

Analysis and Quantification of  
2,2',4,4'-Tetrabromodiphenyl Ether using Gas  
Chromatography Coupled with a Low-Resolution  
Mass Spectrometry  
CHEM 4303  
Analytical Separations

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**Abstract**

Gas chromatography with a mass spectrometer was utilized for analysis.

# 1 Introduction

Gas chromatography (GC) is a separation technique that analyzes volatile compounds [1]. Consequently, this analysis can lead a lot of useful situations such as the determination of the purity of a compound or even quantifying individual components in mixtures [1]. In GC, the analyte is volatilized and carried through the column by the mobile phase, often called the carrier gas [2]. This carrier gas can either be He or H<sub>2</sub> [2]. These gases are often chosen as the carrier gas as they are chemically inert and would therefore not react with the analytes [1].

Polybrominated diphenyl ethers (PBDEs) are a class of halogenated compounds that are commonly used as flame retardants [3]. These compounds are an environmental health hazard as they have the potential to accumulate in the food chain [4]. In addition, 2,2',4,4'-Tetrabromodiphenyl ether, also known as BDE-47 [5], is a PBDE congener, and has been found to cause neurotoxic effects in adults [4]. Commonly used detection techniques for PBDEs are high-resolution mass spectrometry and low-resolution mass spectrometry (LRMS) [3].

LRMS is commonly done with selected ion monitoring (SIM) [3]. SIM increases the selectivity of mass spectrometry for analytes and reduces its response to everything else [2]. It does this by setting the mass spectrometer to detect just one or even a few  $m/z$  values [2]. One of the advantages of SIM is that the signal-to-noise ratio greatly increases as the mass spectrometer spends its entire analysis time measuring that particular ion, or a couple of ions [2].

Internal standards are used for a number of reasons, such as when sample loss is expected during the sample preparation step, or when the response of the quantity of sample detected differs at each analysis [2]. Essentially, an internal standard is a known quantity of a compound that differs from the analyte, and is added to the mixture containing the analyte to be detected [2].

An injection mode of splitless rather than a split is used when attempting to analyze trace chemicals [2]. Furthermore, a splitless injection mode minimizes solvent tailing by opening the split vent after around 1 min so that the any remaining sample in the injection port can be purged [1].

The main objective of this entire experiment is to detect as well as quantify BDE-47 in a sample of fish oil. This is accomplished by making a method that utilizes a SIM.

## 2 Chemicals, Methods and Instrumentation

### 2.1 Chemicals

In the first week, BDE-47, PBB-77 and '2-HCH, all of each were at a concentration of 50  $\mu\text{g/mL}$  in isooctane, were used as standard solutions. In the second week, fish oil (Exact Norwegian Cod Liver Oil), dichloromethane (emd, Lot 5Q160, CAS: 75-09-2) and PBB-77, at a concentration of 10  $\mu\text{g/mL}$  in isooctane, were used as chemicals. Finally, in the last week, BDE-47, PBB-77 and '2-HCH, each at a concentration of 10  $\mu\text{g/mL}$  in isooctane, were used. Through-

out the entirety of the experiment, hexane (Caledon Laboratory Chemicals, CAS no. 110-54-3, LOT: 89001) and isooctane (OmniSolv, CAS: 540-84-1, LOT: 52054) were used.

## 2.2 Instrumentation

The separation and analysis of the entire experiment was performed on an Agilent 7890A GC, coupled with a 5975C inert XL EI/CI MSD with a triple axis detector. The dimensions of the column used was  $30m \times 0.250mm \times 0.25\mu m$ , by Agilent Technologies. The stationary phase was (5%-Phenyl)-methylpolysiloxane. Each analysis was performed with the injection mode at splitless, with He as the carrier gas, and the flow rate was set at 1 mL/min. The injection mode used for each analysis was splitless, and the injection volume was 2  $\mu L$  for each analysis.

## 2.3 Methods

In the first week of the experiment, a (normalized) full scan spectrum was obtained for BDE-47, PBB-77 and '2-HCH. The upper limit of the scan range was set to 30 u more than the molecular weight of the respective analyte that was being analyzed. For each analysis, the oven temperature was initially set to 100 °C for 5 min, then it was increased to 280 °C at a rate of 10 °C/min, and it was held at that temperature for 7 min. Furthermore, the temperature of the splitless injection port was set to 260 °C, the electron energy was set to 70 eV, and the temperature of the GC-MSD interface was fixed at a temperature of 280 °C.

In the second week of the experiment, two samples of fish oil were prepared by adding 2  $\mu g/mL$  of PBB-77 as the internal standard to the sample, and then having it undergo solid-phase extraction in order to extract lipids. Afterwards, the majority of the solvent was then removed from the sample through rotary evaporation.

In the last week of the experiment, a calibration solution was produced by adding each of BDE-47 and PBB-77, at a volume of 10  $\mu L$ , to a 0.5 mL of isooctane contained in an auto sampler vial, and it was diluted all the way to 1.0 mL with the solvent. 50  $\mu L$  of '2-HCH was added to the calibration solution, while 10  $\mu L$  was added to the fish samples that was prepared last week. Finally, the GC-MS was set to scan only two ions per analyte, the parameters that was selected is shown in table 1. Refer to table ref to see which 2 ions was monitored.

# 3 Results and Discussion

## 3.1 Results

Table 1 shows the parameters that was set in the GC/EI-MS and the mass of the ions that was monitored.

Table 2 tabulates the molecular weight of BDE-47, PBB-77, and '2-HCH.

Table 1: Selected Ion Monitoring Parameters

Compound	Ions monitored (m/z)	Time window (min)
‘2-HCH	181, 219	0.5 - 19
BDE-47	326, 486	19 - 22.5
PBB-77	470, 310	22.5 - 24

Table 2: Molecular weight of BDE-47, PBB-77 and ‘2-HCH

Compound	Molecular weight (u)
BDE-47	486
PBB-77	470
‘2-HCH	291

Table 3 shows mass of fish oil that was weighed out for this experiment.

Table 3: Mass of fish oil weighed out

Sample number	Mass (g)
1	1.1234
2	0.9062

Table 4 tabulates the volume, concentration and mass of BDE-47, PBB-77, and ‘2-HCH that was added into the calibration solution, while table 5 shows the response and relative response factors of the aforementioned analytes to the internal standard, which was PBB-77, in the calibration solutions.

Table 4: Table of data showing the volume and concentration of each analyte in the calibration solution

Component	Volume/mL	Concentration( $\mu\text{g/mL}$ )	Mass/ $\mu\text{g}$	Area
BDE-47	0.01	0.0952	$9.52 \times 10^{-4}$	367089
PBB-77	0.01	0.0952	$9.52 \times 10^{-4}$	230205
‘2-HCH	0.05	0.476	$2.38 \times 10^{-2}$	260358

Table 5: Table of data showing the response and relative response factors of each analyte to the internal standard (PBB-77) in the calibration solution

Component	Mass/ $\mu\text{g}$	Area	Response factor/ $\mu\text{u}$	Relative Response Factor
BDE-47	$9.52 \times 10^{-4}$	367089	$2.59 \times 10^{-9}$	$6.27 \times 10^{-1}$
PBB-77	$9.52 \times 10^{-4}$	230205	$4.14 \times 10^{-9}$	1.00
‘2-HCH	$2.38 \times 10^{-2}$	260358	$9.14 \times 10^{-8}$	$2.21 \times 10^1$

Table 6 shows how much mass of BDE-47 was contained in each sample of fish.

Table 7 shows the mass of PBB-77 and ‘2-HCH that was added to the calibration solution as well as areas of their respective peaks.

Table 6: Table of data showing how much mass of BDE-47 is in each fish sample

Fish sample	Area of BDE-47	Area of PBB-77	Mass of BDE-47 in sample/ $\mu\text{g}$
1 (first run)	13799	100528	$1.64 \times 10^{-5}$
1 (second run)	14383	103212	$1.66 \times 10^{-5}$
2 (first run)	12800	112480	$1.36 \times 10^{-5}$
2 (second run)	13938	100772	$1.65 \times 10^{-5}$

Table 7: Mass of PBB-77 and '2-HCH that was added to the calibration solution

Mass of PBB-77 / $\mu\text{g}$	Mass of '2-HCH/ $\mu\text{g}$
$1.90 \times 10^{-4}$	$4.76 \times 10^{-3}$

### 3.2 Discussion

- maybe talk about the difference between internal standards and standard additions?
- maybe talk about LRMS?

## 4 References

### References

- (1) Vitha, M. F., *Chromatography: Principles and Instrumentation*; Wiley: Hoboken, New Jersey, 2017.
- (2) Harris, D. C., *Quantitative chemical analysis*, 8th ed; W.H. Freeman and Co: New York, 2010.
- (3) Björklund, J.; Tollbäck, P.; Östman, C. *Journal of Mass Spectrometry* **2003**, 38, 394–400.
- (4) Thomsen, C.; Småstuen Haug, L.; Leknes, H.; Lundanes, E.; Becher, G.; Lindström, G. *Chemosphere* **2002**, 46, 641–648.
- (5) Erratico, C. A.; Moffatt, S. C.; Bandiera, S. M. *Toxicological Sciences* **2011**, 123, 37–47.

## 5 Appendix

### 5.1 Calculations

**Calculating the response factor**

$$\frac{\text{Area of Analyte Signal}}{\text{Concentration of Analyte}} = F \left( \frac{\text{Area of Standard Signal}}{\text{Concentration of Standard}} \right) \quad (1)$$
$$\frac{A_X}{[X]} = F \left( \frac{A_S}{[S]} \right)$$

Equation 1 was taken from [2], where  $[X]$  and  $[S]$  represent the concentrations of analyte and of the standard, respectively.

**Calculating the capacity factor of chlorobenzene for figure 2 of the chromatogram**

$$K = \frac{t_r - t_m}{t_m}$$
$$K = \frac{2.343 - 1.438}{1.438} \quad (2)$$
$$K = \frac{0.905}{1.438}$$
$$K = 0.629346 \approx 0.629$$

Equation 2 was taken from [2].

### 5.2 Chromatograms

There are 23 figures of GC/EI chromatograms.