Analytical Chemistry
Special Study 72-17
Job No. 1650006

BIODEGRADABILITY OF AROCLOR 1221

INTRODUCTION

As part of the program to evaluate the environmental compatibility of polychlorinated biphenyl (PCB) products, biodegradation testing on Aroclor 1221 was undertaken to supplement the data obtained previously on the more highly chlorinated materials (Aroclor 1254, Aroclor 1242, Aroclor 1016, and MCS 1043). A semi-continuous activated sludge (SCAS) procedure was employed.

SUMMARY AND CONCLUSIONS

Semi-continuous activated sludge (SCAS) testing of Aroclor 1221 has been carried out at both 1 and 5 mg feed levels and 24 and 48 hour time cycles. The mean disappearance rates and 95% confidence limits obtained are as follows:

Feed Level, Mg	Disappearance Rate, %	
	24 Hour Cycle	28 Hour Cycle
1	73 ± 21	81 ± 6
5	82 ± 17	87 ± 5

From the disappearance rate data and chromatograms of the sludge extracts, it is apparent that the dominant biphenyl, monochlorobiphenyl, and dichlorobiphenyl components are readily degraded. Over the extended period of testing, there was a build-up of those minor components containing three or more chlorines per biphenyl molecule.

Volatility losses were found not to be a significant factor in the overall disappearance rate. In addition, there was no detectable inhibition of the normal sludge growth rate as measured by the suspended solids concentration.

RESULTS AND DISCUSSION

The semi-continuous activated sludge (SCAS) test method employed is patterned after the Soap and Detergents Association standard procedure [JAOCS 42, 986 (1965)] using their modified feed (JAOCS 46, 432 (1969)]. A description of the test method as applied to our work is given in Analytical Chemistry Method 71-32.

Testing of Aroclor 1221 was initiated at a feed rate of 1 mg per 24 hour cycle. The feed level was maintained at 1 mg for 29 weeks during which time 24 hour and 48 hour rate data were obtained. The level was then increased to 5 mg for the duration of the test period. Both 24 hour and 48 hour cycle data were also obtained at this level.

The disappearance rate data were obtained in the following manner. Fifty milliliter samples of mixed liquor were withdrawn after

feeding and at the end of the aeration cycle. The mixed liquor samples were extracted with spectrograde hexane in accord with Analytical Chemistry Method 71-18 and the amount of Aroclor 1221 in the concentrated extracts determined using UV spectrophotometry. From the analytical data, the disappearance rate was calculated by the following equation:

$$\text{Disappearance Rate (\%)} = \frac{C_o - C_n}{C_o} \times 100$$

where C_o = milligrams of test material in unit at beginning of aeration cycle after feeding of test material

C_n = milligrams of test material in unit at end of aeration cycle

During selected aeration cycles duplicate samples were also extracted with nanograde hexane and analyzed by electron-capture gas chromatography (Analytical Chemistry Method 71-35). These analyses provided data in regard to changes in component distribution.

In order to demonstrate the efficiency of the extraction procedure blank mixed liquor samples were spiked in duplicate at the 2.5 and 5 ppm levels, and carried through the extraction and UV analytical procedure. The mean per cent recovery for Aroclor 1221 was 95.8 $\pm$ 1.4.

In Figures 1, 2, and 3, the total amount of Aroclor 1221 present in the unit at the beginning and end of a cycle is plotted vs the elapsed time in weeks. The disappearance rate is similarly plotted in the same figures.

To verify that the Aroclor 1221 disappearance was due to microbial degradation and not to volatilization, off-gases from the SCAS unit were passed through a train of three hexane scrubbers during several complete cycles. For the 24 hour cycle, the disappearance rate due to volatility was 4.2% at the 1 mg feed level and 6.3% at the 5 mg level. These losses are well within the 95% confidence limits of the overall disappearance rate. Because the more volatile components are degraded and/or volatilized within 24 hours, one would expect only minimal additional loss during a 48 hour cycle.

Weekly monitoring of the suspended solids concentration showed that there was no significant inhibition of the normal sludge growth rate during the test period.

In Table I, the chlorine homolog distribution of Aroclor 1221 is compared to those of Aroclor 1242 and Aroclor 1254. It is apparent that the major components in Aroclor 1221 are biphenyl, monochlorobiphenyl, and dichlorobiphenyl. In Figure 4, electron capture chromatograms of standard solutions of these three Aroclors using identical GC conditions are shown. The dominant chlorine homolog

number of the various peaks is indicated.

It is important to note that the electron-capture detector does not have the same response for all components. With the polychlorinated biphenyls, the sensitivity of the detector generally increases as the degree of chlorination increases. In Figure 5, electron-capture chromatograms of concentrated sludge extracts representing samples taken at the beginning of a cycle and after 24 and 48 hours of exposure are shown. The chlorine homolog numbers of the various peaks are again shown. From these chromatograms, the degradation of the dominant monochlorobiphenyl and dichlorobiphenyl components is readily apparent. As the magnitude of these major components diminish, the minor more slowly degraded components can be more readily observed by adjustment of the dilution factor and injection volume. Because of the increase in detector response with increasing level of chlorination, the build-up in the more highly chlorinated homologs is not as great as a visual examination indicates but is nevertheless real. The slight drop off in degradation rate with elapsed time shown in Figure 2 is probably due to the higher proportion of the more slowly degrading components present near the end of the test. The greater resistance of these higher homologs to degradation explains in part their dominance in weathered biological and environmental samples.

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Monsanto Industrial Chemicals Co.
Applied Sciences
St. Louis, Mo.

8/74 - V. W. Saeger, E. S. Tucker

TABLE I

HOMOLOG DISTRIBUTION* OF

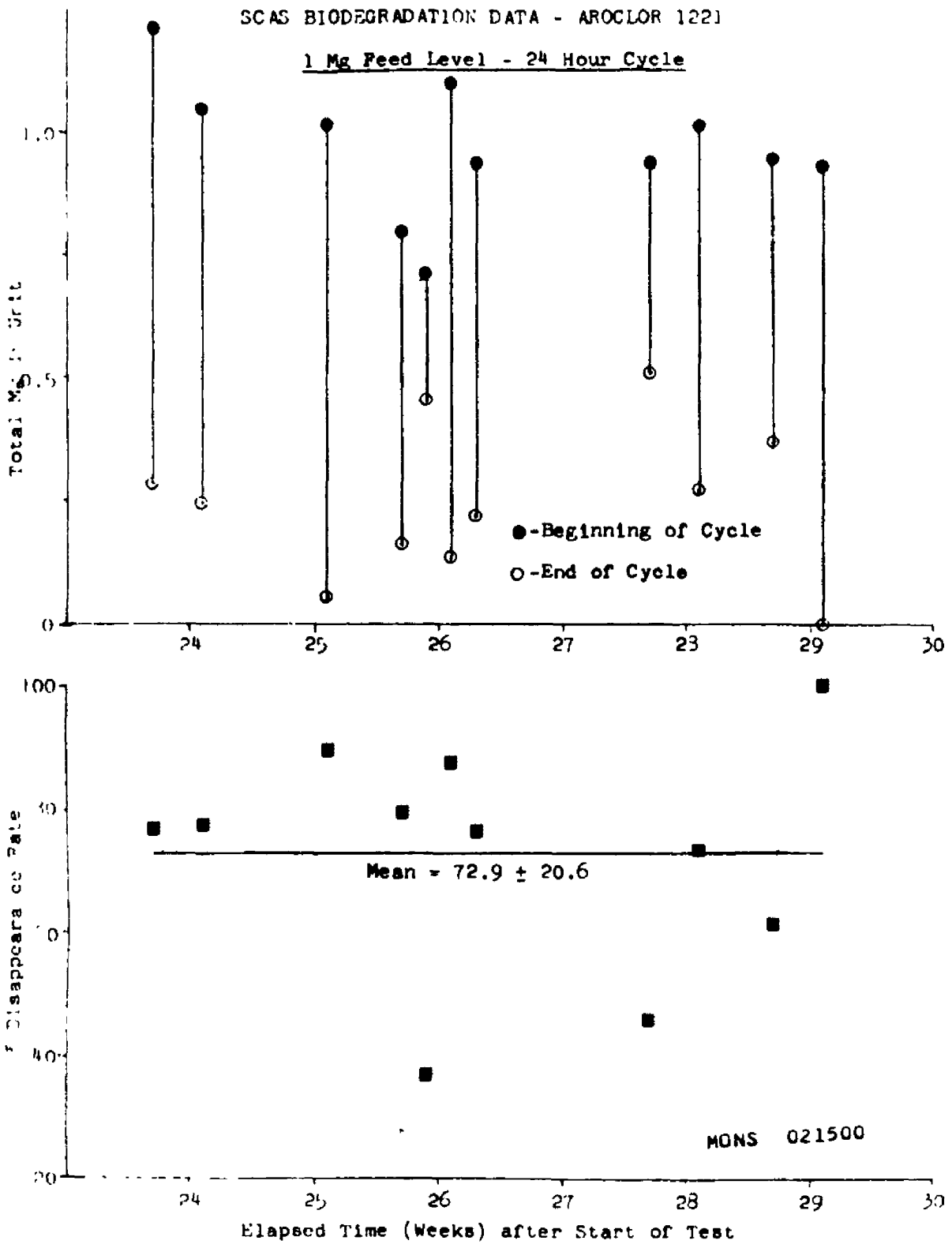
AROCLOR 1221, AROCLOR 1242 AND AROCLOR 1254

Homolog No. of Cl/Biphenyl	Aroclor 1221 (21% Cl)	Aroclor 1242 (42% Cl)	Aroclor 1254 (54% Cl)
0	11	<0.1	<0.1
1	51	1	<0.1
2	32	16	<0.5
3	4	49	1
4	2	25	21
5	<0.5	8	48
6	ND	1	23
7	ND	<0.1	6
8	ND	ND	ND

*Per cent (w/w) by GC/Mass using area correction factors by homolog response

ND = None Detected, <0.01%

FIGURE 1


SCAS BIODEGRADATION DATA - AROCLOR 1221
1 Mg Feed Level - 24 Hour Cycle
Total Mg in Unit
1.0
0.5
0
●-Beginning of Cycle
○-End of Cycle
24
25
26
27
28
29
30
100
80
60
40
20
Mean = 72.9 ± 20.6
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Elapsed Time (Weeks) after Start of Test

FIGURE 2

SCAS BIODEGRADATION DATA - AROCLOR 1221

5 Mg Feed Level - 24 Hour Cycle

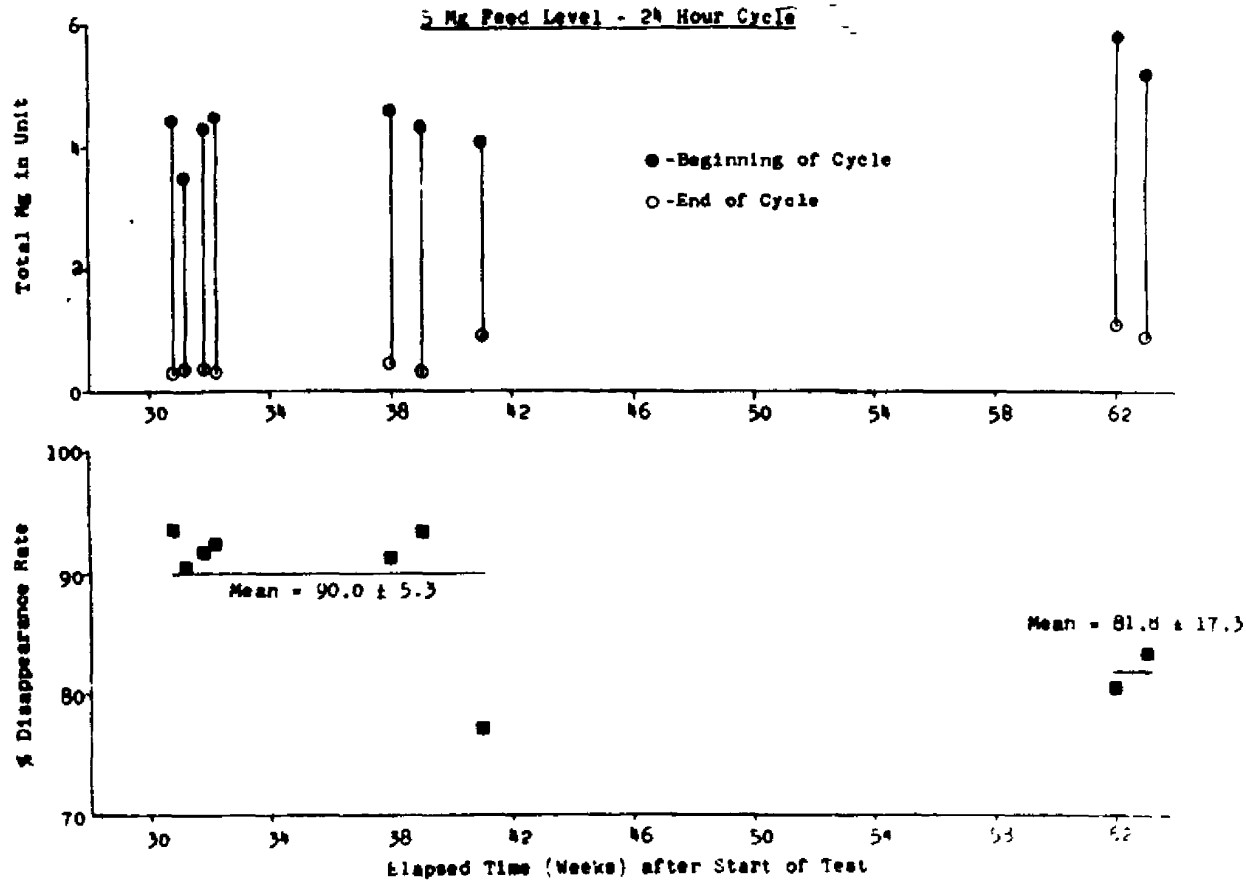

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FIGURE 3

SCAS BIODEGRADATION DATA - AROCLOR 1221

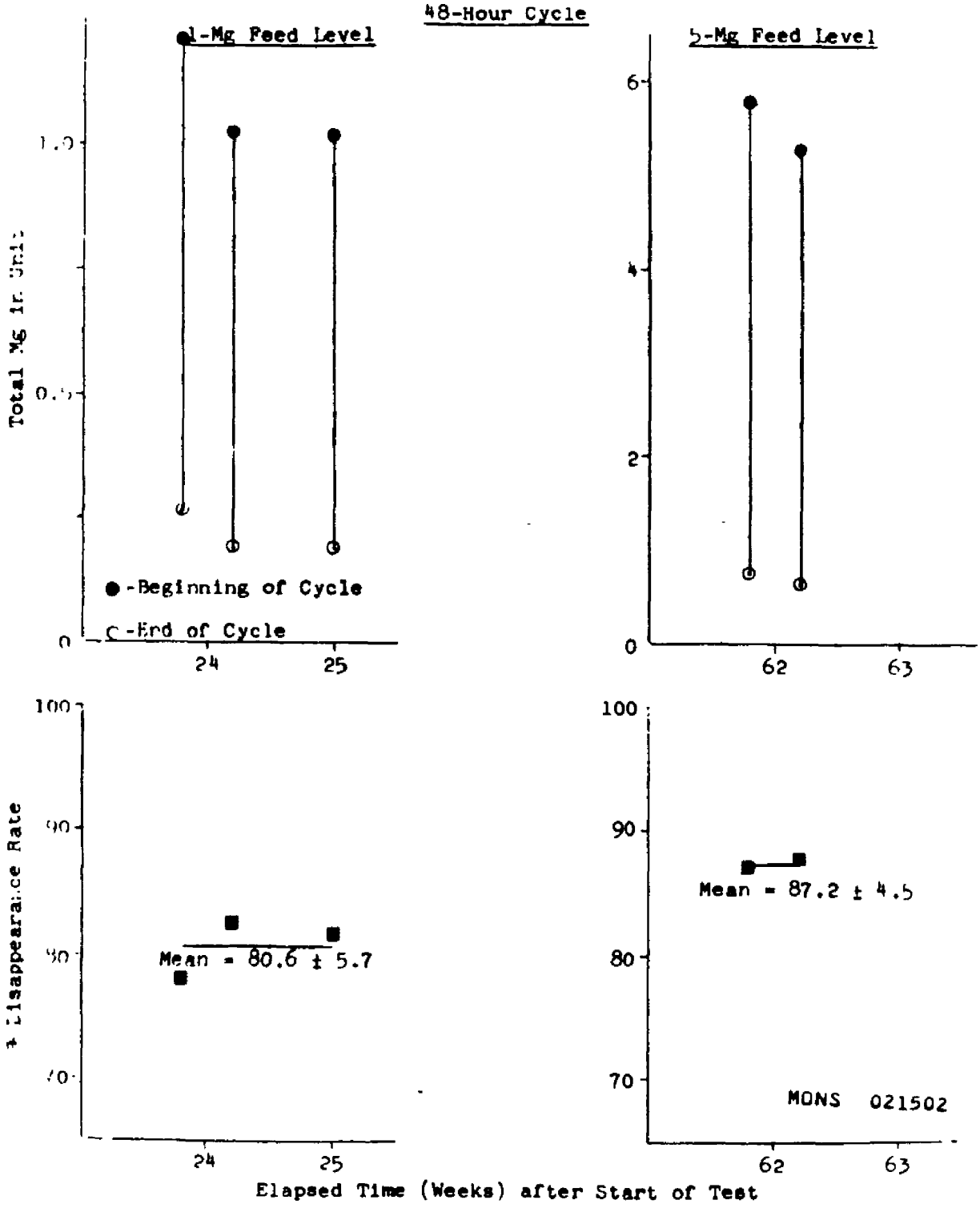

FIGURE 4

ELECTRON-CAPTURE CHROMATOGRAMS OF AROCLOR 1221, AROCLOR 1242, AND AROCLOR 1254

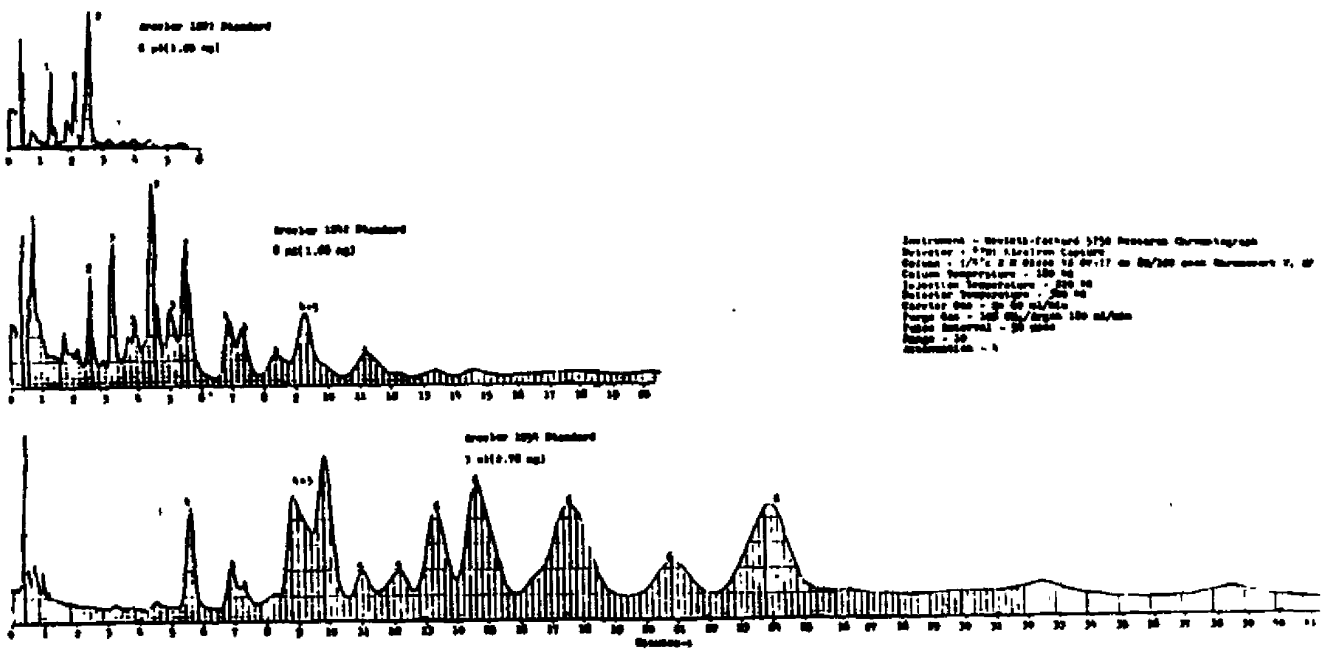

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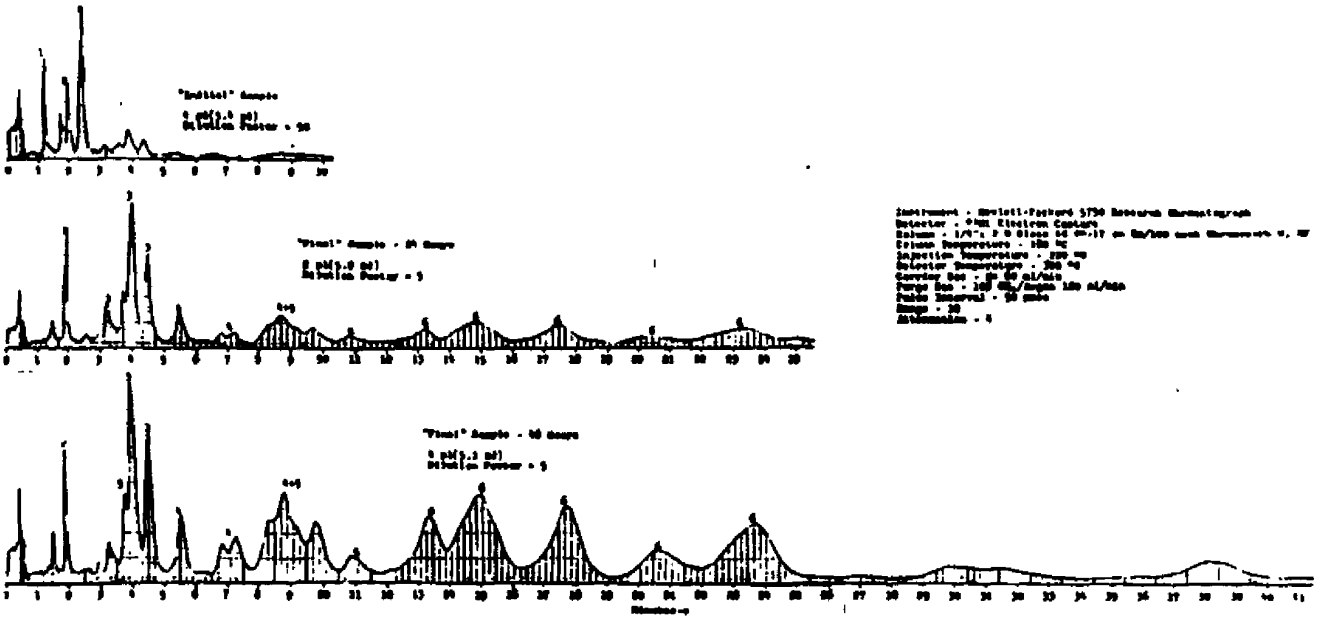
FIGURE 5



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