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Burn severity on women victims of reported immolation attempt cases through gas chromatographic analysis of residuals and simulates

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ABSTRACT

Unburnt and partly burnt cloth samples of the bride reported to be burnt with kerosene were received to the Forensic Science Laboratories. The samples were analyzed using Gas Chromatograph with capillary column and a sensitive Pulse Discharge Helium Ionization Detector. To simulate the real situation of bride burning a set of five samples of cotton cloth measuring 10 x 10 inch was taken and each was sprinkled with known amount of kerosene and burnt for different intervals of time. The burnt portion of the cotton fabrics was sampled by steam distillation followed by extraction into diethyl ether for identification of the residual volatiles by GC. The chromatographic profiles of simulated cotton fabrics were used as standards and were compared with those of pure n-paraffins and those of the samples the victims of reported two cases, the case 1 and the case 2. Analyses of the pattern of GC profiles and the ratio of peak area of C14 to C13 were used for estimating the severity of burn injury of the victims.

KEYWORDS

PDS kerosene;
N-paraffins;
Gas Chromatograph;
PDHID;
Severity of burning.

INTRODUCTION

Dowry is a form of marriage gift agreement made between families of bride and bridegroom. The bride groom family conception of violation of such an agreement or more greed for money may end up in dowry causalities. One such mode of causalities is a bride burning, an unfortunate sinister practice commonly reported in India[1]. In such bride burning cases kerosene, a main sources of fuel for cooking[2], is alleged to be used to douse on before setting the victim on fire. Stringent law enforcement is not yet successful in preventing all such kind of incidents. As a means of initiating legal course against such kind of reported crimes, the cloth samples of the victim are to be analyzed chemically to ascertain the burning aid material used. Whenever a casualty of a woman was reported under suspicious circumstances, particularly when it happens within a period of seven years of the victim's marriage, then it becomes a legal practice to consider it as a suspected dowry casualty[3] and to investigate any possible involvement the victim's husband and her in-laws. Therefore, the investigating officer of any such burn cases will collect the belongings of the victim particularly the clothes and forward

them to Forensic Science Laboratory for an expert examination. Clothes on the victim's body could serve as the best material to detect residual concentration of the fuel used for burning[4].

The samples that were received to laboratory for examination, many a times hardly smell kerosene. Therefore, sensitive chemical methods of sample analyses are to be adopted to analyze the collected cloth samples of the reported victim. The sensitive chemical methods that are commonly adopted in Indian FSLs include UV identification of naphthalene[5], thin layer chromatography[6], HPLC[7], GC[8, 9] and GCMS[10], although no single method is universally effective for all types of accelerants[11]. Capillary gas chromatography is the most accepted technique for the detection of aliphatic hydrocarbons with carbon numbers 9-16 in kerosene[12]. In the present paper the residues of kerosene was detected by Gas chromatography with capillary column and highly sensitive PDHID detector[13].

Kerosene, an inflammable domestic fuel used in homicidal or suicidal burning, is chemically known to consist of flammable paraffins or saturated hydrocarbons with dodecane (C12) as a major constituent and aromatics[14]. An understanding of basic properties such as volatility, osmosis and adsorption of fire accelerants like kerosene on various matrices can help in identifying a particular accelerant[15]. Since cotton clothes known for good fuel retention capacity, therefore, the case 1 and case 2 involving cotton clothes on the victims were chosen here for the GC analysis of burn residuals and the simulated burn residuals. The objective considered here was prompted by a report[16] which explains a relation of disappearance of accelerant with the duration of burning.

Brief history of cases

Case 1: In this, the victim was a young

woman reported to be married four and a half years before the incident of attempt of bride burning. The victim was reported to be doused with kerosene but fortunately escaped unburnt. Later, her cloth samples were received to the laboratory for chemical analysis. Upon inspection it was found that The cloth samples were smelling kerosene but without burn marks on the samples.

Case 2: In this, a young woman married three months before the incident was reported to have committed suicide by burning herself using kerosene. The cause claimed was an unbearable torture given by the in laws and the husband. The Autopsy report on the victim was indicating about 90% burn injuries. The victim's saree, a common cloth Indian woman wear and an underskirt reported to be worn by the victim at the time of the incident were thoroughly packed and received to the laboratory for analysis. The cloth samples of the victim were burnt around 90% and looking charred.

EXPERIMENTAL

Materials

A Chemito make Capillary Gas Chromatograph with Pulse Discharge Helium Ionization Detector (PDHID) detector (Valco) was used for the detection of kerosene residues. The standards of n-alkanes (C9 to C16) were from Sigma Aldrich, cotton clothes, PDS kerosene, diethyl ether (Merck), distillation set and other consumables.

Preparation of simulated cloth samples

Clothes of the two victims in case-1 and case- 2 respectively, were separately cut into small pieces of about 1 x 1 inch size and were subjected to steam distillation. About 20 ml of the steam distillate was collected in duplicate. Residues of ignitable liquids from water were extracted with diethyl ether, concentrated to 2 ml and 0.5 µl was used for GC injection. In an attempt to simulate and gauge the percentage burning of cloth samples of Case-1 and Case-2, six numbers of 10 x 10 inch cotton cloth pieces were taken. Each one of the cloth piece was sprinkled separately with 5 ml of kerosene and burnt for a definite interval of time in an open hall. The burning time, 50 seconds was set so as to get a 50% burnt cloth pieces. Then the fire was put off by covering the burning cloth sample with a thick blanket piece. Then the residual sample was dried in shade for about five hours. It was cut into small pieces and were distilled and the distillate was used for GC analysis as described earlier.

Standard solution containing 0.5 ml nonane

(C 9) / decane (C 10) / undecane (C 11)/ dodecane

(C 12) / tridecane (C 13) / tetradecane (C 14) / pentadecane (C 15) / hexadecane (C 16) was diluted to 50 ml with diethyl ether. A known quantity, 0.5µl of the sample solution was injected at a time to record its chromatogram. The chromatogram obtained in each case was overlaid with those of the other hydrocarbons as shown in Figure 1. Retention times of standard peaks of n-alkanes were given in TABLE 1. The values so obtained were accounting for a good separation of the hydrocarbons.

TABLE 1 : Retention times of n-alkanes

n-alkanes	Name	Retention time (min)
C 9	Nonane	3.557
C 10	Decane	4.725
C 11	Undecane	6.087
C 12	Dodecane	7.477
C 13	Tridecane	8.853
C 14	Tetradecane	10.173
C 15	Pentadecane	11.453
C 16	Hexadecane	12.630

Gas Chromatographic conditions

Injector: Injector temperature: 250° C

Split ratio: 1 : 30

Column: Capillary column DB5, 30m, 2.5 mm id

Oven temperature: 80° C for 2 min, 5° C/min up to 240° C, hold for 5 min

Run time: 20 min.

Carrier gas: Helium with flow rate 1 ml /min

Detector: Pulse Discharge Helium Ionization Detector (PDHID) with temperate set to 200°C

Attenuation: 128

RESULTS AND DISCUSSION

n-Alkanes found in kerosene are well separated as shown in Figure 1

The chromatogram of the steam distillate of burnt cloth pieces not sprinkled with kerosene was showing no peak other than the solvent, diethyl ether. It was confirming that whatever the peaks that were appearing in the subsequent chromatograms of the cloth samples sprinkled with kerosene were accounting for the volatiles residues from the kerosene residues. Therefore this chromatogram was considered as a control chromatogram and it was avoiding the misinterpretation of chromatograms that were obtained for the cloth samples sprinkled with kerosene[17], Figure 2.

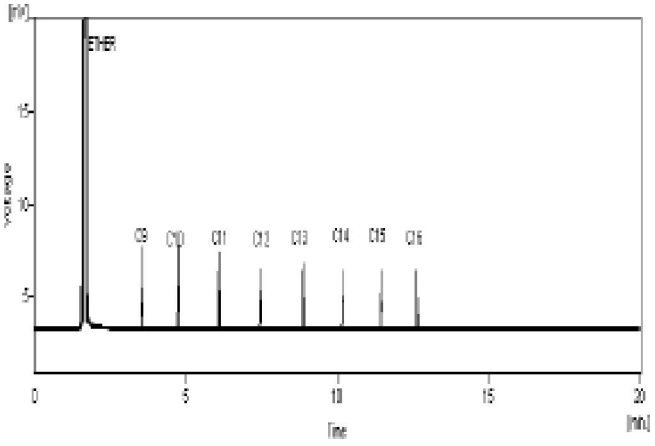

Figure 1 : Combined chromatograms of the standard hydrocarbons

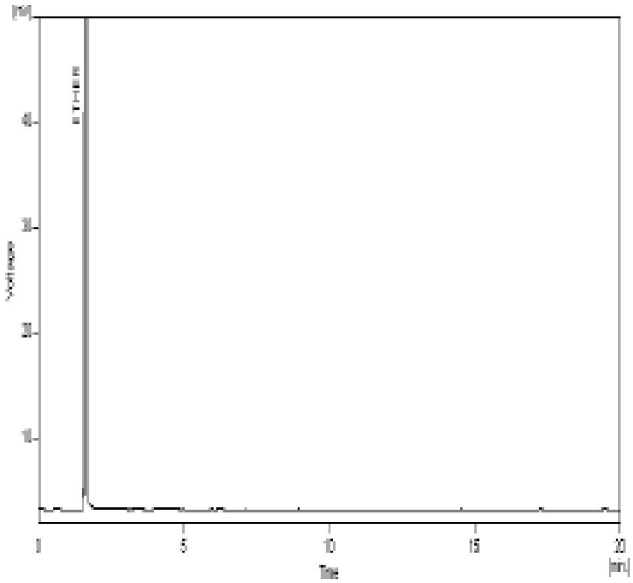

Figure 2 : Chromatogram of the control, distillate of the cloth sample, extracted with ether and burnt without kerosene

The GC profile of the cloth sample of the case 1 in that the victim was reported to be escaped from the spot before she was lighted with fire Figure 3, shows prominent peaks of C9, C10 and C11 and less intense peaks of C12 and C13.

This profile, Figure 3 was similar to the chromatogram obtained for the cloth sample that was sprinkled with kerosene and extracted without burning, as shown in Figure 4. And this observation was also agreeing with the physical inspection of the sample.

The chromatogram, Figure 5 of the sample of case

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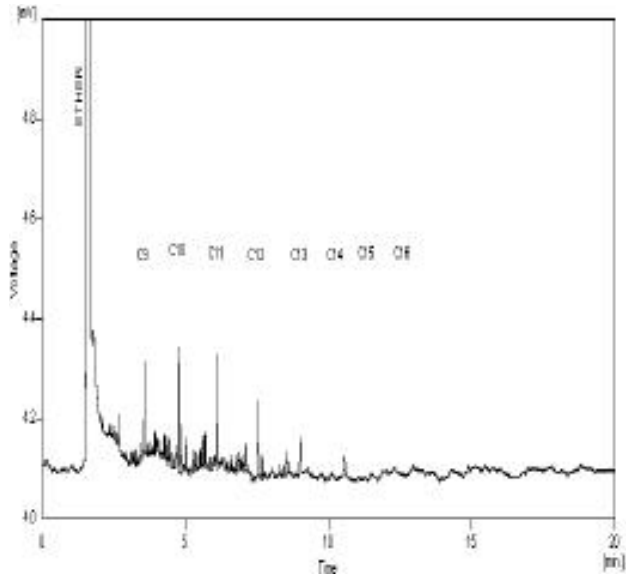

Figure 3 : Chromatogram of the distillate of cloth sample in case 1.

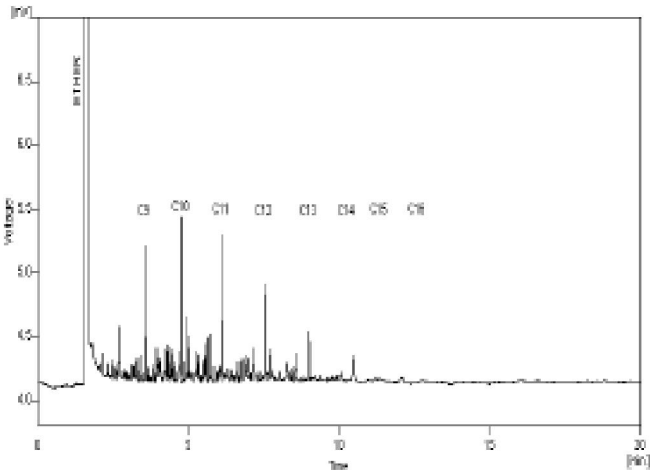

Figure 4 : Chromatogram of the distillate of the cloth sample that was sprinkled with kerosene but not burnt.

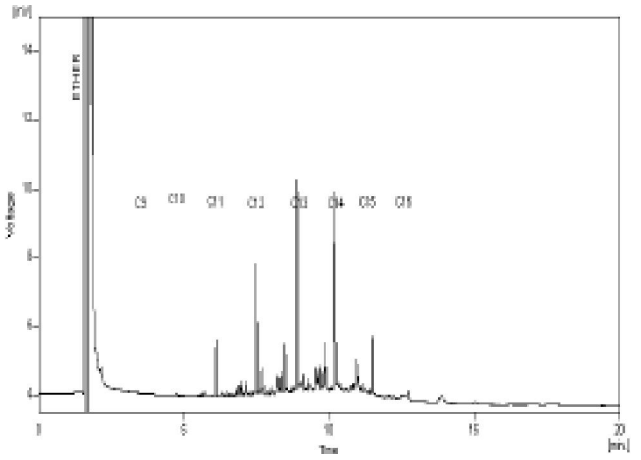

Figure 5 : Chromatogram of the distillate of cloth sample in case 2.

2 in that the doctor's report indicates that the victim was 90% burnt was showing the main peaks corresponding to C13 and C14 but the peaks corresponding to C9 and C10 were almost disappeared. To have its matching counterpart for comparison, the simulated cloth samples were burnt to various intervals of time and the residue so obtained in each case was analyzed separately.

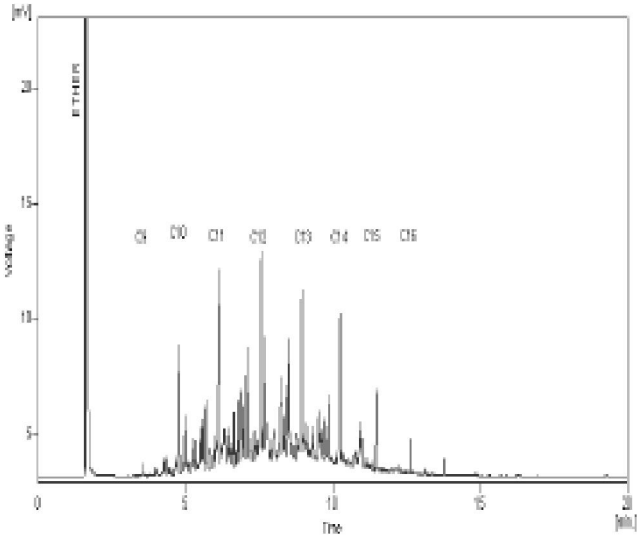

Figure 6 : Chromatogram of the distillate of the cloth sample that was sprinkled with kerosene and burnt for 20 seconds

The chromatograms of simulated cloth samples burnt for 20 seconds as in Figure 6 was having prominent peaks corresponding to C13 and C14 but a weak peak corresponding to C9.

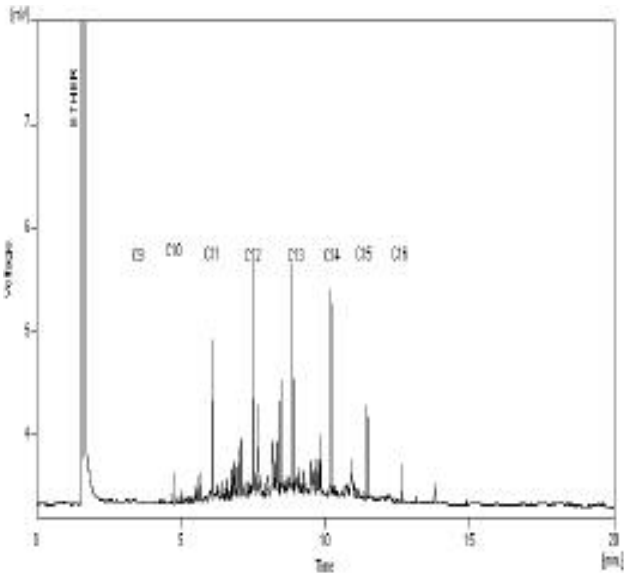

Figure 7 : Chromatogram of the distillate of the cloth sample that was sprinkled with kerosene and burnt for 40 seconds

The chromatogram in Figure 7, for the cloth sample which was burnt for 40 seconds shows a prominent peak corresponding to C13 and a less intense peak corresponding to C11.

Chromatogram in Figure 8 is for the cloth sample which was burnt for 60 seconds shows prominent peaks corresponding to C13 and C14 and the peaks corresponding to C9 and C10 were almost absent.

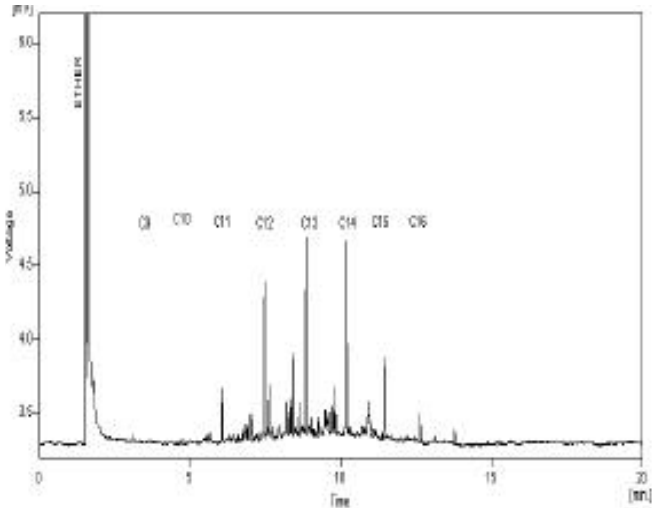

Figure 8 : Chromatogram of the distillate of the cloth sample that was sprinkled with kerosene and burnt for 60 seconds

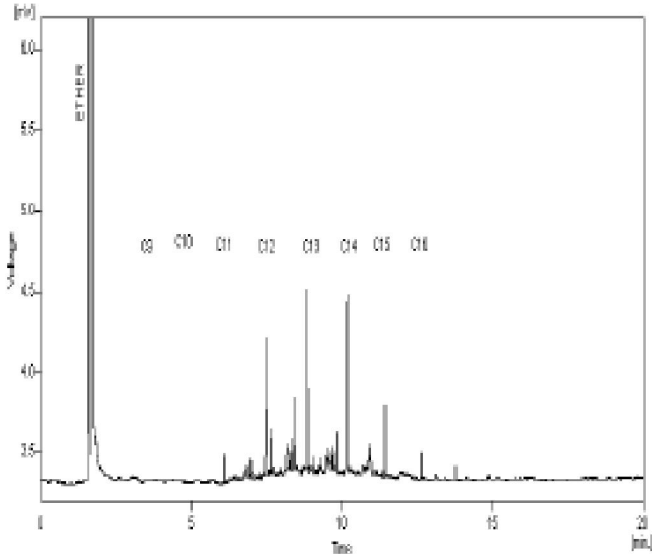

Figure 9 : Chromatogram of the distillate of cloth sample that was sprinkled with kerosene and burnt for 80 seconds

The chromatogram, Figure 9, of the cloth sample burnt for 80 seconds, was similar to that of the chromatogram of the cloth sample burnt for 60 seconds, Figure 8.

Figure 10 is the chromatogram of the cloth sample burnt for 120 seconds, where the cloth was burnt to about 95% of its fabric, was having main peak corresponding to C15 and peaks correspond to C11 and C12 are almost disappeared. The important feature of this chromatogram was that the low volatiles hydrocarbons were getting concentrated with degree of burning and the chromatogram had a good display of the peaks corresponding to C16 and C17.

When the features of chromatograms obtained for the cloth samples that were burnt for various intervals of time (20-120 seconds), were compared with those obtained for the samples of the of case 2, it would be possible to conclude that the victim's cloth sample was matching with the chromatograms of the cloth samples burnt for 60 and 80 seconds, Figure 8 and 9, and more so with 80% burnt sample.

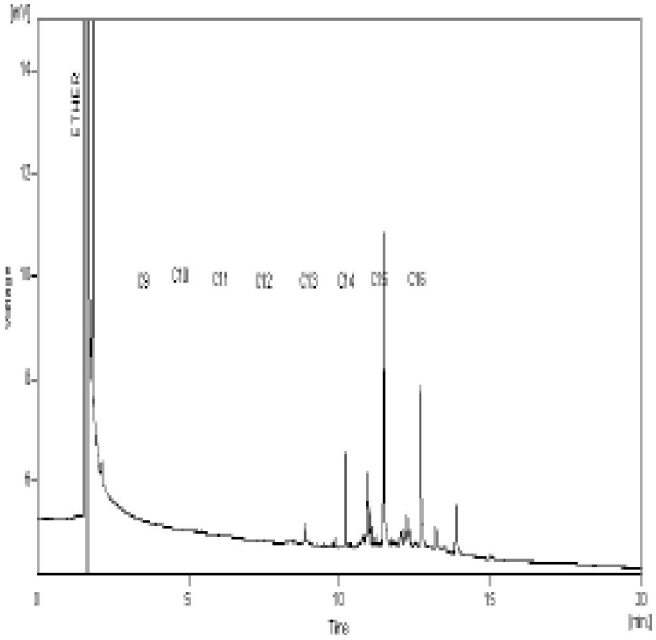

Figure 10 : Chromatogram of the distillate of the cloth sample that was sprinkled with kerosene and burnt for 120 seconds

TABLE 2 : Ratios of peak areas of C14 and C13

Duration of Burning (sec)	Peak area C14 / C13
0	0.763
20	0.895
40	0.926
60	1.068
80	1.148
120	1.824
Case 1	0.842
Case 2	1.326

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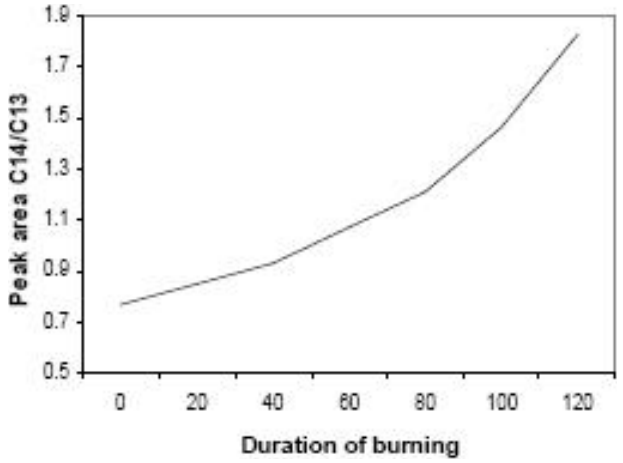

Figure 11 : Graph showing variation of the ratio of peak areas with duration of burning (time in seconds)

Since a minor peak of C11 and equal height peaks of C13 and C14 the sample were more close to the sample that was burnt for 80 seconds. The chromatogram of the cloth sample from the case 1 is that victim's clothes which were unburnt and was closely related to the chromatogram obtained for the simulated cloth sample sprinkled with kerosene but extracted without burning.

There was a matching of the GC profile of the sample from the case 2 in that doctor report was accounting for 90% burn, with that of the simulated sample that was burnt for 80 seconds.

These variations in the features of chromatograms with different burning times can be easily followed by calculating the ratios of peak areas of C14 to C13. The parameter, "peak area ratios" of n-alkanes was used earlier by L. Gieg et al[18] and Sinninghe Damste et al[19] in other contexts. But the one which is used in this paper is for the first time in forensic work which can also serve as an instrumental data for indexing the severity of burns.

The values obtained for ratios of peak areas of C14 to C13 were indicated in TABLE 2 and the corresponding plot was shown in Figure 11, which shows an increasing trend of ratio of peak areas with the burn time of the cloth samples. Peak area ratio of case 1 (0.842) is close to unburnt or 20% burnt sample. Peak area ratio of case 2 (1.326) is close to 80% burnt sample.

A low value of relative standard deviation (%RSD=1.56) was an indication of only an occurrence of slight variation in the chromatograms and ratio of peak areas, C14 to C13) by changing the volume of extract injected and time elapsed between its extraction and injecting it to GC, TABLE 3.

TABLE 3 : Evaluation of the peak areas of 14 and C13, and their ratios with distillates volume and time

No. of trials	Volume of sample injected (µl)	Time after Extraction (min)	Peak area of C 13	Peak area of C 14	Peak area of C14/C13
1	0.5	10	1.821	2.091	1.1482
2	1	10	3.754	4.474	1.1917
3	2	10	5.643	7.110	1.1918
4	1.5	40	4.348	5.104	1.1738
5	1.5	80	3.460	4.250	1.2283

CONCLUSION

The experiments performed here were based on a simple concept that when a victim wearing clothes and doused with kerosene was on fire it was mainly the clothes worn by the victim would be catching fire and start burning. The time so long as the fire was sustaining on the garments so much would be the magnitude of victim's burn injury. The magnitude of injury was considered to be proportional to the amount of less volatile hydrocarbons of the kerosene that were likely to be remained as residuals of kerosene on the fabric support of the burnt clothes. Therefore, the work presented here through GC experimental data is expected help in estimating the kind and nature of pain that the victim might have experienced during the period of burning. This may also help in indexing the severity of the burn injury of the victim and also enables to have a comparative view on the doctor's estimate and the chemical data. Hence, the extent of burning of the cloth samples that were considered to indicate the magnitude of burning were chemically exploited through GC analysis and made an attempt to illustrate the severity of the burns that the victim had and extended it to the victims of two reported incidents, the cases 1 and the case 2. The results obtained from the analyses of GC profiles of the residual hydrocarbons on the various cloth samples were consolidated further through another mode of quantification by plotting the variation of ratio of peak areas of C14 and C13 against the duration of

burning and were used collectively to arrive on the severity of burn of the victims of the cases 1 and 2 with no burn injury and 80-90 percent burn injury respectively.

Even though, the retention of low volatiles on the cloth samples were known to depend on different parameters such as the rate of burning, type of cloth, packing mode, time of packing, time lapsed since packing and the environmental conditions but the variation in the features of the GC profiles of the cloth samples observed with duration of burning was giving an idea of retention of low volatile alkanes, particularly C14 and C13 of kerosene on the burnt cloth samples and the increasing ratio of C14 to C13 was further consolidating for the severity of burns caused on the victims by the kerosene.

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