Original Article

Investigation of Kerosene used as Fire Accelerant Remaining on Different Kinds of Fabrics

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التحقيق في الكيروسين المستخدم كمسارع للحريق المتبقي على أنواع مختلفة من الأنسجة

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Abstract

In arson cases, the detection and identification of fire accelerants is of high importance for elucidation of such crimes. The present study aims to investigate the remaining fraction of kerosene hydrocarbons impregnated on four kinds of textiles (nylon, polyester, wool and cotton).

The volatile fraction was collected by SPME on from non-burnt and burnt samples at successive times (0, 0.5, 1, 2 and 4 h.), then analyzed by GC-MS.

Among the 27 characteristic compounds identified in kerosene, aromatic hydrocarbons were the predominant components, but their evaporation was faster than alkanes in unburnt textiles. Also, in the case of non-burnt samples, the total amount of kerosene residues was higher in synthetic tissues than in natural materials. After burning the different kinds of impregnated textiles, 22 hydrocarbons were detected with a decreasing amount over time, while the concentration of linear alkanes remained higher during the sampling time. All the partially burnt samples displayed much less kerosene residues than in the same unburnt samples. Unlike the non-burnt samples, the profile of kerosene amount as function of time was very similar on the four investigated kinds of fabrics after burning.

These results and the proposed procedure should help forensic investigators in the field of fire debris analysis, in arson cases.

المستخلص

في حالات الحرق العمد، يكون اكتشاف وتحديد مسارعات الحريق أمرًا بالغ الأهمية لتفسير مثل هذه الجرائم. تهدف هذه الدراسة إلى دراسة الجزء المتبقي من هيدروكربونات الكيروسين المشرّبة على أربعة أنواع من المنسوجات (النايلون والبوليستر والصوف والقطن). تم جمع الجزء المتطاير بواسطة SPME على عينات غير محترقة ومحترقة في أوقات متعاقبة (٠، ٥,٠، ١، ٢ و ٤ ساعات)، ثم تم تحليلها بواسطة GC-MS. من بين المركبات المميزة السبعة والعشرين المحددة في الكيروسين، كانت الهيدروكربونات العطرية هي المكونات السائدة، ولكن التبخر كان أسرع من الألكانات في المنسوجات دون الاحتراق. أيضاً، في حالة العينات غير المحترقة، كانت الكمية الإجمالية لمخلفات الكيروسين أعلى في الأنسجة الاصطناعية منها في المواد الطبيعية.

بعد حرق الأنواع المختلفة من المنسوجات المشبعة، تم اكتشاف ٢٢ مادة هيدروكربونية بكمية أقل مع مرور الوقت؛ بينما يبقى تركيز الألكانات الخطية أعلى خلال وقت أخذ العينات. أظهرت جميع العينات المحترقة جزئيًا بقايا كيروسين أقل بكثير من تلك الموجودة في نفس العينات دون احتراق. على عكس العينات غير المحترقة، كان شكل كمية الكيروسين وتوافقه مع الوقت متشابهًا جدًا في الأنواع الأربعة التي تم فحصها من الأقمشة بعد الاحتراق. تساعد هذه النتائج والإجراءات المقترحة المحققين الجنائيين في مجال تحليل حالات الحريق.

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1. Introduction

Arson is one of the most widespread crimes. It is generally committed by persons who aim to destroy not only buildings and their contents, but also any physical evidence of their crime [1]. Official statistics shows that thousands of deliberate fires are committed every year on dwellings, buildings, vehicles and other properties in the UK and the USA [2,3]. Products derived from petroleum such as gasoline (petrol), diesel, and kerosene are often utilized as accelerants by arsonists for increasing the rate and spread of fire [1,4]. These accelerants generally consist of complex mixtures of various hydrocarbons which may be aliphatic or aromatic, with straight, branched or cyclic skeletons [4–7]. Although ignitable liquids have similar chemical properties, their boiling point, polarity, and volatility vary and cover a large range of values [5,8]. After a fire, the traces of possibly present accelerants remaining at a fire scene will depend on several factors such as the amount and kind of ignitable liquid used, the time passed after fire, the nature of items it was poured on, and the fire strength [5,9].

In forensic fire investigations, the detection and identification of accelerants from fire debris is of primary concern [8,10,11]. Thus, due to the destructive nature of arson crimes, the fire investigators encounter a unique set of problems [5,7,8,12]. For example, the scene itself can include a large area and contain a huge amount of debris, all of which must be isolated and examined [13]. However, in case any accelerant has been detected, a suitable extraction and analysis of these traces will be a challenge for the laboratory fire expert [1,4,8].

To face this challenge, several extraction techniques have been developed to collect samples for proper analysis [4,5,14]. Solvent extraction is a traditional technique which needs the use of a suitable solvent, but it is a time-consuming procedure [3,14]. Head-space techniques are based on extraction and concentration of the volatile compounds from the vapor phase above the sample [5,14]. In passive (or static) techniques, the volatile constituents diffusing from the sample are collected on a suitable adsorbent such as charcoal, Tenax, or a solid-phase micro-extraction (SPME) fiber, whereas in dynamic head-space extraction the volatile fraction is forced to flow through the adsorbent material. In dynamic mode, the sensitivity is much better because higher amounts of the vapors can be collected on the adsorbent material [1,4,6,8,14,15].

Since it was developed in 1989, SPME has been utilized in a wide range of analytical applications, including investigations into arson crimes [12,14,16–18]. In 2002, the American Society of Testing and Materials (ASTM) published ASTM E 2154-15A Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration with SPME [19]. This procedure is generally preferred to other methods because it is solvent-free, rapid, low-cost and can be automated [5,8,16,19–22]. Moreover, unlike other sampling techniques, SPME allows transfer of all the adsorbed material into the chromatographic system, making this procedure suitable for detection of low traces [1,4,15]. The volatile analytes, emitted by solid or liquid samples can be collected directly on the SPME fiber [23]. The SPME device is made of a fused silica fiber coated with a thin layer of an appropriate polymeric sorbent [23,24]. The coated fiber is located inside a syringe needle, which can be directly inserted into the injection port of the chromatographic system [23]. Gas chromatography coupled with mass spectrometry (GC/MS) is a very powerful technique for qualitative and quantitative investigations of various complex mixtures of volatile compounds [1,4,5]. It has been widely used in many fields, among them arson analysis [5,9]. Several forensic investigations showed that ignitable liquid residues can be easily extracted from fire debris by using SPME and then analyzed by GC/MS [1,5,8,12,22,25]. As an example, the persistence of fuel residues on synthetic carpet samples with different thicknesses was investigated before and after burning [25].

The purpose of this work was to identify and determine the amount of kerosene residues remaining on different natural and synthetic textiles before and after combustion at different time periods using SPME for extraction and GC-MS for analysis. Furthermore, the obtained results could allow comparison of the persistence of volatile ignitable compounds on different investigated materials, and

optimization of the parameters for their proper sampling and identification.

2. Materials and Methods

2.1 Materials and chemicals

The selected substrate materials for the experiments were four kinds of textiles, both natural (cotton and wool) and synthetic (polyester and nylon). These samples were collected at a local textiles supply house (Riyadh, Saudi Arabia). Kerosene samples were purchased from local petrol stations in Riyadh, Saudi Arabia. For collection of the volatile fraction before and after burning, nylon arson evidence bags with 12 × 18 cm dimension were purchased from Tritech Forensics (Executive Park Blvd Southport NC, USA). The solid-phase microextration SPME device equipped with a fiber coated with 100 μm polydimethysiloxane (PDMS) was purchased from Supelco (Bellefonte, PA, USA). According to the provider instructions, the fiber was conditioned in a gas chromatography (GC) injector at 250 °C for 1 h before its use for the extraction of kerosene volatile residues.

2.2 Instrumentation

Gas chromatography analysis was performed using an Agilent 6890N gas chromatograph coupled with Agilent 5973 mass selective detector using the experimental conditions described in Table-1. The mass spectrometer was run in electron impact mode with an ionization energy of 70 eV, and the quadrupole mass analyzer was utilized at 230 °C ion source temperature.

2.3 Sample Preparation and Extraction

This study was divided into four stages as follows: the first stage consisted of investigation of kerosene composition as a reference sample. 60 μL of kerosene were poured into a 15 mL empty amber vial, then heated for 30 min at 50°C. An SPME fiber was inserted into the amber vial for 15 min to adsorb the volatile kerosene fraction and then transferred immediately to the GC-MS injector for 100 sec.

In the second stage, a set of textile pieces (polyester, nylon, cotton and wool) were prepared as reference samples in two ways: first without burning, and then by burning them using a lighter without adding kerosene, as blank samples. This step aimed to insure there is no interference between fire accelerant and substrate materials. Each sample was placed into an individual arson bag, and then heated for 30 min at 50°C. Extraction of the volatile fraction from each textile sample kept in the arson bag was then performed by inserting the SPME needle through the bag for 15 min to allow the analytes to be adsorbed. After that, the SPME syringe was transferred immediately to the GC–MS injection port for 100 sec. Between two injections, the SPME syringe was placed in the heated injector of the GC for about 20 min to ensure that it was free of any contamination.

In the third stage, the experiments were performed by pouring 2 mL of kerosene in a circular shape on each textile sample (polyester, nylon, cotton and wool). Indeed, a previously published paper showed that impregnation of a textile sample with 2 mL of fire accelerant was convenient for investigation of fire residues (25). Every sample was stored in a separate arson bag and the volatile fraction was collected using an SPME syringe at five different time periods (0.0, 0.5, 1, 2 and 4 h).

Finally, in the last stage, 2 mL of kerosene was poured on each textile sample, and left to saturate for one minute and then burned for about 45 seconds. in a fume hood with controlled ventilation. The fire was extinguished by covering the substrate material with a glass vessel. After a 2-min cooling time, partially burned samples were transferred to arson bags at five different periods of time (0.0, 0.5, 1, 2 and 4 h). As mentioned in stages two and three, the same procedure was repeated with each kind of textile under the same conditions. For each analysis, the experiment was carried out in triplicate, and the average values were estimated.

Table 1- *Experimental parameters.*

Parameter	Value
Injector temperature	250 °C
Injection mode	Splitless (split delay 1 min.)
Transfer line temperature	250 °C
Carrier gas	Helium, 1.0 mL/min
Column type	Agilent HP-5 MSI capillary column (30 m length, 0.25 mm i.d. and 0.25 μm film thickness)
Scan range	30–300 amu
SPME Fiber	100 μm polydimethylsiloxane (PDMS)
Textile substrate materials	Cotton, wool, polyester and nylon
Dimensions of substrate materials	Square-shaped pieces with approximately 10×10 cm size
Volume of kerosene	2 mL
Heating time before sampling substrate materials	30 min at 50 ºC
SPME sampling time	15 min, headspace
Sampling periods	0, 0.5, 1, 2 and 4 hours
Time of partial burning	45 seconds
SPME sampling time	15 min, headspace
Oven program	
Initial temperature	50 °C (held 5 min)
Ramp rate	20 °/min
Final temperature	300 °C (held 10 min)

3. Results and Discussion

3.1 Main constituents of kerosene

Table-2 shows the main constituents identified in kerosene as reference. It should be noted that kerosene includes a large number of volatile components which are eluted in 12 min. with a good separation. Among the 27 components reported in Table-2 with their retention times and formula, nine characteristic hydrocarbons were selected as distinctive chromatographic peaks: octane (C_8H_{18}), ethylbenzene (C_8H_{10}), nonane (C_9H_{20}), benzene 1-ethyl-3-methyl (C_9H_{12}), nonane 3-methyl (C_9H_{20}), decane ($C_{10}H_{22}$), undecane ($C_{11}H_{24}$), dodecane ($C_{12}H_{26}$), and tridecane ($C_{13}H_{28}$). These constituents can be considered to confirm the presence or absence of kerosene on a substrate. This result is consistent with the criteria recommended by ASTM- E 1618 standard for characterization of kerosene [26]. Table-3 summarizes the different classes of hydro-

carbons which were identified in kerosene, the major ones in this fuel being aromatic components (11 compounds) which correspond to the higher percentage, followed by linear paraffines (*n*=8), then by branched alkanes (*n*=6) and cycloalkanes compunds (*n*=2). Among the 11 aromatic hydrocarbons, 10 were alkyl substituted benzenes and 2-methyl naphthalene, while the linear alkanes ranged from heptane to tetradecane.

In order to detect any interference between the volatile fraction emitted by each sample of tissue and kerosene components, four textile pieces (nylon, polyester, wool and cotton) free from any ignitable liquid were sampled by SPME, with and without burning, then analyzed by GC-MS as blank samples. The obtained results showed that no organic compounds were detected in these experiments. Thus, no volatile hydrocarbons were emitted by the four textiles.

Jhaumeer-Laulloo et al. investigated the remaining fraction of fire accelerant on various burnt and unburnt ma-

Table 2 - *The main hydrocarbons identified in kerosene.*

N°	t_R (min)	Compound	Formula	Class of compounds*	%
1	2.350	Heptane	C_7H_{16}	1	0.16%
2	2.630	Methyl-cyclohexane	C_7H_{14}	3	0.33%
3	3.317	Heptane 3-methyl	C_8H_{18}	2	0.70%
4	3.849	Octane	C_8H_{18}	1	2.59%
5	4.399	Heptane 2,4-dimethyl	C_9H_{20}	2	0.20%
6	4.576	Heptane 2,6-dimethyl	C_9H_{20}	2	0.45%
7	5.274	Cyclohexane, 1,3,5-trimethyl-	C_9H_{18}	3	0.26%
8	5.560	Ethylbenzene	C_8H_{10}	4	1.64%
9	5.755	Benzene, 1,3-dimethyl-	C_8H_{10}	4	2.75%
10	6.436	Nonane	C_9H_{20}	1	5.65%
11	7.048	Octane, 2,6-dimethyl-	$C_{10}H_{22}$	2	3.75%
12	7.385	Benzene propyl	C_9H_{12}	4	3.14%
13	7.511	Benzene 1-ethyl-3-methyl	C_9H_{12}	4	10.12%
14	7.643	Nonane 3-methyl	C_9H_{20}	2	4.74%
15	7.780	Benzene, 1-ethyl-2-methyl	C_9H_{12}	4	4.46%
16	7.969	Benzene, 1,2,3-trimethyl	C_9H_{12}	4	7.83%
17	8.066	Decane	$C_{10}H_{22}$	1	13.95%
18	8.690	Benzene, 1-methyl-3-propyl	$C_{10}H_{14}$	4	6.69%
19	8.873	Benzene, 1-methyl-4-propyl	$C_{10}H_{14}$	4	7.64%
20	9.205	Undecane	$C_{11}H_{24}$	1	10.45%
21	9.428	Benzene, 1,2,4,5-tetramethyl-	$C_{10}H_{14}$	4	2.82%
22	9.657	(Benzene, 1-methyl-4-(1-methylpropyl	$C_{11}H_{16}$	4	3.32%
23	10.086	Dodecane	$C_{12}H_{26}$	1	4.11%
24	10.201	Undecane-2,6-dimethyl	$C_{13}H_{28}$	2	1.06%
25	10.864	Tridecane	$C_{13}H_{28}$	1	0.83%
26	11.082	Naphthalene 2-methyl	$C_{11}H_{10}$	4	0.24%
27	11.562	Tetradecane	$C_{14}H_{30}$	1	0.13%

Class of compounds; 1, linear alkanes; 2, branched alkanes; 3, cycloalkanes; 4, aromatics; 5, other*

Table 3- *Percentage of the main hydrocarbons identified in kerosene.*

Hydrocarbon classes	Number of hydrocarbons	Percentage (%)
Linear alkanes	8	29.63%
Branched alkanes	6	22.23%
Cycloalkanes	2	7.40%
Aromatics	11	40.74%
Total	**27**	**100%**

terials. They showed that some background hydrocarbons were emitted by the substrate and could interfere with the fuel constituents [27]. In the same study, they used various kinds of materials (cloth, paper, wood, leather, soil) and detected background compounds only in some substrates, while only toluene was found as a background compound in cloth and was not detected in kerosene. In the present study which was carried out on fabric samples, the preliminary investigations on the different kinds of textiles showed that no volatile hydrocarbons were emitted by the fabrics, with or without burning. Our results showed that all detected compounds corresponded to kerosene residues.

3.2 Evaporation rate of kerosene on textiles

Four kinds of textiles were investigated at different times (0, 0.5, 1, 2 and 4 hours) after pouring 2mL of kerosene on them. Sampling and analysis of these samples were done using an SPME syringe, followed by GC-MS analysis. The evaporation rate of kerosene impregnated in four textiles is shown on the charts in Figure-1. Among the 27 identified constituents in this stage, the most abundant are linear alkanes such as decane, undecane, dodecane and nonane. They are followed by monocyclic substituted aromatic hydrocarbons such as 1-ethyl-3-methylbenzene, 1-methyl-4-propylbenzene and 1-methyl-3-propylbenzene. It was also observed that most hydrocarbons were detected even 4 hours after impregnating textiles with kerosene. Comparison of the kerosene composition remaining in the four investigated textiles as a function of time shows

a similar distribution. In addition, the evaporation rate of light hydrocarbons is faster than that of heavy components which remain almost constant even after 4 hours, as shown in Figures-1A to 1D for peaks eluted after 9.2 min.

On the other hand, comparison of the four textiles fabrics shows some differences in their retention capacity towards kerosene constituents. As an example, the peak area of most remaining hydrocarbons in the synthetic fabrics (nylon and polyester) is higher than in natural materials (wool and cotton). This is clearly observed for the seven major peaks in kerosene which are decane, undecane, 1-ethyl-3-methylbenzene, 1,2,3-trimethylbenzene, 1-methyl-3-propylbenzene, 1-methyl-4-propylbenzene and dodecane. Figure 2 shows the evolution of the percentage of each hydrocarbon class in the different kinds of fabrics impregnated with 2 mL kerosene at successive times (0, 0.5, 1, 2 and 4 h.). The distribution of the kinds of hydrocarbons observed in this figure is consistent with the composition of kerosene given in Table-2. However, their variation as a function of time is notably different. Thus, the aromatic hydrocarbons which have the highest content at 0 h. decrease faster than the other classes in the four investigated textiles fabrics. Their percentage drops from approximately 48% to 20% in synthetic fabrics (nylon and polyester), and from 49% to 13% in natural textiles (wool and cotton). On the other hand, the linear paraffins which represent about 40% of total initial hydrocarbons at 0 h. have a remaining content of about 28% in synthetic textiles and 20% in natural fabrics. As a result, the content of linear alkanes becomes higher than benzenic compounds before 2 h. in synthetic materials, and before 1 h. in the case of natural textiles. In contrast, the evaporation rate of branched alkanes occurs at a similar rate in the four textile samples, with rate decreasing from about 11% at 0 h. to 3% at 4h. Regarding cycloalkanes which are present at low concentration at 0 h. (about 0.5%), they were not detected later.

3.3 Evaporation rate of kerosene on textiles after burning

In this stage, 2 mL of kerosene were added to each of the same four textile samples which were then partially

burnt for 45 seconds, in order to investigate the remaining fraction of ignitable liquid after 0, 0.5, 1, 2 and 4 h. The selected period of burning was set at 45 seconds because it corresponded to the combustion of about half of the tissue sample. The volatile fraction of each substrate was collected by SPME, and then analyzed by GC-MS. The charts included in Figure-3A to 3D show the remaining volatile components of kerosene in the four burnt textiles. Comparison of the peak area of the main hydrocarbons in this figure with that of the same peaks in Figure-1 shows that the ratio of each compound after burning is much lower than the same peak before burning. The charts included in Figure-3 show that the hydrocarbons present in kerosene can be divided into four categories, according to their evaporation rate after burning. Among the 27 hydrocarbons found in kerosene in the previous stages, only 22 were detected in this step. Most volatile constituents eluted before 5.7 min. were lost after the burning step; these evaporated compounds correspond to linear, branched and cyclic alkanes from C7 to C9 respectively. Also, the kerosene constituents eluted between 5.7 and 7.9 min. (before 1,2,3-trimethylbenzene) were mostly detected at 0 h., whereas they were present in trace amounts later. Meanwhile, the hydrocarbons heavier than C9 and eluted after 8 min. such as n-decane remained present in all samples until 4 hours with relatively high amounts. Among these constituents, it can be observed that the peaks eluted between 8.0 and 10.0 min. decreased gradually with sampling time, while the peak area of the heaviest hydrocarbons eluted after dodecane (tR=10.086 min.) remain almost unaffected by burning even after 4h. In contrast with results obtained in unburnt textile samples, the charts given in Figure-3 show that the evaporation rate of the different hydrocarbons is quite similar on the different kinds of tissues. The evolution of the different classes of hydrocarbons in the four kinds of textiles impregnated with kerosene after burning is shown in Figure-4 at different sampling times (0, 0.5, 1, 2 and 4 hours). When compared to the results given in Figure-2, the quantity of linear alkanes is higher than other classes in all investigated samples, from 0.0 to 4 hours); their total content decreased from 54% to about 8% for all textiles. The

benzenic hydrocarbons regularly decrease with the same rate, without intersection, from about 40% to 2%. In case of branched alkanes, their percentage decreased with time from roughly 7% to 1%. In contrast, the cycloalkanes were not detected in most samples, even at 0 hour.

3.4 Comparison of evaporation rate of kerosene on textiles before and after burning

Figure-5 shows the total peak area of all detected hydrocarbons in each investigated textile sampled at successive times (0, 0.5. 1, 2 and 4 h.) before and after burning. Obviously, the total amount of kerosene residue detected in any burnt sample is much lower than that found in the same textile sample without combustion. Comparison of the total peak area measured at 0 h. between burnt and unburnt textiles shows values in a ratio of about 9. This ratio increases with time, because the burning process causes a rapid loss of kerosene compounds. According to the charts shown in Figure-5, the approximate ratio values between unburnt and burnt fabrics are 9, 12, 14, 20 and 25 corresponding to the sampling times 0, 0.5, 1, 2 and 4 hours, respectively. As seen in Figures-1, 2 and Figure-5 that the total amount of kerosene constituents in the non-burnt samples is notably higher in synthetic fabrics than in natural fibers, while in the case of burnt samples (Figures-3 and 4) the remaining amount of kerosene is almost the same in the four fabrics.

Comparison of the total amount of kerosene hydrocarbons on four kinds of textiles without burning showed that it decreases with time depending on the fabrics. The synthetic textiles had a higher retention capacity than the natural fibers. The percent of remaining kerosene after 4 hours was approximately 52%, 49%, 37% and 36% for nylon, polyester, wool and cotton, respectively.

As shown in Figure-5, the total remaining kerosene compounds measured 4 hours after burning different fabrics were much lower than those obtained without burning. They corresponded to the following values: 11%, 10%, 9% and 7% for nylon, polyester, wool and cotton, respectively. This marked difference between natural and synthetic fabrics could be explained by their respective chemical composition and polarity. Nylon is based on aliphatic or semi-
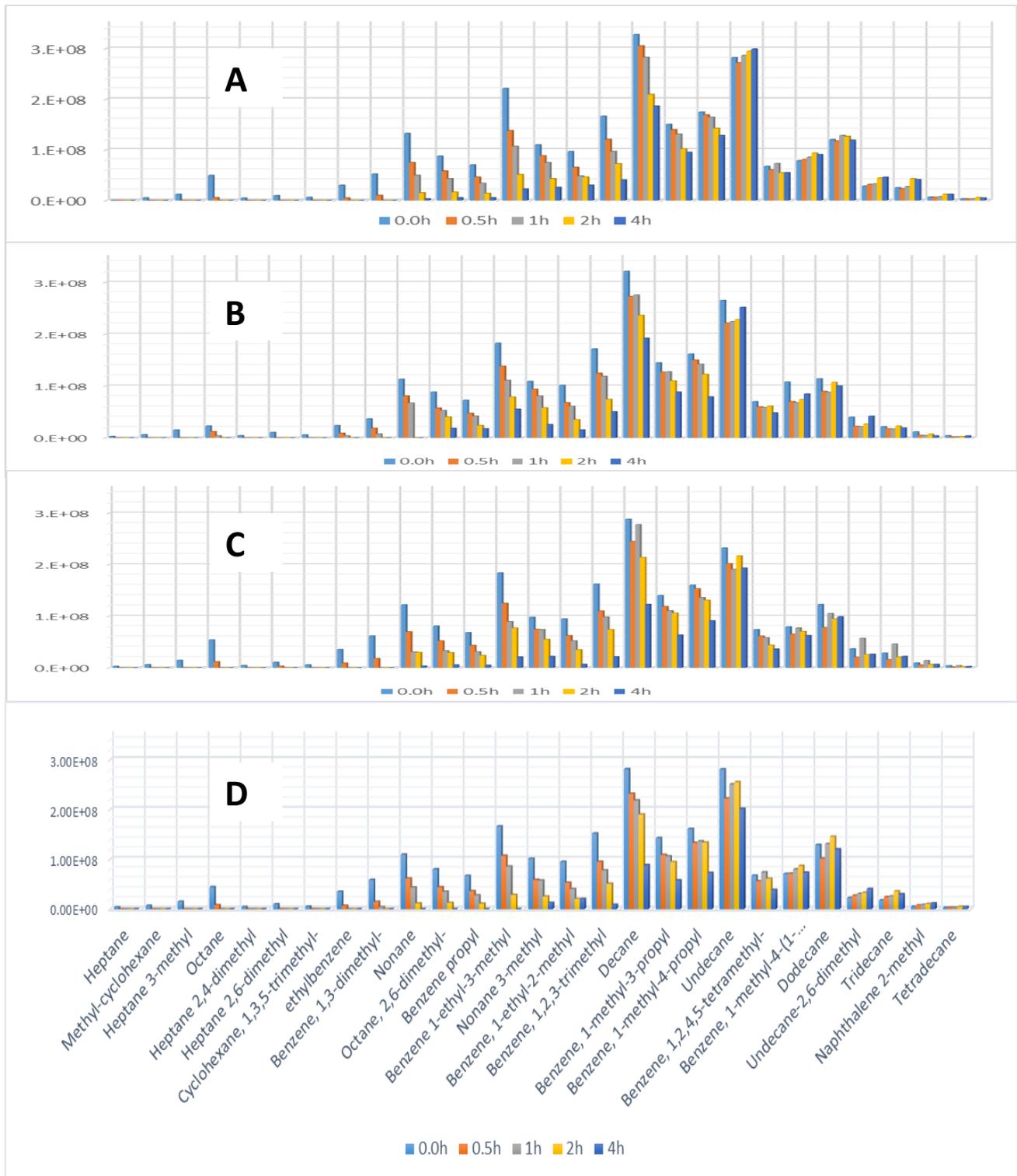
Figure 1- *Evaporation of kerosene components on textiles before burning at different times (A: nylon, B: polyester, C: wool, D: cotton).*
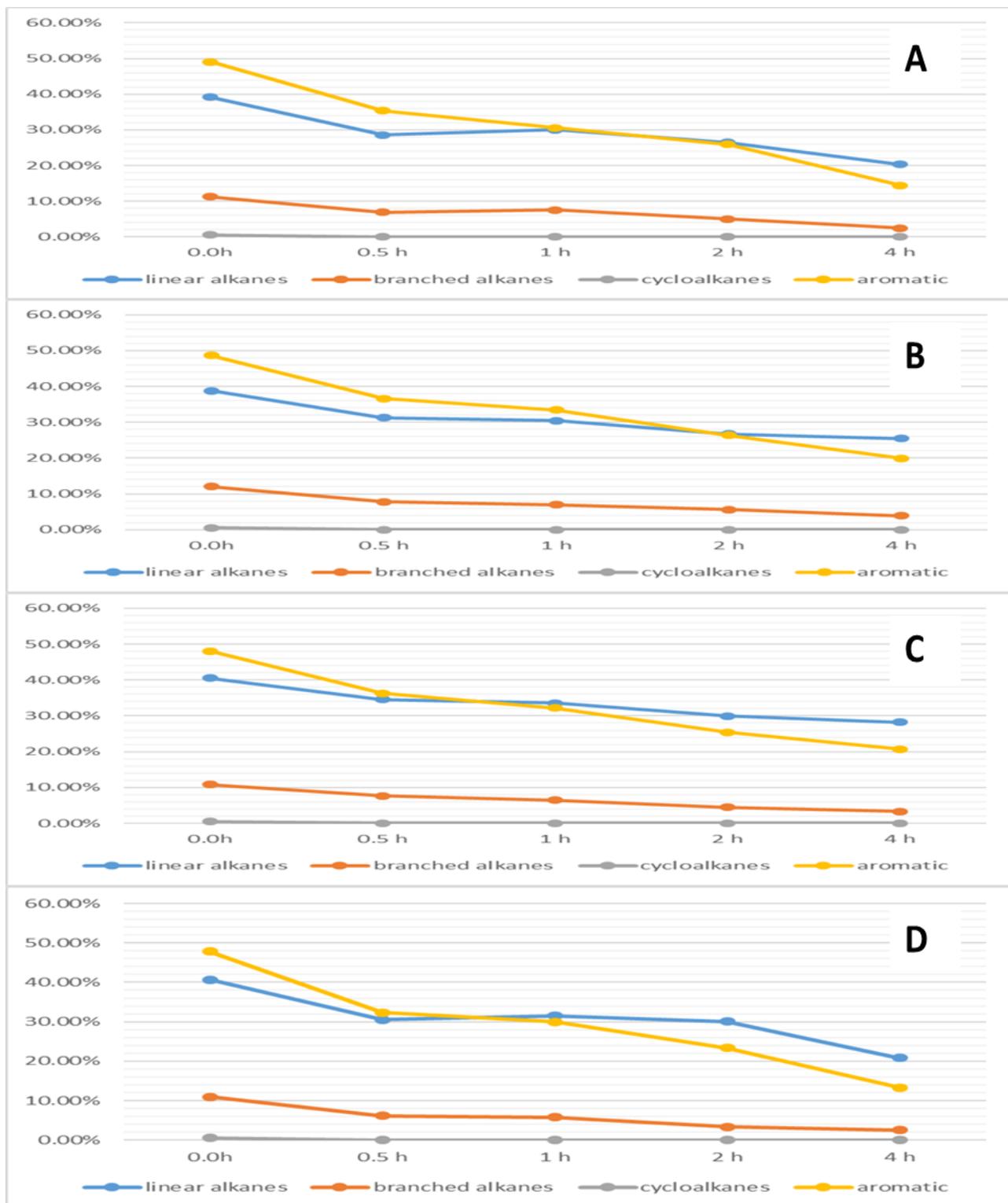
Figure 2- *Evaporation of hydrocarbon classes in kerosene components on textiles before burning at different times (A: nylon, B: polyester, C: wool, D: cotton).*
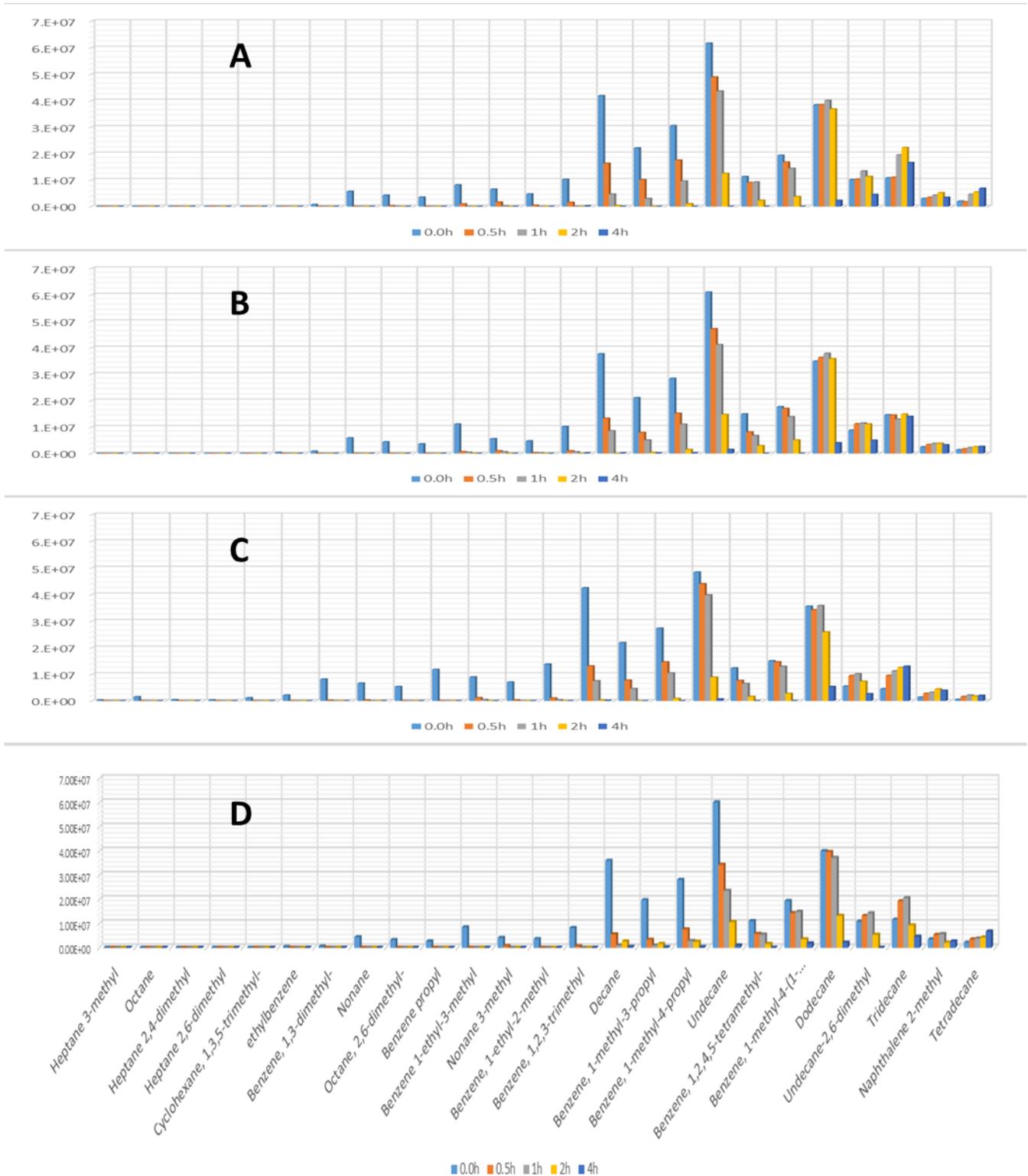
Figure 3- *Evaporation of kerosene components on textiles after burning at different times (A: nylon, B: polyester, C: wool, D: cotton).*
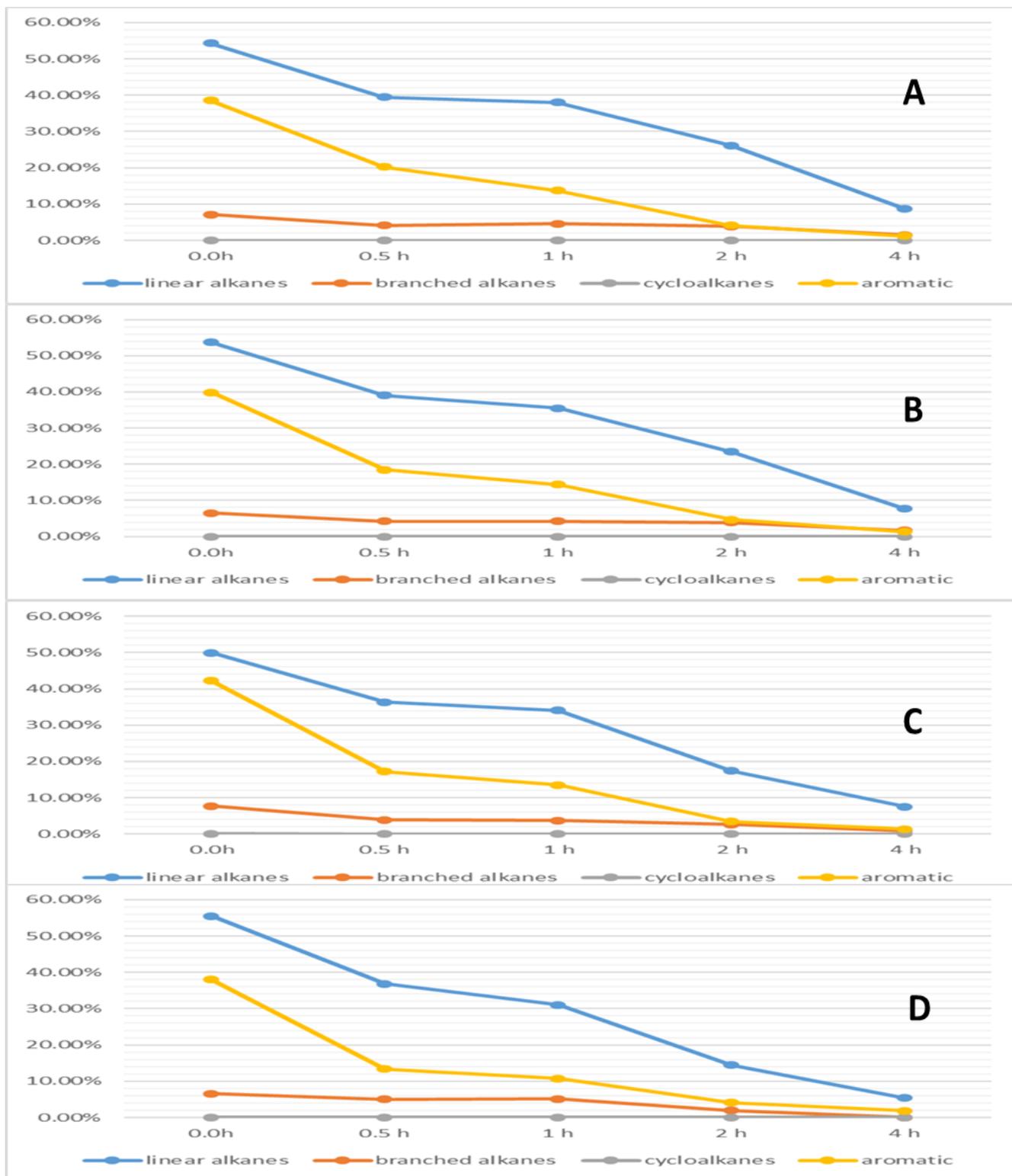
Figure 4- *Evaporation of hydrocarbon classes in kerosene components on textiles after burning at different times (A: nylon, B: polyester, C: wool, D: cotton).*
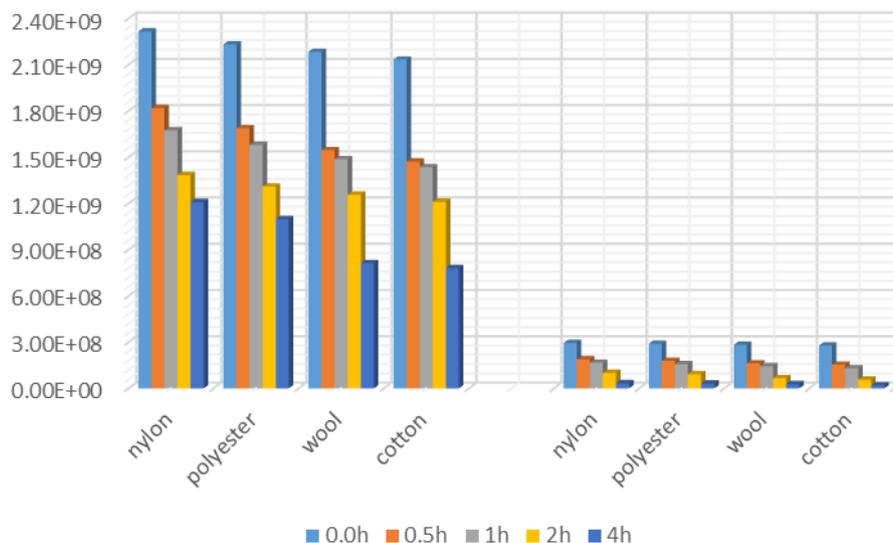
Figure 4- *Evaporation of total hydrocarbon content in kerosene components on textiles before (A) and after burning (B) at different times.*

aromatic polyamides while polyester textiles are generally made of poly-ethylene terephthalate fibers. These two synthetic materials involve some non-polar groups in their structure which make them more compatible with the non-polar hydrocarbons present in kerosene. On the other hand, cotton is made of cellulose fibers whereas wool consists of keratin which is a fibrous protein, both of them being highly polar materials. Thus, the different behavior of synthetic and natural textiles towards non-polar hydrocarbons could be mainly due to their relative polarity.

4. Conclusion

The present work aimed to investigate the rate of evaporation of kerosene impregnated on four kinds of textiles before and after burning at different times. In the analytical procedure, the samples were packed in arson bags and the volatile compounds were collected by SPME while their separation and identification were carried out by GC-MS. This procedure proved to be fast, convenient, sensitive and eco-friendly. Moreover, this technique can be easily used for forensic investigations. Of the twenty-seven main constituents characterized in kerosene, 11 were benzenic hydrocarbons, eight n-alkanes, six branched alkanes and two cycloalkanes. The evaporation rate of different hydrocarbons showed that the seven higher compounds have a

longer persistence on the four unburnt textiles, even after 4 hours (decane, undecane, 1-ethyl-3-methylbenzene, 1,2,3-trimethylbenzene, 1-methyl-3-propylbenzene, 1-methyl-4-propylbenzene and dodecane). These characteristic hydrocarbons can be used as specific indicators of kerosene. Moreover, the decrease of aromatic compounds which are predominant in kerosene is faster than other hydrocarbon classes in the four investigated textiles. Also, synthetic fabrics (nylon and polyester) had a higher retention capacity of kerosene than natural materials (wool and cotton). In case of burnt textiles samples impregnated with kerosene, the lightest hydrocarbons were not detected at all, while the peak area of heaviest compounds eluted after dodecane remained almost constant even after 4 h. In contrast with the unburnt samples, different classes of hydrocarbons showed a similar decrease, such that the linear alkanes remained higher over all the sampling period. The total amount of residual kerosene in any of the burnt textile samples was much lower than in the same non-burnt sample. On the other hand, the persistence of hydrocarbons on non-burnt synthetic fabrics was markedly higher than on natural materials; whereas the four kinds of textiles showed the same retention of kerosene after burning. The evaporation rate of kerosene on different textiles before and after burning showed that the remaining amount of linear al-

kanes was higher than other classes of hydrocarbons. This interesting result can be explained by the lower volatility of linear alkanes compared to both branched and unsaturated hydrocarbons with the same number of carbons. The higher retention capacity of nylon and polyester towards hydrocarbons compared to that of cotton and wool could be due to the lowest polarity of synthetic textiles which corresponds to a higher adsorption of hydrocarbons on their fibers. The present study showed that application of the SPME coupled with GC-MS is a powerful technique for analysis of ignitable residues on different kinds of textiles and should be helpful in the forensic field.

Acknowledgments

Conflict of Interest

Nill

Source of funding

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