B.F.GOODRICH CHEMICAL COMPANY

Inter-Organization Correspondence

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To	J. D. Franklin	Date	October 18, 1974
Location	Calvert City Laboratory	From	R. L. Parrish

Subject: EFFICIENCY OF CARBON ADSORPTION - CARBON DISULFIDE DESORPTION IN AMBIENT VINYL CHLORIDE TEST PROCEDURE

Objective

Determine the carbon adsorption-carbon disulfide desorption efficiency as they relate to ambient vinyl chloride testing.

Conclusions

With limitations pointed out in the text of this report, conclusions are:

1. Efficiency of the adsorption of the ambient vinyl chloride onto the activated carbon is 99%.

2. Efficiency of the extraction of vinyl chloride off the activated carbon with carbon disulfide is 100%.

Future Course of Action

Carbon tube testing for ambient vinyl chloride, under the conditions noted herein, will assume 100% efficiency for adsorption and extraction of vinyl chloride in relation to the activated carbon.

Discussion

The vinyl chloride ambient perimeter surveillance program will employ two types of sampling.

Grab samples are to be taken on the wind vectors.

Charcoal tube samples are to be taken at stationary points over a 24 hour sampling period.

Chris Orsborn is looking for a D.C. powered pump that will sample over a 24 hour period. Until one is found, an A.C. powered Millipore pump is available.

The selected sampling rate is 1000 cc per minute of air. Over a 24 hour period, this rate will provide enough sample volume (at the expected VCl concentrations) to assure good analytical accuracy.

It is essential to know the adsorption efficiency, in respect to vinyl chloride, of the activated carbon at this sampling rate.

A laboratory experiment was carried out wherein the carbon adsorption and the carbon disulfide extraction efficiencies were determined.

40069

Summary of Lab Work

A sampling train is prepared using three 150 mm polyethylene tubes each containing 8.3 grams of Nuchar WV-H activated carbon. Teflon tubing is used to connect the tubes together. The sampling train is connected to a gas cylinder containing a 48 ppm vinyl chloride in air standard gas. A dry gas meter is used to measure the total sample volume. The standard gas is sampled for exactly 8 minutes at a rate of approximately 1000 cc per minute. After sampling, the tubes are extracted with carbon disulfide and analyzed in the manner used for personnel monitoring testing.

Calculations

A. Theoretical Micrograms

The theoretical total micrograms vinyl chloride adsorbed is calculated from the total volume of standard sampled multiplied by the standard concentration:

$$\text{Total ugs VCl} = \text{volume} \times \frac{1 \text{ mole air}}{\text{molar volume}} \times \text{std. concentration} \times \text{mole Wt. VCl} =$$

$$7.924 \text{ liters} \times \frac{1 \text{ mole air}}{24.6 \text{ liters}} \times \frac{48 \times 10^{-6} \text{ mole VCl}}{1 \text{ mole air}} \times \frac{62.5 \times 10^{+6} \text{ ug VCl}}{\text{mole VCl}} = 966 \text{ ugs VCl}$$

Where:

Volume = volume gas sampled as measured by dry gas meter =

0.280 cu. ft. x 28.3 liter/cu. ft. = 7.924 liters

$$\text{Molar volume} = 22.4 \text{ liter} \times \frac{760 \text{ mm}}{751.3 \text{ mm}} \times \frac{296^{\circ}}{273^{\circ}} = 24.6 \text{ liters}$$

$$\text{Standard concentration} = 48 \text{ mole ppm or } \frac{48 \times 10^{-6} \text{ mole VCl}}{1 \text{ mole air}}$$

Mole Wt. VCl = 62.5×10^{6} ugs VCl/mole VCl

B. Sampling Rate

$$\text{Sampling rate} = \frac{\text{Volume sampled}}{\text{Time of sample}} = \frac{7.924 \text{ liters}}{8 \text{ minutes}} = 0.990 \text{ liters/minute or}$$

990 cc per minute

C. Analytically Determined Micrograms

The analytically determined total micrograms vinyl chloride adsorbed is calculated from the analysis of the extract of each tube. A blank (14 ugs) is subtracted from the analysis of each tube. The blank is derived from the instrument response for a CS_2 extract of 8.3 grams of fresh activated carbon.

Calculation

1. Calibration of Gas Chromatograph

Method: A 48 mole ppm vinyl chloride in air mixture is the calibration standard gas. With a Precision gas tight syringe, 2.5 cc of the standard gas are injected into the instrument. The area response is recorded and calculated. This response is divided into the micrograms vinyl chloride in the standard injection to obtain the GC calibration factor.

Calculation of GC factor

$$\text{GC factor} = \frac{\text{Std. injection} \times \frac{1 \text{ liter}}{1000 \text{ cc}} \times \frac{1 \text{ mole air}}{\text{mole volume}} \times \text{mole conc. std.} \times \text{mole Wt. VCl}}{\text{Instrument response}}$$

$$= \frac{2.5 \text{ cc} \times \frac{1 \text{ liter}}{1000 \text{ cc}} \times \frac{1 \text{ mole air}}{24.6 \text{ liter}} \times \frac{48 \times 10^{-6} \text{ mole VCl}}{1 \text{ mole air}} \times \frac{62.5 \times 10^{6} \text{ ug VCl}}{1 \text{ mole VCl}}}{24837 \text{ mm}^2}$$

$$= 1.23 \times 10^{-5} \text{ ugs VCl/mm}^2$$

Where:

$$\text{mole volume} = 22.4 \text{ liter} \times \frac{760 \text{ mm}}{751.3 \text{ mm}} \times \frac{296^{\circ}}{273^{\circ}} = 24.6 \text{ liter}$$

Instrument response = 138.6 mm x 1.4 mm x 128

2. Calculation of Dilution Factor

The dilution factor is the ratio of the microliters extract injected into the instrument to the total volume of the extract.

Therefore:

$$D = \frac{1}{2 \text{ ul}} \times \frac{1000 \text{ ul}}{1 \text{ ml}} \times 50 \text{ ml} = 2.5 \times 10^{4}$$

3. Micrograms VCl per Tube

Calculation

Micrograms VCl per tube = (GC factor x response x dilution factor) - blank

Tube #1 (9-26-74)

ugs VCl = $(1.23 \times 10^{-5} \text{ ugs/mm}^2 \times 166.4 \text{ mm} \times 0.6 \text{ mm} \times 32 \times 2.5 \times 10^{4}) - 14$ ugs

= 968 ugs

Tube #2 (9-26-74)

ugs VCl = $(1.23 \times 10^{-5} \text{ ugs/mm}^2 \times 61 \text{ mm} \times 1.3 \text{ mm} \times 1 \times 2.5 \times 10^{4}) - 14$ ugs

= 10 ugs

Tube #3 (9-26-74)

ugs VCl = (1.23×10^{-5} ugs/mm^2 x 48.6 mm x 0.9 mm x 1 x 2.5×10^4) - 14 ugs

= 0 ugs

4. Total Micrograms on the 3 Tubes

Total ugs 3 tubes = ugs Tube #1 + ugs Tubes #2 + ugs Tube #3 =

968 ugs + 10 ugs + 0 ugs = 978 ugs.

D. Adsorption Efficiency

In routine sampling, a single carbon tube is in the sampling train. Therefore we are interested in the vinyl chloride adsorption on the 1st tube (in the experiment). So the adsorption efficiency is here defined as the percent vinyl chloride adsorbed on the 1st tube.

Below this efficiency is calculated by two different methods.

In the first method, the percent adsorption efficiency is the ratio of the analytically determined VCl on tube #1 versus total analytically determined VCl on the 3 tubes.

In the second method, the percent adsorption efficiency is the ratio of analytically determined VCl on tube #1 versus the theoretical VCl purged through the tubes.

The two methods are in good agreement ascertaining that essentially 100% of the VCl in the air being sampled is adsorbed on the 1st tube.

Calculations

Method 1

$$\% \text{ Adsorption efficiency tube \#1} = \frac{\text{ugs VCl tube \#1}}{\text{ugs VCl on 3 tubes}} \times 100\% =$$

$$\frac{968 \text{ ugs}}{978 \text{ ugs}} \times 100\% = 99\%$$

Method 2

$$\% \text{ Adsorption efficiency tube \#1} = \frac{\text{ugs VCl tube \#1}}{\text{theorectical ugs VCl}} \times 100\% =$$

$$\frac{968 \text{ ugs}}{966 \text{ ugs}} \times 100\% = 100\%$$

E. Extraction Efficiency

The extraction efficiency is a measurement of the ability of the CS_2 solvent to "wash" the VCl off the carbon into the CS_2. It is defined herein by the following calculation:

$$\% \text{ extraction efficiency} = \frac{\text{ugs VCl tube \#1}}{(\text{theoretical ugs VCl})\ (\%\ \text{adsorption eff. Method 1})} \times 100$$

$$= \frac{968 \text{ ugs}}{(966 \text{ ugs})\ (99\%)} \times 100\% = 101\%$$

Comments in Conclusion of Report

This experiment is intended to give a relatively precise estimate of the adsorption and extraction efficiencies. This is essential to analytical accuracy.

It is recognized that some parameters that could affect adsorption are not evaluated in this work. A high concentration of contaminants (humidity, other hydrocarbons, etc.) can decrease the efficiency.

The lab work was done on September 26, 1974.

R. L. Parrish

RLP/lw

cc: C. L. Woods, Jr.
D. B. Schrock
E. E. Atkins
R. W. Edwards
CTF (Avon Lake Development)

STAFF TECHNICAL SERVICE REPORT NO. 308

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B. F. Goodrich Chemical Company

A DIVISION OF THE B. F. GOODRICH COMPANY

DEVELOPMENT CENTER

A METHOD FOR ANALYZING VCM AT THE PART-PER-BILLION LEVEL

COMPANY CONFIDENTIAL

M. M. O'Mara and J. G. Quisenberry

Date Completed: June 5, 1974 Date Issued: June 7, 1974

Project No.: 3690 Department No.: 5026

Abstract:

A gas chromatographic method based on flame ionization detection and coconut charcoal adsorption has been developed for detecting VCM in the atmosphere at the 1 part per billion (ppb) level. The basic principle involves the adsorption of a 250cc air sample on activated charcoal contained in the sample loop of a gas chromatograph. The loop is heated to 200°C. to desorb VCM and the VCM is then analyzed chromatographically. A calibration curve ranging from 5 ppb to 280 ppb was experimentally determined. The curve was linear and a linear regression analysis of the data revealed a ± 3.0% deviation in the slope of the calibration curve. At the 20 ppb level, a 9% deviation in reproducibility (5 runs) exists.

A complete description of the method is provided. The general method is potentially applicable at the parts-per-trillion level and lower.

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I. Introduction

The need to analyze vinyl chloride monomer (VCM) in the low parts per billion (ppb) range is obvious as monitoring proceeds away from the point source. A number of approaches can be used to monitor at this level but the most obvious and best developed method is based on the use of gas chromatography. Since neither flame ionization nor electron capture are sensitive enough to measure at this level (recent advances in microcoulometric detectors might make this a viable approach) a pre-chromatographic concentrating step is called for. The literature contains a number of publications in this area but the articles by West[1] and Scheel[2] provide an adequate background to this type of approach. About 3 years ago, Scheel personally described to me his work in this area. His studies on the thermal desorption rather than the solvent desorption of coconut charcoal were of interest to our pyrolysis work at that time. In fact, we have previously studied the thermal desorption of materials from molecular sieves.[3] West, in his work, described the use of gas chromatography to analyze air pollutants which were thermally desorbed from activated alumina, silica gel and charcoal.[1] The work described in our report is an extension of West's method, optimized to the analysis of VCM in air and modified for part per billion analysis.

II. Analytical Approach

In essence, the sample loop of an 8-port gas chromatographic sampling valve is replaced with a 6" x $\frac{1}{4}$" stainless steel tube which contains ~0.2g of coconut charcoal. Two of the sample ports are used to flush a 250 ml gas sample container with helium through the charcoal bed. Once this flushing operation is complete, the charcoal bed is heated to 200°C. At that point, the gas sampling valve is actuated thereby diverting the chromatographic carrier gas through the carbon bed and onto the chromatographic column. In this way, the VCM is removed from the carbon bed and deposited on the chromatographic column. A typical analysis is then carried out. The limiting factor in terms of sensitivity in this analysis is the 250 ml sample container. With this constraint, analysis is limited to ~1 part-per-billion.

III. Problems

Although the approach was rather straightforward, two problems arose which should be recognized by those attempting to duplicate the procedure. The carbon bed contains glass wool to prevent carbon movement and loss inside the sampling loop. We found that unless the glass wool is thermally conditioned, ghost peaks occur in the chromatographic analysis (see Appendix). The second problem occurred in making up standards at the low part-per-billion level. Our previous work in preparing standards involved the part-per-million level and at that time no problems developed in these analyses.[4] However, in the part-per-billion range we noticed that initially it was very difficult to reproduce our standards especially in the 5 - 20 ppb region. The problem was finally traced to residual VCM in

our make-up air. An analysis of the air near the air compressors inlet (roof of boiler house) revealed 100 ppb of residual VCM. We solved this problem by putting an activated carbon bed on our air stream. However, to assure ourselves of true zero VCM grade air, all standards were prepared from cylinder air which was tested for VCM before use. Once these two problems were recognized, the analytical development of the method was relatively simple.

IV. VCM Calibration Curve

All standards were prepared by mixing a 19 ppm VCM standard with air and flowing this mixture into the 250 ml sample container. With our flowmeter ranges, we are limited (lowest) to a 2 ppb calibration standard. A 1 ppm VCM standard will be ordered. This will allow us to prepare standards [illegible] if this becomes necessary.

Table 1 contains a summary of the [illegible] gas chromatographic peak areas for those standards. [illegible] are also shown in Figure 1. A typical chromatographic analysis at the 5 ppb [illegible] is shown in Figure 2. It is important to note that the chromatograph was not at the most sensitive setting during this 5 ppb analysis. If it were, the peak would be 4 times the size shown in Figure 2. Thus with a steady baseline at maximum sensitivity, an analysis of 1 part-per-billion of VCM is quite reasonable.

The gas chromatographic data in Table 1 was hand calculated because of a malfunction in PACE (off-line computer). PACE-obtained data (see Appendix) was reliable above 20 ppb but for VCM concentrations below this, the data was not self-consistent.

A linear regression analysis of the expanded calibration data in Table 2 (see Appendix) yielded the following equation:

$$[\text{VCM}]\ \text{ppb} = 1.99\ (\text{G.C. Area}) - 4.81\ \text{ppb}$$

The slope was 1.99 [illegible].06 ppb/area with a correlation coefficient of 0.990. The excellent linearity of the calibration curve is indicative of a number of important phenomena. If there is any loss of VCM during the purging operation, it is independent of the concentration of VCM. Also if any VCM remains on the charcoal, this too is concentration independent. We were concerned about this latter possibility in that we might be building a "memory" on the charcoal bed. However, repeated blank runs have been carried out and to date this does not appear to be a problem. If very high levels of VCM are deposited on the charcoal subsequent analyses could shown a "memory" to this initial deposition.

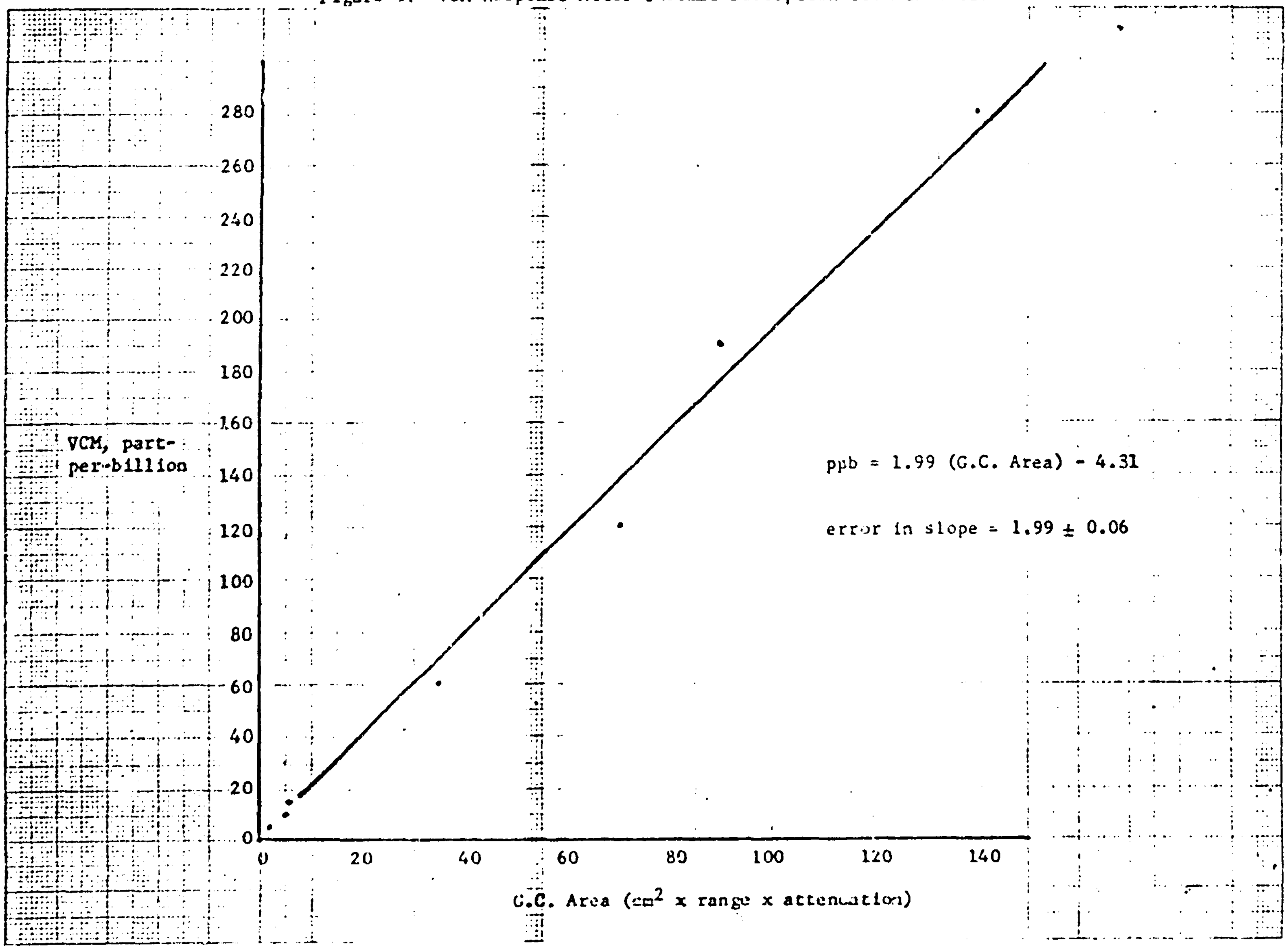
Table 1

Calibration Data for VCM Adsorbed On Carbon and Chromatographically Analyzed After Thermal Desorption

VCM Concentration (ppb)	Peak Area[(a)]
5	2.5
10	5.0
15	6.2
20	14.9
40	22.4
60	35.1
120	69.7
190	90.6
280	140.4

(a) Defined as "the peak height times the peak width at half height times the range times the attenuation". PACE data was not reliable in the 5 to 20 ppb region; the PACE problem is correctable. These values are average values of 2 or more determinations.

Figure 1: VCM Response After Thermal Desorption from Charcoal



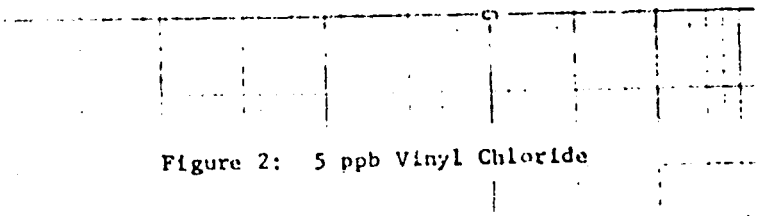
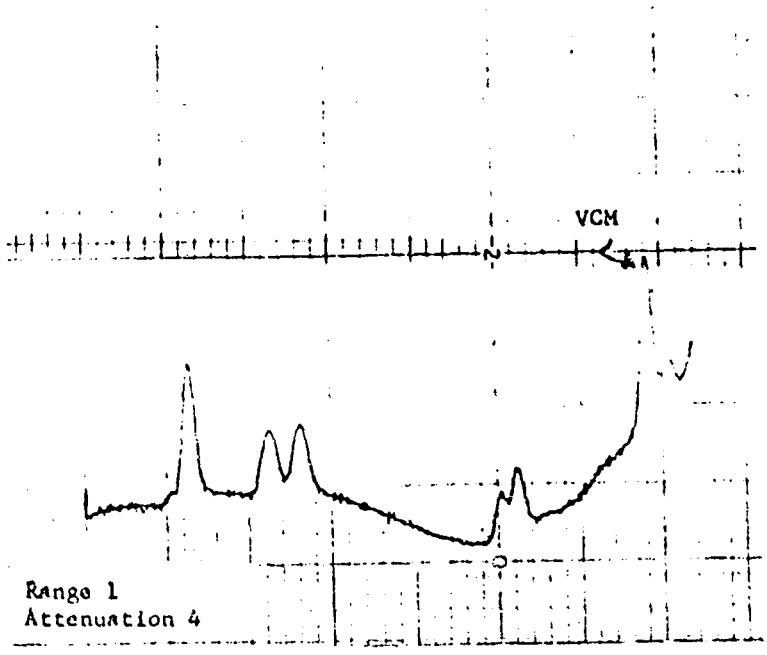


Figure 2: 5 ppb Vinyl Chloride



V. Discussion

Two approaches were possible with this technique. One (that chosen) involved making one carbon adsorption bed for the gas chromatograph and sampling with the 250 ml glass containers. The other approach involved making a series of carbon beds and sampling directly with these. We chose the former method for a number of reasons. Ultimately we had control over the adsorption experiment. In the field, sampling with the sampling container, neither the sampling rate or the sampling time are especially critical. For example, sampling at a rate of 1 or 2 liters/min. for any period of time over a few minutes is adequate. However, much tighter control over both the sampling rate and the time would be absolutely critical if sampling was done with the carbon bed directly. We also checked the flowmeter on one of the portable pumps with a precision flowmeter and found it to be out of calibration by 11%. In terms of sampling with the glass vessels, this deviation is unimportant. However, it is not unimportant in sampling with the carbon bed. Before any analysis is attempted, a 11% error is introduced immediately.

Another demand we placed on the analysis was rapid turnover. A recent analysis of automobile exhaust demonstrated the problem if too much material is adsorbed on the charcoal. The chromatograph must be baked out after every run. With the automobile exhaust samples, it took an hour to clean the chromatograph of the high boiling components that were trapped out of the exhaust. This, of course, would be no problem if we had a number of chromatographs available for the analysis. In light of the number of samples that need to be run, rapid turnover was a necessary constraint. This seemed to eliminate direct use of the carbon bed because of the other components that would be deposited in relatively high yields. Finally, the sampling rate was a potential problem from another standpoint besides control. Very little carbon (~0.2g) is involved in the adsorption. We initially started out with .5g of carbon but this had to be abandoned because it led to a rather diffuse VCM chromatographic peak. To keep the adsorption efficiency high, the sample containers are purged at a flow rate of 100 cc/min. or 1/10th the sampling rate that would be used in the field. Efficiency might be quite low at this field rate especially in light of the small amount of carbon that must be used to obtain acceptable chromatographic results.

Needless to say all of these problems can be overcome if analysis below a part-per-billion is important. Efficiency studies can be carried out, the portable pumps can be fitted with high precision flowmeters, and the chromatographic analysis time can be lengthened, for example. In terms of developing a rapid, reliable method for analyzing VCM in the 1 ppb region, we feel the method chosen was the best compromise.

V. Discussion

Two approaches were possible with this technique. One (that chosen) involved making one carbon adsorption bed for the gas chromatograph and sampling with the 250 ml glass containers. The other approach involved making a series of carbon beds and sampling directly with these. We chose the former method for a number of reasons. Ultimately we had control over the adsorption experiment. In the field, sampling with the sampling containers, neither the sampling rate or the sampling time are especially critical. For example, sampling at a rate of 1 or 2 liters/min. for any period of time over a few minutes is adequate. However, much tighter control over the sampling rate and the time would be absolutely critical if we were sampling with the carbon bed directly. We also checked the flowrate of one of the portable pumps with a precision flowmeter and found it to be out of calibration by 11%. In terms of sampling with the glass containers this is unimportant. However, if it is not unimportant in [illegible] analysis is attempted, a 11% error [illegible].

Another factor we placed on the analysis was rapid turnover. A [illegible] demonstrated the problem if too much water is allowed to accumulate on the charcoal. The chromatograph must be baked out after every run. Since the automobile exhaust samples, it took an hour to clean the charcoal bed of the high boiling components that were trapped out of the exhaust. Time, of course, would be no problem if we had a number of chromatographs available for the analysis. In light of the number of samples that needed to be run, rapid turnover was a necessary constraint. This served to eliminate direct use of the carbon bed because of the other components that were detected at relatively high yields. Finally, the sampling rate was a potential problem from another standpoint besides control. Very little carbon (~0.2g) is involved in the adsorption. We initially started out with .5g of carbon but this had to be abandoned because it led to [illegible] of the desorption peak. To keep the adsorption efficiency high, the beds must be purged at a flow rate of 100 cc/min. or less to simulate the rate that would be used in the field. Efficiency might be poor here at this rate, especially in light of the small amount of carbon that must be used to obtain acceptable chromatographic results.

Needless to say all of these problems can be overcome if analysis below a part-per-billion is important. Efficiency studies can be carried out, the portable pumps can be fitted with high precision flowmeters, and the chromatographic analysis time can be lengthened, for example. In terms of developing a rapid, reliable method for analyzing VCM in the 1 ppb region, we feel the method chosen was the best compromise.

Appendix I

Procedural Information Relating

To The Analysis of VCM at the 1 ppb Level

I. Chromatograph

Model: Hewlett-Packard Model 5710A
H_e: 37.5 cc/min.
H_2: }
Air: } factory specifications
Column Temperature: Initial - 80°C. for 2 minutes
program - 16°C./minute
final - 200°C. for 2 minutes
Injection Port Temperature: 150°C.
Detector Temperature: 250°C.

II. Column

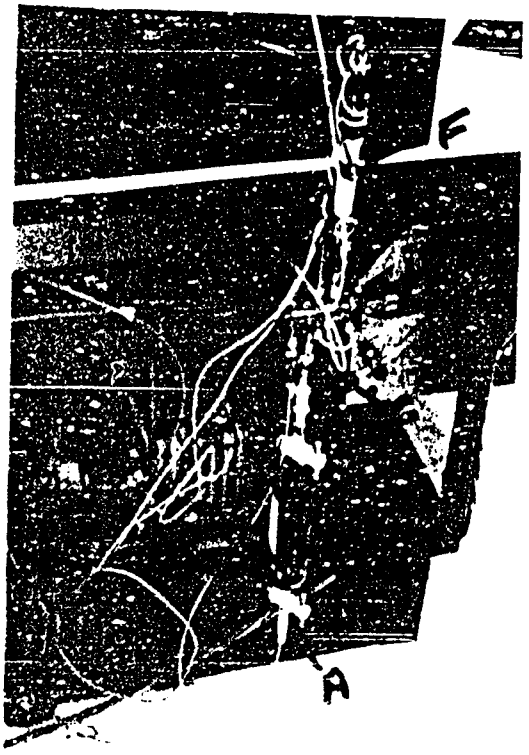
8' X 1/8" Porapak QS, 50/80 mesh

III. Gas Sampling Valve

A 6" x 1/8" stainless steel column containing 0.7306g of Fisher Scientific activated charcoal (Catalog Number 5-685-8), mesh size 6-14, was prepared. Glass wool was placed at both ends of the bed to prevent movement. It is important that the charcoal be heated to 250°C. overnight to avoid ghost peaks during analysis. The 1/8" column is then placed in a vertical position, interfaced with 1/8" stainless steel tubing and connected to a gas sampling valve in the position occupied by the gas sampling loop. The photograph below (Part IV) shows the gas sampling valve and carbon bed. The carbon bed is encased with a heating element and a thermocouple was inserted to monitor temperature. Adsorption is carried out at 25°C. and desorption at 200°C.

IV. Gas Sampling Valve

Any 8-port gas sampling valve can be used to interface the carbon bed to the chromatograph. Two of the ports are used for the carbon bed, two of the ports are used to purge the sample vessel through the carbon bed and two of the ports are used to flush the carbon bed onto the chromatographic column. The two remaining ports are "looped" together to provide a by-pass for purging. The location of the helium line, gas sampling container, effluent line, etc. are shown below and labeled accordingly. Two metering valves are also shown in the photograph. These are necessary to close off the carbon bed during the heat up procedure.



A - helium purge line to bottom of sampling vessel

B - sampling vessel

C - metering valves for isolating carbon bed

D - 8-port gas sampling valve

E - carbon bed

F - thermocouple on carbon bed

V. [illegible]

The following description covers the procedural aspects of analyzing VCM with the carbon bed.

The 250 ml sampling vessel containing vinyl chloride monomer is interfaced to the sampling valve (see photograph) the helium purge line, teed from the main line through a metering valve, is connected to the bottom of the sampling vessel. The two metering valves on the gas sampling valve are opened, the stopcock at the top of the sampling vessel is opened, followed by the stopcock at the bottom. The helium flow through the vessel onto the carbon bed (at 25°C.) is maintained between 100 - 110 cc/min. for 7.0 minutes. At the end of this purge time, the bottom stopcock, top stopcock and the two metering valves on the sampling valve are closed (in the order described). At this point, the heater on the carbon bed is turned on. In our system, it takes approximately 3 minutes to reach 200°C. Once the thermocouple on the carbon bed indicates 200°C., the valve is "pulled" or "pushed" to bring the carbon bed on stream with the chromatographic column.

The temperature on the bed is allowed to rise to 225°C. (about 1 minute after the valve is actuated). We believe this may be necessary to avoid memory on the carbon bed. The heater on the bed is then turned off. Once the valve is actuated, the chromatographic process is initiated [(1) 2 minute delay at 80°C., (2) program to 200°C. at 16°C./minute, (3) hold at 200°C. for 2 minutes].

VI. Graphic Calibration Data

In this section, the average data contained in Table 1 will be expanded to include all data.

As mentioned [illegible], the PACE data was not self-consistent. A summary of all data is [illegible] all standards, both PACE and hand calculated analyses are contained [illegible]. We discovered the error in PACE while running the 10 ppb [illegible] [illegible] and the two peaks were visually over- [illegible] [illegible] calculated or hand plotted data. [illegible] with the visual observation. However, [illegible] [illegible]. From 20 ppb to 250 ppb, PACE data [illegible] the hand calculated data. In these cases, the VCM is [illegible] and this is due to the current PACE problem.

The [illegible] reproducibility previously mentioned was determined from the 20 ppb data. While the 120 ppb data shows a greater spread, this data may be [illegible] because of VCM contamination in the make-up air of the [illegible].

VII. [illegible]

The linear regression analysis was carried out on all the data in Table 2. The following data relate to the regression analysis:

(1) [illegible]
(2) [illegible] -1.81

IX. [illegible]

The general technique described in this paper can be used in a number of other applications. For example, it can be used for analyzing pollutants on a thermal conductivity gas chromatograph where increased amounts of sample are required. For the analysis of compounds that are not sensitive to flame ionization, this technique coupled to thermal conductivity gas chromatography may be very adequate.

The true potential of the technique has not been evaluated. It offers the potential to analyze quantitatively at almost any level.

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Table 2

PACE and Hand Calculated Data for VCM Standards

VCM Standard, ppb	G.C. Area	
	PACE	Hand-Calculated(1)
5	.000993	2.60
5	.000393	2.34
10	.00904	5.10
10	.01616	4.95
20	.00645	14.0
20	.00655	13.5
20	.00731	13.8
20	.00796	17 8
20	.00767	15.2
30	.0111	22.4
15	.0198	6.50
15	.0082	6.00
60	.0187	34.9
60	.0174	35.3
120	.0410	81.9
120	.0347	69.8
120	.0292	57.7
190	.0448	93.3
190	.0438	86.6
280	.0643	134.2
280	.0711	146.6

(1) Peak height x peak width x attenuation x range. These values are based on a 1.198 MV full scale G.C. recorder.

References

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2. L. D. White, et.al., American Industrial Hygiene Assoc. Journal, 31, March/April 1970, 225.

3. M. M. O'Mara, J. A. Nikora, "A Pyrolysis-Gas Chromatographic Technique For Identifying Absorbed Materials", I.O.C., 9/14/69.

4. M. M. O'Mara, C. A. Lees, B.F.Goodrich Technical Report, February 28, 1974.