Section A-Research paper

Application of GC-MS/MS in Profiling of Polycyclic Aromatic Hydrocarbons on Completely Burned Cloth Matrix for Source Identification in Fire Investigation

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Abstract. Fire burning cases are most challenging in the field of forensic investigationwhenit is important to prove the whether the incident of fire isdue to presence of any fire accelerant or not. Routine fire accelerant identification in forensic laboratory involves the extraction and analysis by GC-FID and its identification is based on comparison of obtained chromatogram with control chromatogram of petrol, diesel and kerosene. This routine method of analysis shows certain limitation when other than above mentioned fire accelerants involved in the incident. Polycyclic aromatic hydrocarbons (PAHs) ubiquitous in nature present in petroleum products in varying concentrations. They are used as a marker for chemical fingerprinting of crude oil, adulteration detection of kerosene in petrol and diesel, source liability determination in environmental contamination, and oil spill cases. The present study conducted to show how PAHs can be utilize in the identification of fire accelerant in forensic investigation. In present study cloth sample was burned with 15 different fire accelerants and extracted with Hexane:Acetone: Dichlromethane with ultrasonicator and 18 PAHs were quantified with GC-MS/MS to create chemical profile for all fire accelerant used in this study. It was found that all different 15fire accelerantsproduce different 18 PAHs profile qualitatively and quantitatively hence PAHs profiling could be used in forensic investigation in replacement of routine fire accelerant identification by pattern comparison method.

Keyword.Fire Investigation, Forensic Science, GC-MS/MS, Polycyclic aromatic Hydrocarbons, Ultrasonicator.

INTRODUCTION

Fire investigation in the field of forensic scienceis most challenging mainly where the lability is to prove the whether the fire is intentional or accidental. The crime related to fire investigation is arson i.e. deliberate malicious and wilful burning of someone's property with intention. [1,2] Arson caused huge financial damage to individual and to the society with loss of life and damage of property [3] Most common fire accelerants used are petrol, diesel and kerosene etc. however there are some other combustible materials also which are now a days also used as a fire accelerantsengine oil, lubricating oil, furnace oil etc. based on availability of accelerants fire accelerants are classified in two categories first one is house hold solvent and second one is industrial accelerants. House hold fire accelerants contain those solvents which are easily available at home such as nail paint remover, room air fresheners, deodorants, liquor and perfume which consist of volatile solvents such as ethanol, butanol and acetone. Even in COVID-19 pandemic use of sanitizer is increased whose main component is ethyl alcohol. Second class that is industrial based solvents are petroleum ether, butanol, furnace oil, kerosene, petrol, diesel this are also used to commit the crime. Routine fire accelerant identification

consists of extraction of fire debris with suitable solvent and then analysed it withGC-FID and wGC-MS. Pattern obtained after analysis is compared with pattern obtained after analysing control burned material with petrol, diesel and kerosene. Identification is based on the carbon chain distribution which is different in petrol (C5-C10), kerosene (C11-C18)and diesel (C18-C28). If other than these any petroleum product found i.e lubrication oil, furnace oil then identification is quite difficult because it consists of wide range of carbon chain which starts from C20 to C50. Hence routine fire accelerant identification based on pattern comparison is not advisable in cases wherein other than petrol, kerosene and diesel are used. Hence in present study polycyclic aromatic hydrocarbons is used in identification of possible fire accelerant whether it is household or industrial.

Recent studies focus on use of polycyclic aromatic hydrocarbons i.e., PAHs for source identification in oil spill cases in environmental forensics to prove the liability of contamination of any area due to industrial waste or any other activity. polycyclic aromatic hydrocarbons ubiquitous micropollutants [4,5] they consist of two to three rings hydrophobic organic aromatic compounds, lipophilic in nature. The 16 PAHs listed by United nations Environmental Protection Agencywhich consist of naphthalene,acenaphthene,acenaphthylene, fluorene, benz[*a*]anthracene, fluoranthene, anthracene, benzo[*ghi*]perylene, indeno[*1,2,3-cd*]pyrene, benzo[*k*]fluoranthene, chrysene, pyrene, benzo[*b*]fluoranthene, phenanthrene, dibenz[*a,h*]anthracene and benzo[*a*]pyrene[6-8] Petroleum products are one of the complex mixtures containing polycyclic aromatic hydrocarbons as one of group of compounds[9] Hence PAHs are used in petrogenic source determination however PAHs also produces after burning of any organic sources hence they are also useful in identification of pyrogenic sources.Mitra J (2018) [1] conducted study wherein author had studied described how nail paint remover, camphor and perfume produces different pattern of 16 PAHs content. However,author does not studytemperature factor. Hence in present study different 15 house hold and industrial solvent burned in two different conditions i.e. in partial and in complete burning condition to study 18 PAHs qualitatively and quantitatively.

MATERIAL AND METHODS

Sample Preparation

15 different fire accelerants were selected i.e., Sanitizer, Liquor, Nail paint remover, Petroleum Ether, Butanol, Toluene, Surgical Spirit, Kerosene, Petrol, Diesel, Thinner, turpentine, Liquid Paraffin, Lubricating oil and furnace oil. Each accelerant was poured on a cloth sample which was selected as a matrix for burning and it was burned completely. Once the samples were prepared stored in air tight glass gar and kept at room temperature till the extraction. Table no. 1 gives list of fire accelerants used with its coding in complete and partial burned condition.

Chemicals, Apparatus and Instruments

Chemicals- Hexane, Acetone and Dichloromethane (HPLC) grade were used.

Apparatus- Centrifuge Tube (FEP) 50 mL, Micropipette- 1 mL & 0.2 mL, Vials -2 mL, Round Bottom Flasks, Funnel, Whatman Filter paper, Measuring Cylinder

Instruments- Balance, Vortex, Rota Vapor, Ultrasonicator, Agilent technologies GC-MS/MS, 7890B Gas chromatography system, 7000C Mass spectrometer triple quad.

Extraction

Transfer 2 gm of sample in 50 mL centrifuge extraction tube.30 mL of mixture of Hexane:Acetone:DCM (1:1:1) was added then it wasultrasonicated at room temperature for 30 mins. 30mL of solvent filtered in round bottom flask using Whatman Filter paper. Solvent was evaporated on Rota vapor till 10 mL final aliquot left in the round bottom flask. 1 mL of aliquot collected in a GC vial and out of that 2 µL of aliquot injected in GC-MS-MS. For quantification 18 PAHs standard was used which consist of 18 PAHs listed in table no. 2. 18 PAHs Certified reference material of 2000 µg/mL diluted in benzene: dichloromethane (50:50) of 1 mL was purchased from SUPELCO Sigma Aldrich. Table 2, represent 18 PAHs list used for profiling.As per ICH guideline of method development and validation, for calibration curve 8 points calibration was used in which 8 solutions of different concentration of standard 18 PAHs were prepared i.e. 5 ng/mL, 10 ng/mL, 25 ng/mL, 50 ng/mL, 75 ng/mL, 100 ng/mL, 200 ng/mL and 500 ng/mL. Each prepared sample extract and standard were analysed with GC-MS/MS system. Agilent technologies 7890B GC system with 7000C GC/MS triple quad system was used which consist of HP-5ms or Equivalent, Length-30mtr. I.D.-0.25mm, Film thickness-0.25µm column. Temperature program set with oven temperature 80°C-2.4min-50ºC/min.-175ºC-0.0min-10ºC/min-250ºC-0.0 min-8ºC/min-285ºC-4.0 min-100ºC/min-300ºC-2.0 min.MMI-Front injector, with Temperature program-85ºC-0.02 min-600ºC/min-250ºC-0.0 min. Electron Ionization detector source was used with carrier flow of Helium set at 1mL/min and final run time of 30 min was calculated. Acceptance criteria for recovery study was found to be 80% to 120%. Limit of quantification calculated not less than 0.1 ng/mL.

TABLE 1- List of Fire accelerant used in the study

SR. NO.	ACCELERANT	COMPLETE BURNING
1	Sanitizer	CC-1
2	Liquor	CC-2
3	nail paint remover	CC-3
4	petroleum ether	CC-4
5	Butanol	CC-5
6	Toluene	CC-6
7	surgical spirit	CC-7
8	Kerosene	CC-8
9	Petrol	CC-9
10	Diesel	CC-10
11	Thinner	CC-11
12	Turpentine	CC-12
13	liquid paraffin	CC-13

14	lubricating oil	CC-14
15	furnace oil	CC-15

TABLE-2: list of 18 PAHs used for profiling

SR. NO.	STANDARD NAME	SR. NO.	STANDARD NAME
1	Acenaphthene	10	Dibenz[a,h]anthracene
2	Acenaphthylene	11	Fluoranthene
3	Anthracene	12	Fluorene
4	Benz[a]anthracene	13	Indeno[1,2,3-cd]pyrene
5	Benzo[b]fluoranthene	14	1-Methylnaphthalene
6	Benzo[k]fluoranthene	15	2-Methylnaphthalene
7	Benzo[ghi]perylene	16	Naphthalene
8	Benzo[a]pyrene	17	Phenanthrene
9	Chrysene	18	Pyrene

RESULT AND DISCUSSION

Figure 1 represent calibration curve for Naphthalene similar it was obtained for all other PAHs. Figure 2 represent GC-MS/MS chromatogram of completely burned cloth with Sanitizer similar it was also obtained for all other ignitable liquids and Table 3 represent PAHs profile for each ignitable liquids after burning.

FIGURE 1- Calibration curve for Naphthalene

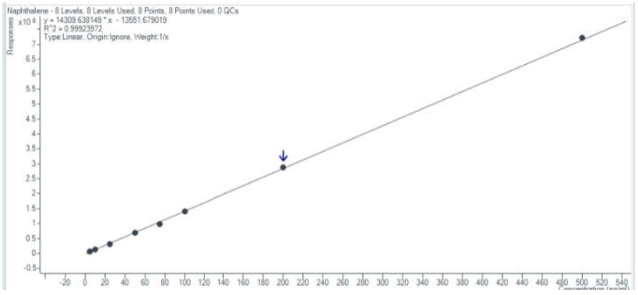

FIGURE 2- GC-MS/MS Chromatogram of completely burned cloth with Sanitizer

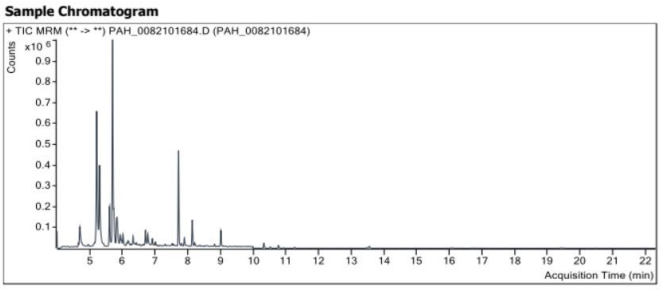

TABLE-3: PAHs profile for all 15 samples

18-PAHs	CC-1	CC-2	CC-3	CC-4	CC-5	CC-6	CC-7	CC-8	CC-9	CC-10	CC-11	CC-12	CC-13	CC-14	CC-15
Naphthalene	✓	✓	✓	✓	✓	✓	✓	-	✓	✓	✓	-	✓	✓	✓
2-Methylnaphthalene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1-Methyalnaphthalene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Acenaphthylene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Acenaphthene	-	-	-	-	-	-	-	-	-	✓	-	-	✓	-	✓
Fluorene	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Phenanthrene	-	✓	-	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Anthracene	-	✓	-	✓	✓	✓	-	✓	✓	✓	-	✓	✓	✓	✓
Fluoranthene	-	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pyrene	-	-	-	-	✓	✓	-	✓	-	✓	-	✓	✓	✓	✓
Benzo(a)anthracene	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Chrysene	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	✓
Benzo(b)fluoranthene	-	-	-	✓	✓	-	-	-	✓	-	-	-	✓	✓	✓
Benzo(k)fluoranthene	-	-	-	-	-	✓	-	-	-	✓	-	-	✓	✓	✓
Benzo(a)pyrene	-	-	-	-	-	✓	-	-	-	✓	-	-	✓	✓	✓
Dibenz(a,h)anthracene	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	✓	-	-	✓	-	✓

Sanitizer Sample

Now a days after COVID-19 pandemic sanitizer is most commonly used inflammable and disinfectant solvent found in household. When 18 parameters that is 18 PAHs were taken to analyse and quantified then it was found that 4 out of 18 PAHs were found in complete burning condition Naphthalene,2-Methylnaphthalene,1-Methyknaphthalene, Acenaphthylene quantified in complete burned sample as 0.021ng/mL, 0.109ng/mL, 0.058ng/mL and 0.044ng/mL. Sanitizer mainly consist of 70-80% ethanol with water used as a diluent. When sanitizer burns it produces invisible flame. Approximately 60% alcohol by volume is flammable and easily catches fire even with commonly used lighter. It tends to burn relatively cooler as compared to petroleum product with peak flame temperature between 500° and 1000°F. Ethanol has a flash point of approximately 55°F and a boiling point of 173°F. The peak temperatures 1 to 2 inches above the flame reached 1000°F.[10]

Country Made Liquor Sample

When 18 parameters that is 18 PAHs were taken to analyse and quantified then it was found that 9 out of 18 PAHs were found in complete burning condition Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene and Benzo(a)anthracenequantified in complete burned sample as 0.004 ng/mL, 0.0662 ng/mL, 0.0421 ng/mL, 0.141 ng/mL, 0.079 ng/mL, 0.166 ng/mL, 0.012 ng/mL, 0.099 ng/mL and 0.024 ng/mLrespectively. Country liquor also called Indian made Indian liquor, it is ethanol distilled from molasses, which is a by-product in sugar production. It consist of ethanol concentration approximately between 11-47% with addition of some flavouring agent [11] the United States Fire Administration has recorded that approximately 50% of university-fire fatalities nationwide involved people who were under the influence of alcohol or handling alcoholic beverages while incident happened. Liquor also consists of ethanol which is also considered as inflammable solvent. When any spilled alcohol comes in contact with fire it catches fire which is invisible in nature. Its peak temperature was found as similar to fire due to sanitizer. It was found that 44% reported fire cases involving the use of alcohol in Sweden.[12]

Nail Paint RemoverSample

When 18 parameters that is 18 PAHs were taken to analyse and quantified then it was found that 6 out of 18 PAHs were found in complete burning condition Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene and Benzo[a]anthracene quantified in complete burned sample as 0.111 ng/mL, 0.1302 ng/mL, 0.0831 ng/mL, 0.08 ng/mL, 0.031 ng/mL and 0.08 ng/mLrespectively.Mitra (2018) [1] analysed nail paint remover fire debris and reported presence ofAcenaphthylene, Fluorene and Benzo [k] Fluoranthene. In present study in similar PAHs also found along with other PAHs.

Petroleum Ether Sample

When 18 parameters that is 18 PAHs were taken to analyse and quantified then it was found that 14 out of 18 PAHs were found in complete burning condition Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene,

Anthracene, Fluoranthene, Benzo(b)fluoranthene and Dibenz(a,h)anthracene complete burned sample as 0.023ng/mL, 0.0672ng/mL, 0.0361ng/mL, 0.054ng/mL, 0.038ng/mL, 0.093ng/mL, 0.002ng/mL, 0.059ng/mL, 0.037ng/mL, 0.024ng/mL, and 0.589ng/mLrespectively. Petroleum ether is a colourless liquid having gasoline like smell with boiling point of 35^{o}C, and flash point -40^{o}C. its flammability limits in air lower 1.4 v% and upper is 8.3 v%.[13] it is used in pharmaceuticals for extraction and in rubber and dye industry. It is coming under class 1 solvent whose flash point in less than 100^{o} Cpetroleum ether.

Butanol

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 11 out of 18 PAHs found in partial burned condition.Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, and Benzo(b)fluoranthene quantified in complete burned sample as0.62ng/mL, 0.343ng/mL, 0.165ng/mL, 0.159ng/mL, 0.268ng/mL, 0.724ng/mL, 0.142ng/mL, 0.295ng/mL, 0.147ng/mL, 0.17ng/mL, and 0.22ng/mLrespectively. Butanol is colourless liquid having strong, sweet alcoholic odour, it is one of the flammable liquids above 29^{o}C, it forms explosive vapour/ air mixture. Flash point of butanol is 35^{o}C, it is slightly more flammable than kerosene and diesel and less flammable than other organic solvents. Vapours forms are heavier than air hence settles at bottom. Lower and upper explosive limit is 1.4% and 11.2% respectively. Its autoignition temperature is 650^{o} C, melting point is -129^{o} F. and vapour pressure is 15.51 mm Hg.

Toluene

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 13 out of 18 PAHs found in partial burned condition. Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Benzo(k)fluoranthene, Benzo(a)Pyrene and Indeno(1,2,3-cd)pyrenequantified in complete burned sample as 13.737ng/mL, 3.426ng/mL, 2.12ng/mL, 2.032ng/mL, 5.179ng/mL, 33.186ng/mL, 4.829ng/mL, 13.116ng/mL, 10.325ng/mL, 39.764ng/mL, 15.266ng/mL, 23.36ng/mL and 11.734ng/mL respectively. Toluene is produces from crude oil in oil refining process thus it is widely used in aviation and automotive fuel its autoignition temperature is 480^{0}C, boiling point- 110.6^{0}C, flash point- 4^{o}C.[14]different pattern obtained for toluene wherein in partial burning condition concentration of Acenaphthene and Anthracene is higher whereas concentration of rest of PAHs were higher in completely burned condition is due to time required to completely ceased the burning and temperature associated same produces the PAHs profile.

Surgical Spirit

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 5 out of 18 PAHs found in partial burned condition. Naphthalene,2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene and Fluoranthene quantified in complete burned sample as4.69ng/mL, 0.245ng/mL, 0.138ng/mL, 0.142ng/mL and 0.006ng/mLrespectively. Fire due in surgical preparation are more common in US upto 650 fires reported annually with death report 5%. In hospitals surgical preparations like surgical spirit act as a spirit whereas anaesthetic oxygen provides oxygen source and diathermy, lasers, cutting

instruments, laparoscopic lights act as an ignition source that cause fire. [15] main component of surgical spirit is ethanol which is flammable in nature and catches fire immediately due to its flash point.

Kerosene

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 9 out of 18 PAHs found in completelyburned condition. 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene,Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, and Benzo(a)anthracene, quantified in completely burned condition as 0.088ng/mL, 0.051ng/mL, 0.047ng/mL, 0.035ng/mL, 0.12ng/mL, 0.039ng/mL, 0.134 ng/mL, 0.05ng/mL, and 0.123ng/mL respectively. Chukwujindu M. A. Iwegbue (2011) conducted study on kerosene stove cook combustion and reported presence of Naphthalene, 2-Methylnaphthalene, Acenaphthylene, Fluorene and Phenanthrene. Similar PAHs also found in present study with addition presence of chrysene, Benzo[a]anthracene, Benzo[b]fluoranthene and Benzo[k]fluoranthene this due to the temperature flame and time of burning at the time of burning. [16]

Petrol

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 10 out of 18 PAHs found in completely burned condition. Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Benzo(a)anthracene, and Benzo(b)fluoranthene quantified in completely burned sample as 0.147ng/mL, 0.090ng/mL, 0.0491ng/mL, 0.065ng/mL, 0.107ng/mL, 0.303ng/mL, 0.022 ng/mL, 0.135ng/mL, 0.106ng/mL and 0.041ng/mLrespectively.Ana L´ucia C. Lima et.al (2005) conducted study on combustion derived petrol exhaust and reported presence on Naphthalene, chrysene, fluoranthene, pyrene, Benzo[a]anthracene, Benzo[k]fluoranthene, Benzo[a]pyrene, Benzo [g,h,i] Perylene, Indeno [1,2,3-Cd] Pyrene similar PAHs profile observed in present study. [17]

Diesel

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found 15 out of 18 out of 18 PAHs found in complete burned condition. Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(k)fluoranthene, Benzo(a)Pyrene and Benzo(g,h,i)Perylenequantified in completely burned sample as 0.259ng/mL, 1.918ng/mL, 1.845ng/mL, 0.806ng/mL, 0.157ng/mL, 1.856ng/mL, 3.545ng/mL, 0.578ng/mL, 0.669ng/mL, 2.468ng/mL, 0.503ng/mL, 0.293ng/mL, 0.138ng/mL, 0.019ng/mL and 0.027ng/mLrespectively. Souza and Corrêa (2016) conducted study on profiling of PAHs in diesel and diesel exhaust particulate matter and gas phase. Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Pyrene, and fluoranthenereported in diesel fuel however Fluorene, Phenanthrene, Fluoranthene, and Pyrene reported in diesel combustion particulate matter and they were found in reduce concentration in diesel exhaust as compared to diesel sample[18]

Thinner

When 16 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 8 out of 18 PAHs found in completely burned condition. Naphthalene,2-

Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene, Fluoranthene, and Benzo(a)anthracene quantified in completely burned sample as 0.306ng/mL, 0.150ng/mL, 0.058ng/mL, 0.044ng/mL, 0.011ng/mL, 0.015ng/mL, 0.058ng/mL and 0.032ng/mL respectively.Thinner is used as solvent in paint, it is a mixture of Toluene, Acetone, Hexane, Methanol, Benzene, 2-propanol etc. [19] it falls under class II of flammability classification having flash point >= 101.00^{o}F, with autoignition point 446.00^{o}F, boiling point ranged 298-400^{o}F and vapour density 4.7. it easily evaporated and vapours may travel long distances to other areas. [20]

Turpentine

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 9out of 18 PAHs found in completelyburned condition. 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, and Benzo(a)anthracene quantified in partially burned sample as 0.105ng/mL, 0.044ng/mL, 0.037ng/mL, 0.024ng/mL, 0.011ng/mL, 0.005ng/mL, 0.105ng/mL, 0.166ng/mL and 0.056ng/mL respectively. It is obtained from distillation of resins from pine tree. It is natural product falls under class 3 flammability classification, flash point- 97.00^{o}C boiling point 155-185^{o}C. Zou et.al. 2001 conducted study where in reported Fluoranthene, Phenanthrene, Anthracene, Pyrene, Benzo[a]anthracene, Chrysene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene, Indeno [1,2,3-Cd] Pyrene, Dibenz [a,h] Anthracene and Benzo [g,h,i] Perylene in pine wood combustion [21] however turpentine is also biproduct of pine oil similar were obtained in present study.

Liquid Paraffin

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 15 out of 18 PAHs found in the completely burned condition. Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)Pyrene and Benzo(g,h,i)perylenequantified in complete burned condition as 0.274ng/mL, 0.411ng/mL, 0.330ng/mL, 0.261ng/mL, 0.047ng/mL, 0.173ng/mL, 0.448ng/mL, 0.091ng/mL, 0.381ng/mL, 0.413ng/mL, 0.2ng/mL, 0.107ng/mL, 0.034ng/mL, 0.052ng/mL and 0.025ng/mL respectively. Liquid paraffin is refined distillation fraction of petroleum used in pharmaceutical and cosmetic industry. It is viscous colourless liquid, flash point >112^{o}C, boiling point -60-9^{o}C with autoignition temperature >165^{o}C.Monarca (1980) reported Anthracene, Pyrene, Fluoranthene, Benzo[a]anthracene, Benzo[k]fluoranthene, Benzo[b]fluoranthene, Benzo[a]pyreneBenzo [g,h,i] Perylene, Dibenz [a,h] Anthracene and Indeno [1,2,3-Cd] Pyrene in liquid paraffin [22]

Lubricating oil

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 13 out of 18 PAHs found in completely burned condition. Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, and Benzo(a)pyrenequantified in completely burned sample as0.121ng/mL, 0.131ng/mL, 0.104ng/mL, 0.165ng/mL, 0.082ng/mL, 0.091ng/mL, 0.071ng/mL,

0.196ng/mL, 0.117ng/mL, 0.113ng/mL, 0.09ng/mL, 0.031ng/mL and 0.028ng/mLrespectively. Wang et.al. (1980) conducted study on lubricating oil exhaust obtained by deriving gasoline engine vehicle at different distances and lubricating oil combustion pattern of PAHs were obtained and reported Naphthalene, Fluorene, Phenanthrene, Chrysene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Dibenzo[a,h]anthracne, Benzo[ghi]perylene and Indeno [1,2,3-cd]pyrene.[23]

Furnace Oil

When 18 parameters that is 18 PAHs were considered for analysis and quantification then it was found that 17 out of 18 PAHs found in completely burned condition. Naphthalene, 2-Methylnaphthalene, 1-Methylnaphthalene, Acenaphthylene, Acenaphthene Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenz(a,h)anthracene, Indeno(1,2,3-c,d)Pyrene and Benzo(g,h,i)Perylenequantified in completely burned sample as11.016ng/mL, 30.147ng/mL, 21.307ng/mL, 1.097ng/mL, 1.551ng/mL, 3.594ng/mL, 8.646ng/mL, 1.305ng/mL, 0.921ng/mL, 5.411ng/mL, 4.144ng/mL, 11.651ng/mL, 2.287ng/mL, 1.265ng/mL, 2.983ng/mL, 0.714ng/mL and 0.773ng/mLrespectively.

CONCLUSION

Based on above study it was found that chemical solvents such as ethanol, butanol, acetone does not consist of PAHs in its initial level however after burning PAHs produces which are varying in concentration hence helpful in source identification however solvent which are produce from petroleum products itself consist of PAHs in varying concentration, after burning PAHs pattern produces for each petroleum derived solvent shows decrease in their concentration but PAHs are still detected in those solvents hence PAHs profiling also helpful in source identification in industrial petroleum solvents. From forensic point of view partially burned samples more relevant than completely burned samples because as chances of identification of exact source is higher in partially burned sample as compared to completely burned samples. Second fire extinguishing process such as application of water to ceased fire burning does not affect source identification in partial burned condition. Hence based on above study it was concluded that polycyclic aromatic hydrocarbon profiling could be used in forensic investigation in replacement of routine fire accelerant identification by pattern comparison method. Advance research needs to be done to study the effect of other factors on PAHs profiling in source identification.

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