

TECHNICAL NOTE

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A Study to Determine the Limit of Detectability of Gasoline Vapor from Simulated Arson Residues

REFERENCE: Loscalzo, P. J., DeForest, P. R., and Chao, J. M., "A Study to Determine the Limit of Detectability of Gasoline Vapor from Simulated Arson Residues," *Journal of Forensic Sciences*, JFSCA, Vol. 25, No. 1, Jan. 1980, pp. 162-167.

ABSTRACT: An experimental study to determine the effect of collection delay and combustion time on successful detection of the accelerant gasoline was made with samples of wood, carpet with padding, and soil. The maximum time allowed for collection and analysis of samples in which a positive result could be obtained was called the limit of detectability. This limit was found for each sample under study by using various combustion times to 20 min and collection delays to 162 h after the fire was extinguished. The limit of detectability decreased in a regular manner with an increase in combustion time and delay in collection. The relative values for the limit of detectability for different surfaces could prove to be a valid and valuable criterion in the selection and collection of the proper physical evidence at fire scene examinations.

KEY WORDS: criminalistics, arson, gasoline

No person can argue with the fact that arson is one of the major property crimes in this country. Although the incidence of arson is not as high as the crimes of robbery, auto theft, or breaking and entering, it is comparable in number with the homicides committed each year [1]. One factor that makes arson such a major crime is the loss of money by the victims. The latest report from the National Research Committee of Fire Research has established the annual loss from wrongful setting of fires in 1975 at between five and six billion dollars [2]. It is also estimated that perhaps as high as 40% of all fires are caused by arson and that more than 10 000 deaths from fire occur each year in the United States [3].

It does not take much research before one realizes that there is a dearth of current literature dedicated specifically to the criminalistic aspects of accelerant detection in suspected arson residues. The purpose of this paper is to make an exploratory study of simulated arson residues for the detection of an accelerant, specifically gasoline. The court testimony of the criminalist on the identification of the flammable accelerant is extremely important to the

Presented at a joint meeting of the Mid-Atlantic Association of Forensic Scientists and the Northeastern Association of Forensic Scientists, Mt. Holly, N.J., 16 April 1977. Received for publication 6 Dec. 1978; revised manuscript received 9 June 1979; accepted for publication 13 June 1979.

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success of the prosecution because the discovery of an accelerant establishes "intent" of the arsonist, a requirement under most statutes [4].

An experimental study to determine the effect of collection delay and combustion time on successful detection of the accelerant gasoline by gas-liquid chromatography (GLC) was made with samples of wood, carpet with padding, and soil. The maximum time allowed for collection and analysis of the samples in which a positive result could be obtained was called the limit of detectability. This limit was found for each sample under study by using various combustion times to 20 min and collection delays to 162 h after the fire was extinguished.

Materials and Methods

Four sets of materials were placed together and each set was evenly doused with a litre of gasoline.⁴ Each set consisted of 30-cm² areas of plywood, carpet with padding, and sandy soil. The gasoline-soaked sets of materials were allowed to remain undisturbed for 5 min, then ignited. The fires were allowed to proceed for 5, 10, 15, and 20 min and were then immediately extinguished with sufficient water to eliminate the flames and leave no smoldering residue. A fifth set without gasoline was also ignited as a control and similarly extinguished after 10 min.

A 10-cm³ sample of each material was collected from each set immediately following extinguishment, producing a total of 15 samples per collection. Additional collections were made at eleven predetermined intervals following extinguishment, yielding a total of twelve collections of 15 samples each, thus producing 180 total samples. The collecting was accomplished by using 30-cm³ serum vials with rubber septums crimped immediately after sampling. A layer of Saran® wrap was placed over the mouth of the bottle before the septum was crimped to minimize the possibility of any reaction taking place between the sample and septum.

Each sample was heated on a steam bath for about 15 min. A 1.0-cm³ specimen of the heated headspace vapor was removed from each sample with a disposable syringe. Analysis was made by injection into a Varian Aerograph 2400 Series GLC equipped with a Varian A-6 1-mV recorder. A 1.8-m (6-ft), 6.35-mm (¼-in.) outside diameter glass column packed with 7% Bentone-34 plus 10% diisodecylphthalate (DIDP) on Chromosorb Q 80-100 mesh was used with nitrogen gas as a carrier at 50 cm³ per minute flow. The flame ionization detector was kept at 190°C and the column was isothermal at 100°C. Attenuation was ×512 for 1 min following injection, then changed to ×128 for 3 min, followed by 26 min at ×8. Thus a total of 30 min elapsed between the injection of each specimen, although peaks of any interest were eluted within 20 min of the injection.

Temperature programming was not used since the upper limits of the DIDP have been reported to be around only 150°C [5] and satisfactory separation of xylenes and ethylbenzene, common constituents of gasoline [6], have been reported at even lower temperatures by Spencer [7]. Substrate blanks were prepared in the same manner as the experimental samples and also subjected to GLC. No interfering peaks were eluted that could have erroneously been interpreted as a flammable hydrocarbon.

Results

Before analysis was begun it was necessary to establish a valid criterion for the positive identification and detection of the accelerant. Several studies into analysis of fire debris have shown that the composition of gasoline changes during combustion [6,8-10] since it is a complex mixture of hydrocarbons whose composition varies unpredictably by brand [6].

⁴ Regular leaded Texaco gasoline was used throughout this study.

Although gasoline is a complex mixture there are certain compounds common to all brands of gasoline. These compounds are represented by the peaks labeled on the chromatogram in Fig. 1. Some brands of gasoline produced peaks in addition to those shown in Fig. 1 but these did not interfere with the identification of the established peaks. The minimum criterion for a specimen to be determined positive for the gasoline was the appearance of the benzene, toluene, ethylbenzene, *p*-xylene, *m*-xylene, *o*-xylene, *sec*-butylbenzene, 1,3,5-trimethylbenzene, and 1,2,4-trimethylbenzene peaks. Specimens having fewer than these peaks were considered negative for the scope of this experiment.

Table 1 shows the individual results of the GLC analysis for each specimen using the criterion previously established for a positive result. A graphic representation of Table 1 showing the relationship between collection delay, combustion time, and the positive detection of the gasoline for each sample is shown in Fig. 2.

The limit of detectability for gasoline vapor from wood was much lower than that for carpet and soil, as shown by Fig. 2. Carpet with padding showed a much higher retention than wood for burns of 5, 10, and 15 min, although both wood and carpet showed zero gasoline detectability after 30 min of combustion regardless of how quickly the sample was collected. The only sample to show any gasoline residue after 20 min of burning was soil. The soil showed a remarkable detectability limit of 160 h after 5 min of burning, but this unusually high limit decreased rapidly after 5 min, although it remained significantly higher than wood and carpet during the entire study.

Discussion

The chromatogram shown on Fig. 1 of known gasoline shows the excellent separation of the individual xylene isomers obtained by using the Bentone-34/DIDP column. Separation of the xylene isomers by GLC using Bentone-34 columns has been the subject of various publications [7,11,12]. The Bentone-34/DIDP column used in this study was a modification of the column investigated by Spencer [7] in 1963.

The composite experimental results of Table 1 that are shown in Fig. 2 clearly show a measurable difference in the limit of detectability of gasoline between the substances wood, carpet, and soil. Wood showed the lowest limit of detectability relative to the carpet and soil, regardless of the combustion time or delay in collection. In general, though, the *difference* between the detection limits of each substance decreased proportionally as combustion time increased until a difference of zero was obtained after 20 min of combustion with the exception of the soil. However, the comparative difference in Fig. 2 clearly shows regularity between the comparative individual differences as combustion time increases, especially between the wood and carpet. The difference in the limit of detectability between the soil and carpet was fairly constant, showing little difference, but this consistency developed only after 5 min of combustion because of the unusually high (162 h) limit of detectability for soil obtained for 5 min of combustion.

After a combustion time of 20 min the gasoline could not be detected from either wood or carpet even if the sample had been collected immediately after extinguishment. The soil, however, continued to give positive results at 20 min up until a collection delay of 5 h.

The area under each curve shown in Fig. 2 represents all points where gasoline could be detected for each surface within the parameters of this study. For example, after a 6-h delay in collection time for a sample of wood following a combustion of 14 min it would not be possible to detect the accelerant gasoline because it has exceeded its limit of detectability for those conditions. Interpolating from the graph in Fig. 2 shows the limit of detectability for carpet and soil under the same conditions would be about 8 and 12 h, respectively.

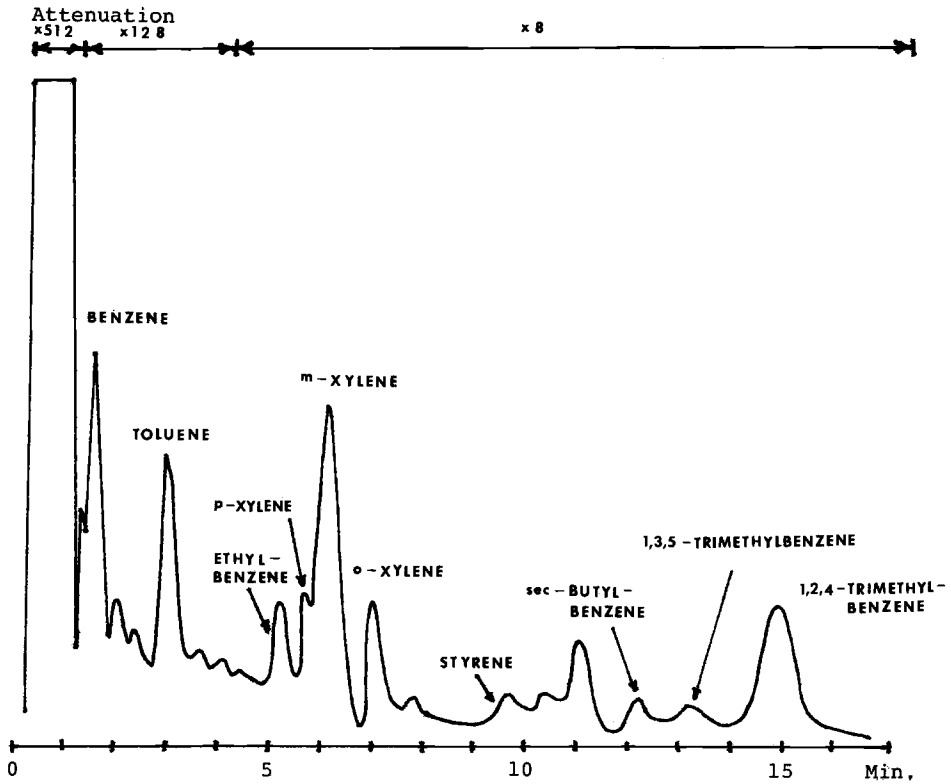


FIG. 1—Gas chromatogram of gasoline (regular leaded Texaco gasoline).

TABLE 1—Results^a of GLC analysis of specimens.

Time ^b After Burn, h	Sample Burning Time											
	5 min			10 min			15 min			20 min		
	W ^c	C	S	W	C	S	W	C	S	W	C	S
0	+	+	+	+	+	+	+	+	+	o	o	+
3	+	+	+	+	+	+	+	+	+	o	o	+
6	+	+	+	+	+	+	o	+	+	o	o	o
9	+	+	+	o	+	+	o	o	+	o	o	o
12	o	+	+	o	+	+	o	o	o	o	o	o
18	o	+	+	o	o	+	o	o	o	o	o	o
24	o	+	+	o	o	o	o	o	o	o	o	o
30	o	o	+	o	o	o	o	o	o	o	o	o
42	o	o	+	o	o	o	o	o	o	o	o	o
66	o	o	+	o	o	o	o	o	o	o	o	o
90	o	o	+	o	o	o	o	o	o	o	o	o
162	o	o	+	o	o	o	o	o	o	o	o	o
186	o	o	o	o	o	o	o	o	o	o	o	o

^a Gasoline detected is +; gasoline not detected is o.

^b Refers to time elapsed since indicated burn.

^c W = wood; C = carpet with padding; and S = soil.

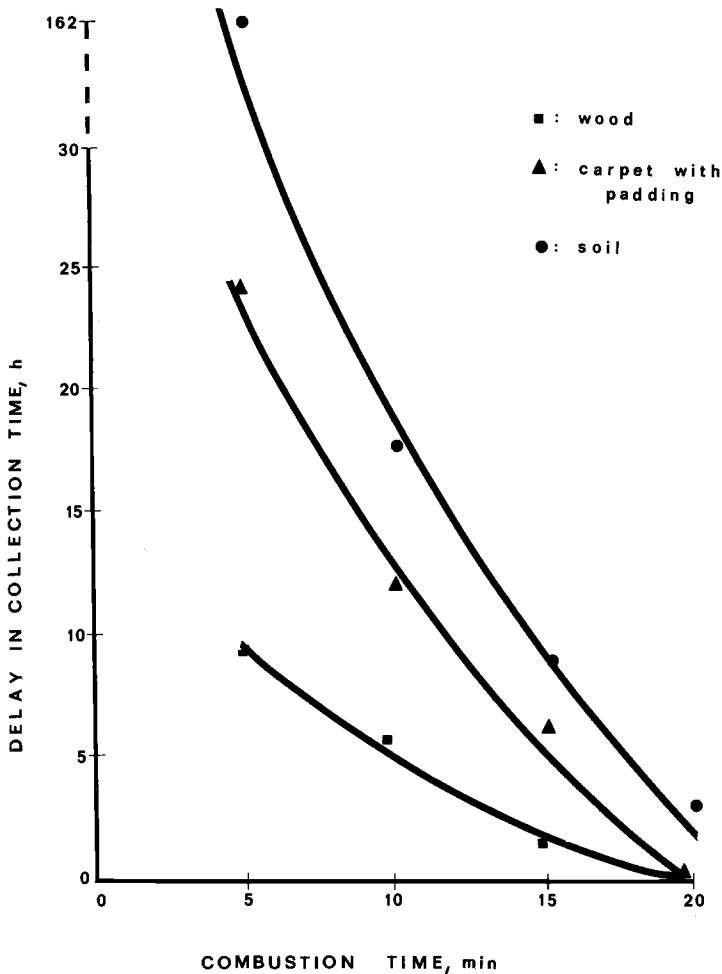


FIG. 2—Limit of detectability of gasoline vapor for wood, carpet with padding, and soil.

Summary

The surfaces of wood, carpet with padding, and soil were subjected to a controlled experiment using the accelerant gasoline. The specimens used for analysis were obtained by sampling the heated headspace vapor from each sample collected. Analysis was made by GLC with programmed attenuation changes using a Bentone-34/DIDP packed column that effectively separated benzene, toluene, ethylbenzene, the xylene isomers, *sec*-butylbenzene, 1,3,5-trimethylbenzene, and 1,2,4-trimethylbenzene, common constituents of gasoline.

Each surface was allowed to burn for various periods of time and various delays in collection were made before the samples were obtained for analysis. For each surface under study, the limit of detectability for the accelerant gasoline was determined quantitatively. This limit represented the maximum time allowed for the collection of the samples for which the subsequent analysis would yield a positive result for the detection of the accelerant. The limit of detectability depended on the variables of combustion time and collection delay. This limit was significantly different for each surface within this study. This suggests that knowledge of the relative limit of detectability of different surfaces

could be valuable in the collection of proper evidence from fire scenes for subsequent accelerant detection and identification.

The criminalist has little control over the time of extinguishment of a fire, and rarely does he collect his own arson evidence. Instead, he is confronted with the shoveled remains of debris collected from what was believed to be the origin of the fire. Additional research into the determination of the limit of detectability of gasoline from additional surfaces may prove helpful in this area. A more complete study using as many different surfaces as possible that are common to fire scene examinations is needed. A study such as this may show that the *relative* limit of detectability of each surface could be a valid and valuable criterion for the proper selection and collection of physical evidence from suspected arson residues.

Unfortunately, a controlled study of this nature cannot take into account the factors affecting the same accelerant under the conditions of a full-scale dwelling fire. In such a fire the accelerant may be either entirely consumed or altered in such a way that the usual GLC and headspace vapor method commonly employed today would fail to produce any positive results. Further research into the recovery and identification of these higher molecular weight residues of gasoline using simplified GLC techniques such as those used by Armstrong and Wittkower [13] and Clodfelter and Hueske [14] is needed.

Although some research using sophisticated techniques has been done in this area by Mach [6], it would not be feasible for less well-equipped forensic science laboratories to perform routine analyses in this matter.

Acknowledgments

The authors are grateful to Mr. E. Kline, fire marshall of Burlington County, N.J., the Rancocas Fire Company #1 for their assistance, and Miss D. Joyce for typing the manuscript.

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