

The mixture revealed a representative chromatograph in which the prominent peaks of all the Aroclors were identifiable separately. There were several peaks common to all of the Aroclors, For example, peak nos. 5,6,8,9,10 and 11 were present in all the chromatograms, had similar appearance and aligned closely to all the chromatograms. These peaks increased in size as the percentage of chlorine in the Aroclors increased. Also, the presence of smaller peaks in the earlier stages was indicative of the type of Aroclor that can be expected in any unknown sample. In low chlorine-containing PCB solutions, smaller peaks were evident at earlier stages which slowly disappeared as the percent chlorine increased. A comparative evaluation of peak heights of different Aroclors and their mixtures is represented in Table 1.

In earlier investigations, either Aroclor 1254 or 1260 was used for the quantitation of PCBs. Individual peaks were selected for comparison with unknown samples. These methods though applicable had following drawbacks: (1) PCBs present in the environmental or unknown samples may not resemble exactly any of the Aroclors separately, (2) more than one type of Aroclor may be present in the unknown sample, (3) metabolic processes may reduce or alter the representation of chlorinated biphenyls on the chromatograms, (4) there might be changes occurring on prolonged storage of the solution, (5) there might be certain impurities or unchlorinated biphenyls which may seriously interfere with the resolution pattern, and (6) it is not practical to run all the Aroclors for comparison with the unknown sample.

Thus a method of quantitation can be based on individual biphenyls or on a mixture of certain PCB solutions which are suspected to be present in the environment or contaminated samples, and

TABLE 1.

COMPARATIVE EVALUATION OF PEAK HEIGHTS (CMS)
OF DIFFERENT AROCLORS AND THEIR MIXTURES

Peak No.	1232	1242	1248	1254	1260	Mixture
1	2.20	*	*	*	*	1.00
2	1.60	2.70	*	*	*	1.70
3	1.10	1.70	0.50	*	*	1.25
4	0.80	1.40	0.40	*	*	0.95
5	3.20	5.50	2.60	*	*	3.85
6	1.70	2.75	1.00	*	*	2.05
7	0.40	0.55	1.30	1.00	*	0.70
8	0.60	0.95	1.25	0.20	*	0.90
9	0.65	1.10	1.75	0.10	*	1.10
10	2.90	5.00	7.90	4.90	0.35	5.40
11	0.60	1.00	1.20	9.00	3.90	1.60
12	0.20	0.25	0.25	4.10	4.10	1.70
13	0.25	0.45	1.50	6.80	1.20	2.50
14	0.25	0.50	1.80	10.90	7.40	5.10
15	*	0.20	1.30	6.90	12.90	5.40
16	*	*	0.25	6.50	10.30	4.30
17	*	*	*	1.10	6.10	1.80
18	*	*	*	0.70	4.60	1.00
19	*	*	*	0.25	8.50	2.10
20	*	*	*	0.10	3.75	0.80
21	*	*	*	*	1.50	0.30
22	*	*	*	*	0.25	0.10
23	*	*	*	*	0.70	0.10

*Indicates the absence of particular peak.

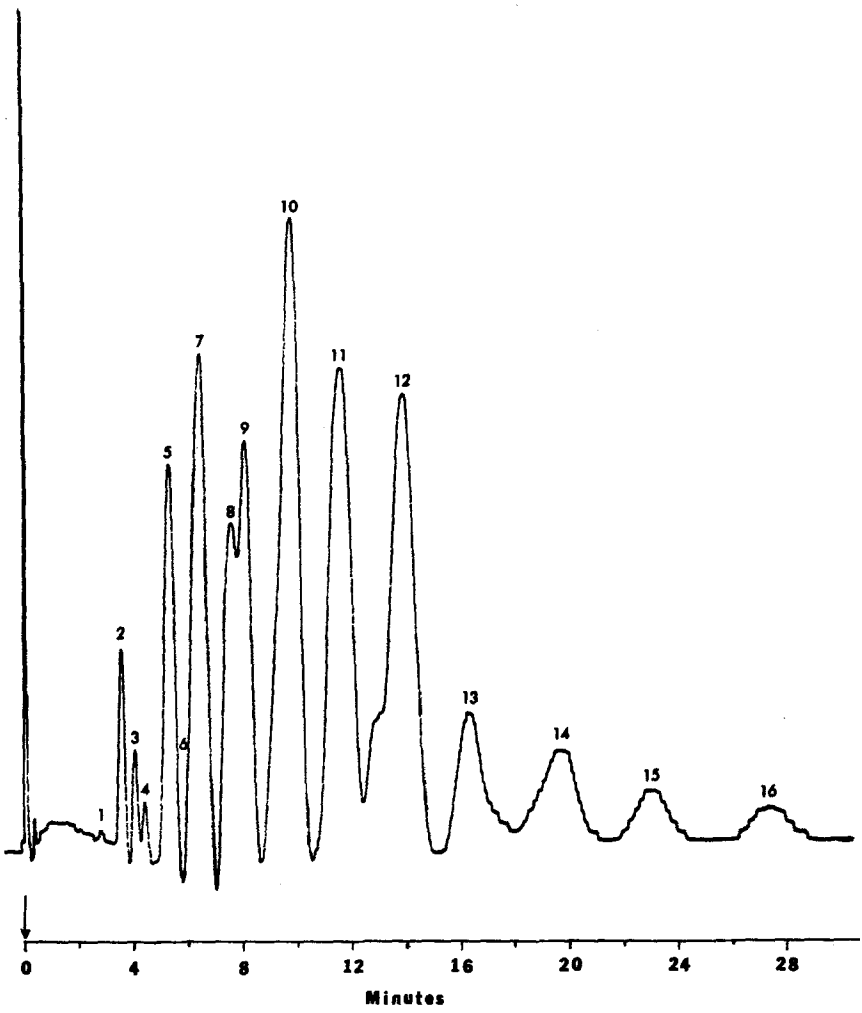

FIGURE 1. Gas chromatograph of Aroclor 1254.

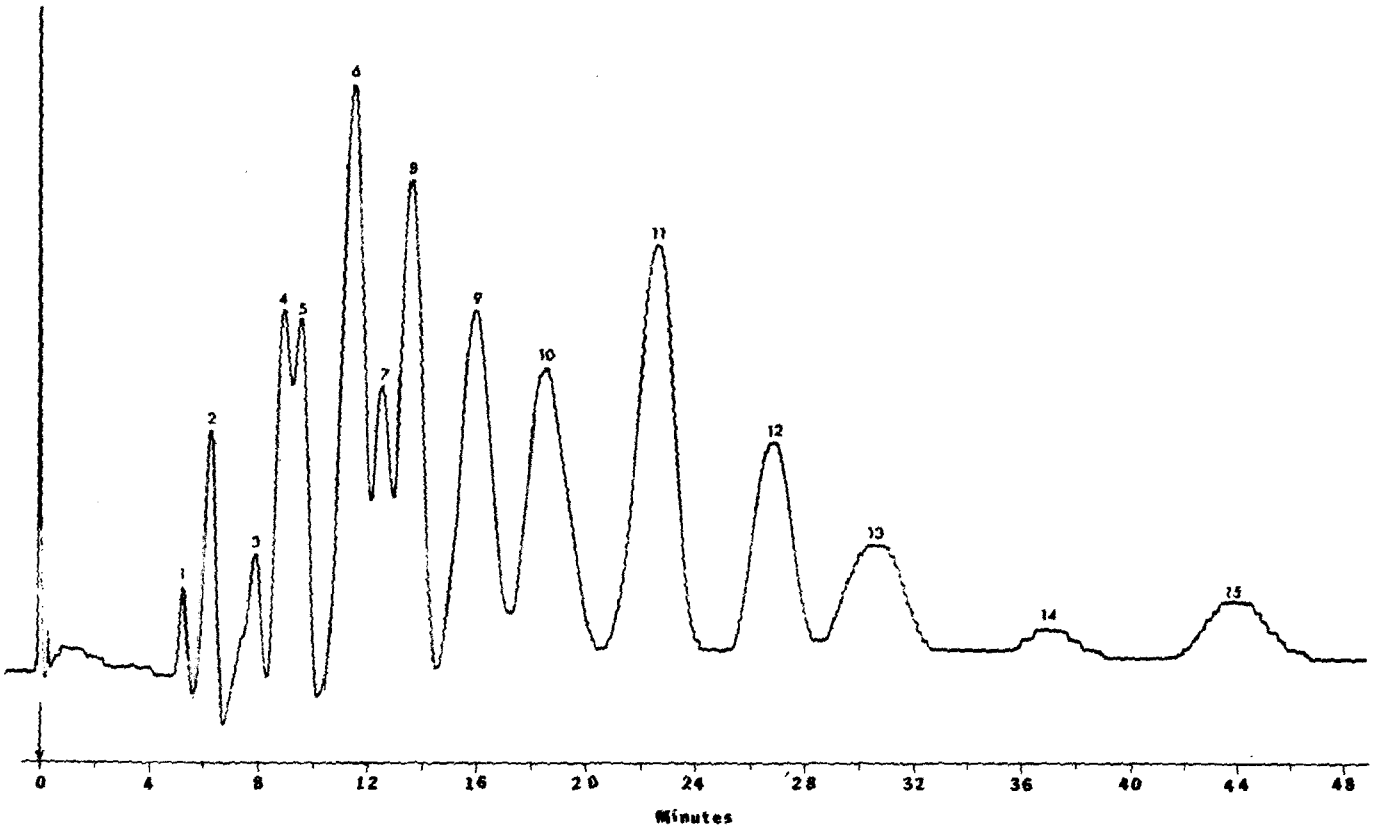

FIGURE 2. Gas chromatograph of Aroclor 1260.

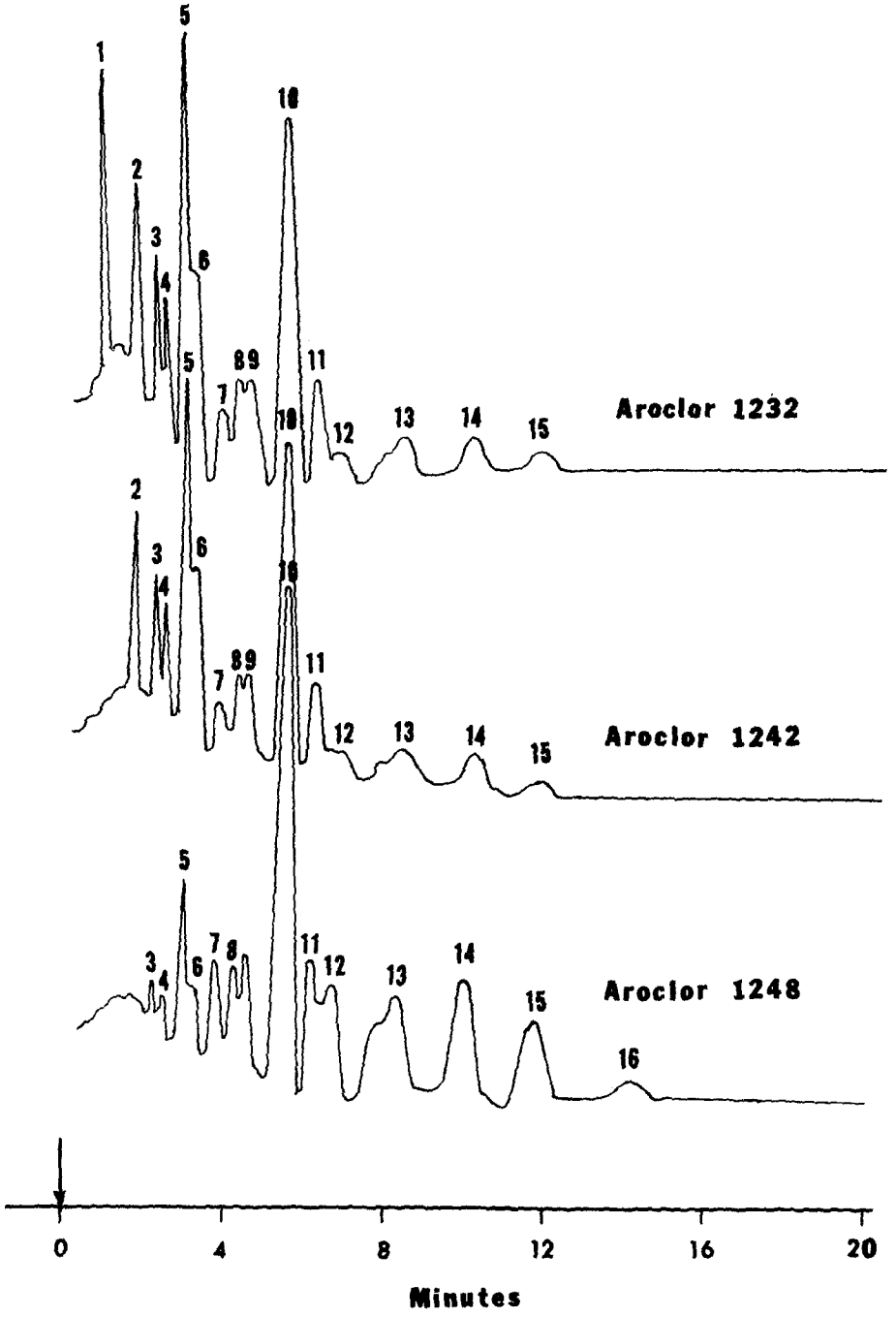

FIGURE 3. Comparative gas chromatographs of Aroclors.

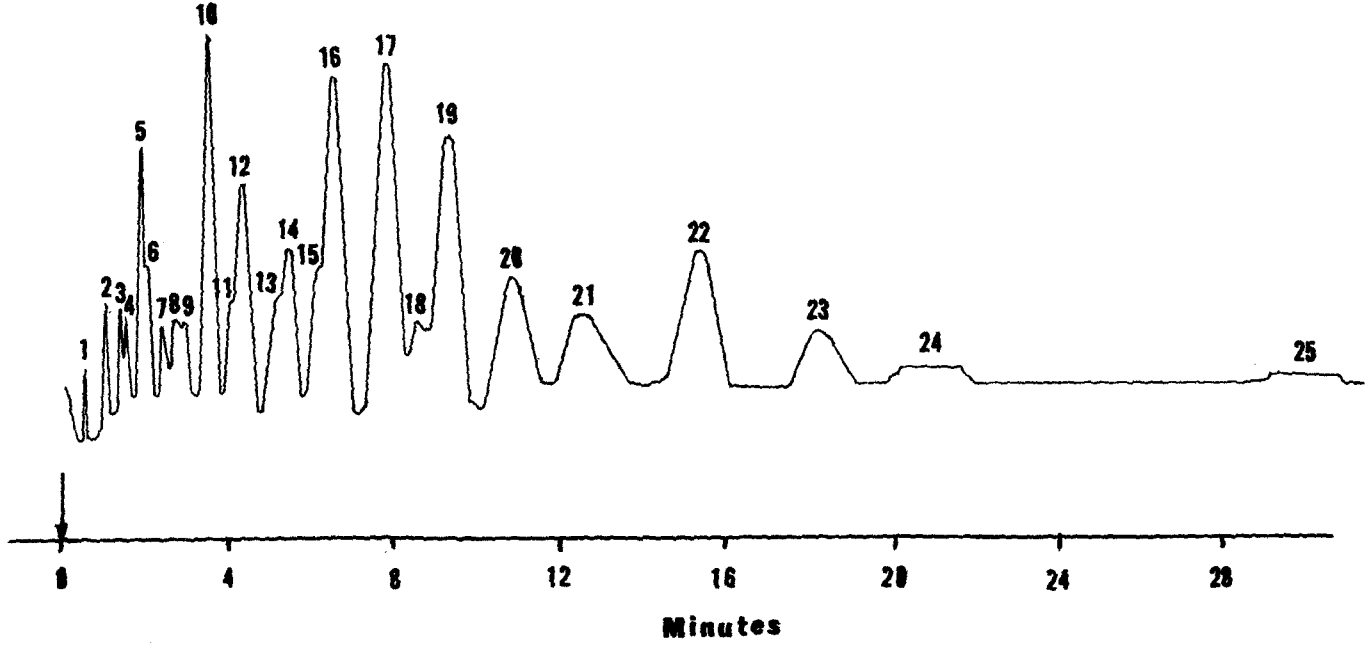

FIGURE 4. Gas chromatograph of Aroclor mixture.

thereby a better assessment can be made by the comparison of this particular mixture with the unknown samples. At least this procedure will provide a guideline for the type of PCBs that can be expected in a particular sample.

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