ABSTRAKS

Bahan penggalak kebakaran berasaskan petroleum biasanya berkait rapat dengan pembakaran yang disengajakan. Dalam kebanyakan kes pembakaran yang disengajakan, bahan penggalak kebakaran berasaskan petroleum seperti petrol, minyak tanah dan diesel digunakan untuk meningkatkan tahap keamatan api. Namun, bahan penggalak kebakaran seperti pelarut cat dan terpentin tidak boleh diabaikan kerana bahan ini mudah diperolehi. Bahan penggalak kebakaran berasaskan petroleum terdiri daripada beratus-ratus sebatian yang membuatkannya sukar untuk dikenalpasti. Selain itu, sifat kompleks bahan penggalak kebakaran berasaskan petroleum menyukarkan penyelidik pembakaran untuk menentukan asal dan punca kebakaran. Oleh kerana itu, pengenalan yang tepat jenis bahan penggalak kebakaran berasaskan petroleum adalah sangat penting untuk penyelidikan pembakaran. Penggunaan kromatografi gas/spektrometer jisim (GC/MS) dan teknik kimometrik untuk mengenalpasti jenis bahan pengalak kebakaran berasaskan petroleum diselidik dalam kajian ini. Penyedian sampel sisa kebakaran dilakukan dengan menggunakan teknik penjerapan ruang kepala dinamik dan dianalisis menggunakan GC-FID dan GC-MS. Bahan penggalak kebakaran berasaskan petroleum yang digunakan dalam kajian ini adalah petrol, diesel, minyak tanah, terpentin dan pelarut cat. Pendekatan kimometrik digunakan kepada data yang diperoleh daripada GC/MS untuk pengkelasan berdasarkan jenis masing-masing. Analisis komponen utama (PCA), analisis gugusan dan SIMCA digunakan untuk menentukan keberkesanan dalam pembentukan kumpulan berdasarkan jenis. Ini dilakukan kepada data kromatografi ion dan luas puncak yang diperoleh daripada GC-MS. Kajian ini telah menunjukkan bahawa kaedah penyediaan sampel sisa kebakaran secara teknik penjerapan ruang kepala dinamik dapat dilakukan dengan berkesan. Disamping itu, PCA dan analisis gugusan berjaya mengelaskan bahan pengalak kebakaran dalam jenis kumpulan masing-masing berbanding dengan analisis SIMCA.

ABSTRACT

Petroleum-based accelerants are commonly associated with arson-related fire. In most arson cases, accelerants such gasoline, kerosene and diesel used to increase the rate and intensity of fire. However, other petroleum based accelerants such as turpentine and thinner cannot be ignored because of their easy availability. These accelerants composed of hundreds of compounds that can make identification of fire debris very difficult. Furthermore, the complex nature of petroleum based accelerants pose a problem for the arson investigator to determine the origin of the fire and the cause of the fire. Therefore, correct identification of accelerants is crucial to arson investigation. The application of gas chromatography/mass spectrometry (GC/MS) and chemometric techniques for petroleum-based accelerant identification is presented in this study. Extraction of accelerant was done by using dynamic adsorption-elution headspace technique and analyzed using GC-FID and GC-MS. The petroleum based accelerants used in this study were gasoline, diesel, kerosene, turpentine and thinner. Chemometric approaches were employed to simplify data obtained by allowing them for more accurate classification to their respective groups. Principal component analysis (PCA), cluster analysis and soft independent modeling class analog analysis (SIMCA) were explored for their effectiveness in establishing accelerant groupings. This was done on normalized data of total ion chromatogram and peak areas which were obtained from GC-MS. The extraction of fire debris using the dynamic adsorption/elution technique was successful in isolating the accelerants compounds from the samples. Beside that, PCA and cluster analysis were successfully classify the accelerants according to their respective groups compared to SIMCA analysis.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Arson can be defined as the crime of deliberately setting fire to structures or wild land areas. Fires are set to the property of other person or to their own property for an improper purpose. The motives for arson cases fall within the six categories: vandalism, excitement, revenge, crime concealment, profit, and extremist (Chandler, 2009). Arson fire may also lead to the direct cost of buildings and furnishing lost. Other than that, a direct impact in community is the potential for injury or loss of life as the result of an arson fire.

1.2 Background of the Problem

Arsons are difficult crime to investigate and prosecute. It is because every fire scene need to be treated as a potential arson scene (from the standpoint of security, preservation, and evidence) until clear proof of natural and accidental cause is discovered. Furthermore, the crime itself, if it is successful, destroys the physical evidence at its origin (Almirall and Furton, 2004). In some cases, the evidence is still there but it requires careful and methodical analysis. Arson is a crime that destroys evidence rather than creates one as it progresses and normally there is not much eyewitness evidence. Moreover, the incendiary origin of the fire is often difficult to prove.

The purposes of arson investigation are to determine the cause and origin of fire and also the identification of fire accelerants that have been used. Chemical analysis of fire debris is the most essential step which involves extraction, isolation and identification of residual accelerants in fire debris (Cavanagh *et al.*, 2002).

The interpretation of the chromatographic profiles which are the detection and identification of the accelerants components from the fire debris become more challenging part. It is because fire accelerants composed of hundreds of compounds that makes the identification of fire accelerants becomes difficult. Serious misinterpretation could be made if it is based only on the visual comparison of the chromatogram with those from the standard accelerants.

1.3 Statement of Problem

Arson represents a serious problem both in the cost of lives and money. It also continues to be an urgent national problem and truly a contemporary crime. According to The Star newspaper published on 22th April 2008, the estimated annual cost of fire related damages are as high as RM865.29mil in 2007. Moreover, 80 deaths were recorded while 67 people were injured.

In most cases involving arson, petroleum based accelerants such gasoline, kerosene and diesel used to increase the rate and intensity of fire. However, other petroleum based accelerants such as turpentine and thinner cannot be ignored. This is due to its low cost, easy availability and effective in aiding fire (Dehaan, 2007).

Fire debris analysis is the science related to the examination of fire debris samples which performed to detect and identify fire accelerants (ignitable liquid residues). When fire debris samples suspected to contain traces of ignitable liquid, these samples are collected from the arson scene. They are forwarded to the crime scene laboratory along with the request to identify the presence of any possible fire accelerants (Stauffer *et al.* 2008).

The purposes of fire investigation and fire debris analysis are to determine the origin of the fire and the cause of the fire. However, the complex nature of petroleum based fire accelerants pose a problem for the arson investigator to determine the origin of the fire and the cause of the fire. Many accelerants composed of hundreds of compounds that can make identification of fire debris very difficult. Furthermore, the interpretation of the complex data obtained from arson suspected fire required the experience of a trained analyst. Hence, a powerful tool such as chemometric method is required in interpreting these complex data to classify and identify fire accelerants present in arson crime scene.

1.4 Objectives of the Study

The objectives of this study are as follows:-

i. To extract fire accelerants in fire debris using adsorption/elution headspace method
ii. To analyze fire debris extraction using GC-FID and GC-MS
iii. To classify and identify the fire accelerants using chemometric approaches

1.5 Scope of Study

This study was conducted to identify the target compounds and classify petroleum based accelerants from fire debris. Accelerants such as gasoline, diesel, kerosene, turpentine and thinner were used in this study. The sample matrix used consisted of blue polypropylene types of floor mat. Chemical analysis of the fire debris involved dynamic headspace adsorption using activated charcoal, and elution using carbon disulphide. GC-FID followed by GC-MS analyses were carried out in order to identify the target compounds of fire accelerants present in fire debris. The data obtained from total ion chromatogram and area of selected peaks were used to classify the fire accelerants with the aid of chemometric techniques. The chemometric techniques employed in this study are principal component analysis (PCA), cluster analysis and soft independent modeling class analog (SIMCA).

1.6 Significant of Study

Fire accelerants are complex materials consisting of hundreds of components. This makes their recovery and identification quite difficult. The identification of fire accelerants become more difficult by the contamination result from the pyrolysis of common household item such as plastics, carpet and carpet padding at the fire scene (Bodle *et al.*, 2007; Tan *et al.*, 2000).

Gas chromatography / mass spectrometry (GC/MS) analysis of fire debris has been used to identify residues of fire accelerants. Identification of fire accelerants using GC/MS depends on two main types of pattern matching methods (Keto, 1995; Keto *et al*., 1991). One approach makes use of extracted ion profile matching. With this method, intensity profiles for characteristic ions of fire debris samples are visually compared with the profile of known standard.

Another method depends on target component analysis. A target compound chromatogram (TCC) is developed using the retention time and relative amount for each target compound. Visual pattern recognition is employed to confirm the fit to TCCs of known accelerant. This is done for the identification of an unknown accelerant.

Both these methods require visual inspection for the identification of complex samples of fire accelerant. This process is time consuming and may lead to misclassification. These difficulties can be overcome by using chemometrics techniques.

Chemometric techniques offer powerful tools in interpreting complex data. Principal Component Analysis (PCA) is a significant technique used for dealing with complex data interpretation (Bodle, 2007). PCA and cluster analysis have been successfully applied to interpret complex data in a number of studies such as design and characterization of chromatographic systems, sensor, environmental chemistry, food and other industrial applications.

Hence, the application of PCA, cluster analysis and soft independent modeling class analog (SIMCA) analysis in this study can successfully classify and identify the fire accelerants. Moreover, the results of this study will be particularly useful to the forensic chemists from Jabatan Kimia Malaysia, Jabatan Bomba Malaysia or consultants from the private sector who handles arson cases. It is hoped that this study may assists the analyst in their investigation by helping them to identify and classify the fire accelerants more accurately.

1.7 Hypothesis

It is expected that dynamic adsorption/elution headspace technique can be used as an effective sampling method for accelerants used in arson cases. Beside that, chemometric methods used, PCA, cluster analysis and soft independent modeling class analog (SIMCA) analysis can successfully classify petroleum based accelerants into their respective group.