DETERMINATION OF INORGANIC ANIONS IN CHEMICAL IGNITION MOLOTOV COCKTAIL USING ION CHROMATOGRAPHY

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To my beloved mother and father, family, friends and myself.

To my supervisors for their advices, supports and encouragements.

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ABSTRACT

The Chemical Ignition Molotov Cocktail (CIMC) is one of the improvised incendiary devices (IIDs) that have been used recently in acts of terrorism. It is in the interest of the Police and Fire Department to gather information on the compositions and types of device employed by the determining the inorganic ions present in CIMCs residues, namely sulphate (SO_4^{2-}), chlorate (ClO_3^-), perchlorate (ClO_4^-), and chloride (Cl^-). In simulated ground experiments, these improvised CIMCs using petrol, kerosene and diesel as accelerants were thrown against a brick wall which initiated the fire as a consequence of the exothermic reaction produced by the combination of the concentrated sulfuric acid and potassium chlorate. Ion Chromatography (IC) was employed to determine the ionic composition of the CIMCs residues in order to identify the chemical reagents used for the device. The targeted anions were separated within 56 minutes using $NaHCO_3$-Na_2CO_3 as the eluent. In this study, results from samples of CIMCs showed that sulfate, chlorate, and chloride were detected in most samples. However, perchlorate could not be detected since not all potassium chlorate reacted with sulfuric acid when the bottle broke. Concentration of sulfate ion was higher than the other anions. It was also noted that petrol gave the most powerful explosion on the CIMCs devices as compared to kerosene and diesel. Combustible material such as sugar was also found to give more destructive power on these devices as reflected by the more powerful combustion.

ABSTRAK

Bom petrol pencucuhan kimia (CIMCs) adalah salah satu daripada peranti pembakar yang diubahsuai (IIDs) dan telah digunakan dalam tindakan pengganas kebelakangan ini. Ia adalah satu keperluan bagi Jabatan polis untuk mengumpul maklumat tentang komposisi dan jenis peranti yang digunakan bagi menentukan ion-ion tak organik yang hadir dalam sisa-sisa CIMCs iaitu sulfat (SO_4^{2-}), klorat (ClO_3^-), perklorat (ClO_4^-), dan klorida (Cl^-). Bagi eksperimen simulasi, CIMCs yang menggunakan petrol, diesel dan minyak tanah sebagai bahan pembakar dilontarkan ke dinding batu-bata seterusnya menghasilkan nyalaan api akibat daripada tindak balas eksotermik yang dihasilkan oleh gabungan asid sulfurik pekat dan kalium klorat. Ion kromatografi (IC) digunakan untuk menentukan komposisi ionik sisa-sisa CIMCs untuk mengenalpasti reagen kimia yang digunakan dalam peranti tersebut. Anion yang terpilih telah dipisahkan dalam masa 53 minit menggunakan $NaHCO_3$-Na_2CO_3 sebagai eluen. Dalam kajian ini, hasil daripada sampel CIMC menunjukkan sulfat, klorat dan klorida dikesan dalam kebanyakan sampel. Walau bagaimanapun, perklorat tidak dapat dikesan kerana tidak semua klorat kalium bertindak balas dengan asid sulfurik apabila botol itu pecah. Kepekatan ion sulfat adalah lebih tinggi daripada anion lain. Ia juga menyatakan bahawa petrol memberikan letupan paling kuat pada peranti CIMCs berbanding dengan minyak tanah dan diesel. Bahan mudah terbakar seperti gula juga didapati memberi kuasa yang lebih membinasakan dalam peranti ini berdasarkan oleh pembakaran yang lebih berkuasa.

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LIST OF ABBREVIATIONS

DDW	-	Distilled deionised water
CE	-	Capillary Electrophoresis
CIMCs	-	Chemical Ignition Molotov Cocktails
FRDM	-	Fire and Rescue Department of Malaysia
IC	-	Ion chromatography
IED	-	Improvised explosive devices
IID	-	Improvised incendiary devices
ND	-	Not detected
RMP	-	Royal Malaysia Police
RSD	-	Relative standard deviation
SD	-	Standard deviation

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Improvised incendiary devices (IIDs) are weapons which designed to start fires or destroy properties using fire. The devices have become the popular device used and become a current trend as an act of vengeance. There are a quite number of cases where IIDs are used as weapon in acts of violent, riot and others. These kinds of devices have the potential to create a devastating impact resulting in severe fatalities (Martin-Albera *et al.*, 2012).

One example of an IID is a Molotov cocktail which has been used recently. It is also known as petrol bomb. They are very simple and easy to be constructed, inexpensive and common weapon to use. It is used by arsonist with its primary purpose to set off fire (Ahmad *et al.*, 2011). Molotov cocktail is another incendiary device where mechanical explosions occurs when the bottle with a burning wick is thrown and upon impact, the bottle will break and allows the accelerant to spread and splatter (Bordie, 1973).

These days the petrol bomb has been improved by using chemical reagents to initiate the ignition of the flammable liquid. These devices are called the Chemical Ignition Molotov Cocktail (CIMCs) which are also known as chemical fire bottles.

Cases involving arson have highlighted the interest of forensic scientists in the characterization of the composition of the incendiary devices. For inorganic

explosive devices, it is possible to assume the original devices composition from the inorganic found from the residue (Martin-Albera *et al.*, 2012). However, this has never been reported before with incendiary devices (Martin-Albera *et al.*, 2012). The determination of inorganic ions from the evidence has the potential for revealing the type of weapon and/or its ignition system.

The inorganic ions that are normally analyzed are sulphate, confirming the presence of sulfuric acid, chlorate, as a marker on the employment of potassium chlorate and chloride, which could be produced from the chemical reduction of chlorate salts and is also sometimes employs as a marker (Martin-Albera *et al.*, 2012).

In order to analyze the evidence and acquire some information from it, the forensic scientists need to use several techniques for its identification. In this study, ion chromatography will be used to determine the ionic content of Chemical Ignition Molotov Cocktails (CIMCs) from the residues collected from the simulation used of the CIMCs.

1.2 Statement of Problem

Lately, the number of cases where incendiary devices were used as an act of retaliation has increased. These kind of incendiary devices like Molotov Cocktails were commonly used during riot and from protestors against from police, and they are also being used to attack houses, to burn the house or to threaten the occupants. This device will cause severe damages to whatever is directly or indirectly targeted.

CIMCs used by criminal are normally based on inorganic salts and/or peroxides since these kinds of chemical are readily available, low cost and can be purchased legally (Johns *et al.*, 2008). The major ingredients normally are fuels and oxidizers (Johns *et al.*, 2008). The most common fuels are petrol, kerosene and gasoline, while chlorate and perchlorate are the most common oxidizers used.

In arson investigation, the chemical analysis will be carried out on the collected fire debris resulting from the fire. In chemical analysis, the chemist will deal with extraction, isolation and analysis of the target compound that could be used to accelerate the fire (Ahmad *et al.*, 2012). The search for evidence of any accelerant used at the crime scene is a difficult task because the accelerants are volatile and evaporate quickly. However, in the case of incendiary devices, the accelerant is not only the components as it also contains some chemical reagents to make the reaction more exothermic and result in stronger combustion.

Therefore, the original composition and other characteristics from inorganic ions in the incendiary residues and it also could be determine to ascertain the type of weapon and ignition system used.

1.3 Objectives

The objectives of this study are:

i. To detect the presence of anions in CIMCs, and
ii. To identify the type of ignition system

1.4 Scope of Study

This study is focused on the analysis of the composition by determining the anionic content of the Chemical Ignition Molotov Cocktails (CIMCs).

1.5 Significance of Study

This study will help the Royal Malaysian Police (RMP), Fire and Rescue Department Malaysia (FDRM) or Chemistry Department of Malaysia in the identification of the type of improvised incendiary devices that had been used by the criminals. Analysis of this device will offer important information regarding the materials that been used in making it. This will eventually establish a link between the device and its perpetrators.

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