PAINT DATABASE SYSTEM OF AUTOMOTIVE TOPCOATS FOR FORENSIC PURPOSES

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To my beloved family, friends, Dr Hasmerya Maarof, Tuan Soo Me Tong and Dr. Umi Kalthom Ahmad

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ABSTRACT

Automotive paint traces are one of common physical evidence found at crime scene. The paint traces that come in the size of chip or as a smear found on the road or on the clothing of the victim involved in hit-and-run accident cases can be compared with the paint sample taken from suspected car in order to establish the origin of the paint. The automotive paint sample from 50 Perodua cars were collected from several workshops, auction yards, salvaged used parts and the police station's accident vehicles' yard in Perlis and Selangor. From the 50 automotive paint samples collected, a paint database namely My-Automobile Paint Database Version 1 was developed based on the analyses conducted, which are non-destructive microscopic examination followed by non-destructive infrared spectroscopy and destructive solubility tests. The microscopic examination was conducted using stereomicroscope equipped with a digital camera to examined layer characteristics of paint fragments in terms of colour, number of layers and thickness of each layer. The binder or resins and pigment present in the paint formulation were identified using spectroscopic techniques of FTIR in transmittance and ATR mode. While the solubility test was conducted using various solvents such as chloroform, acetone, concentrated sulphuric acid, xylene, glacial acetic acid and diphenylamine solution in order to identify the solubility parameters of each paint fragment, which are degree of solubility, colour changes and texture changes. My-Automobile Paint Database Version 1 was developed using Microsoft Visual C# 2010 Express with the Microsoft SQL Server 2008 Express as the database storage and this database is capable to provide a possible match data when comparing the unknown paint received from the crime scene to the known paint in the database. Therefore, the origin of the unknown paint can be revealed.

ABSTRAK

Kesan cat automotif adalah salah satu bukti fizikal yang biasa dijumpai di tempat kejadian jenayah. Kesan cat yang datang dalam saiz cip atau sebagai calitan dijumpai di jalan raya atau pada pakaian mangsa yang terlibat dalam kes-kes kemalangan langgar lari boleh dibandingkan dengan sampel cat yang diambil daripada kereta yang disyaki untuk mengetahui asal usul cat. Sampel cat daripada 50 buah kereta Perodua telah dikumpulkan daripada beberapa bengkel, tempat lelongan, tempat barang terpakai dan tempat pengurusan kemalangan balai polis di Selangor dan Perlis. Daripada 50 sampel cat automotif yang dikumpul, pangkalan data cat iaitu *My-Automobile Paint Database Version 1* telah dibangunkan berdasarkan analisis yang dijalankan, iaitu pemeriksaan mikroskopik tak merosakkan diikuti dengan spektroskopi inframerah merosakkan dan ujian keterlarutan merosakkan. Pemeriksaan mikroskopik telah dijalankan menggunakan stereomikroskop yang dilengkapi dengan kamera digital untuk memeriksa ciri-ciri lapisan serpihan cat dari segi warna, bilangan lapisan dan ketebalan setiap lapisan. Pengikat atau resin dan pigmen yang hadir dalam formulasi cat telah dikenalpasti menggunakan teknik spectroskopik FTIR dalam mod pemindahan dan ATR. Manakala ujian keterlarutan dijalankan menggunakan pelbagai pelarut seperti kloroform, aseton, asid sulfurik pekat, xilena, asid asetik pekat dan larutan difenilamina untuk mengenalpasti parameter kebolehlarutan setiap serpihan cat, iaitu darjah kelarutan, perubahan warna dan perubahan tekstur. *My-Automobile Paint Database Version 1* telah dibangunkan menggunakan *Microsoft Visual C# 2010 Express* dengan *Microsoft SQL Server 2008* sebagai simpanan pangkalan data dan pangkalan data ini mampu untuk menyediakan satu kemungkinan padanan data apabila membandingkan cat tidak diketahui yang diterima daripada tempat kejadian jenayah dengan cat yang dikenali di dalam pangkalan data. Oleh itu, asal usul cat yang tidak diketahui boleh dikenal pasti.

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LIST OF ABBREVIATIONS

ATR	-	Attenuated Total Reflectance
cm	-	centimeter
Conc.	-	concentrated
C#	-	C Sharp
FT-IR	-	Fourier Transform Infrared Spectroscopy
g	-	gram
GUI	-	Graphical user interface
HAc	-	acetic acid
IC	-	Identification card
IR	-	Infrared
KOH	-	potassium hydroxide
min	-	minute
MK-FTIR	-	Micro-Fourier Transform Infrared Spectroscopy
MS	-	Microsoft
ml	-	milliliter
n	-	Number of
NAD	-	non-aqueous dispersion
Py-GC-MS	-	Pyrolysis Gas Chromatography Mass Spectroscopy
r.t	-	room temperature
sat.	-	saturated
SEM	-	Scanning Electron Microscopy
SEM-EDX	-	Scanning Electron Microscopy with Energy Dispersive X-Ray
SQL	-	Structured Query Language
t-butanol	-	tertiary-butanol
UV	-	ultraviolet

XRF	-	X-ray Fluorescence
C=O	-	Carbonyl group
C=C	-	Double bond
C-H	-	Hydrocarbon group
μ	-	micro
λ	-	Wavelength
cm^{-1}	-	inverse centimeter
^{o}C	-	degree Celcius
HNO_3	-	nitric acid
H_2O	-	water
CH_2	-	Methylene group
CH_3	-	Methyl group

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CHAPTER 1

INTRODUCTION

1.1 Background Problem

Edmund Locard explained that the principle of "every contact leaves a traces" is important basic in forensic science, where during the contact between two persons there might be evidences present in trace amounts. These trace amounts of evidence found at crime scene then be called as trace evidence (Ho, 1990). Paints, with other types of trace evidence for example; fingerprint, body fluid, glass, fire accelerants, gunshot residues *etc.*, are commonly encountered forms of trace evidence in a large portion of criminal cases examined in forensic science laboratories. Furthermore, this principle is also related to the Theory of Crime Scene Triangle. The theory explains that a crime committed must be proved that every contact happened between object and/or people has linked suspect to crime scene, victim to crime scene and suspect to victim, thus this establish that there might be an involvement of a suspect to a crime or just a presence of a suspect at a crime scene.

The term of 'trace evidence' become generally accepted in forensic science in the sense that it applied to normally very small amounts of materials, which can serve to link an item on which material is found with an otherwise unconnected source of it elsewhere. The trace evidence has potential to provide a sort of associative evidence, as long as it is capable of being transferred from one place to another, can be recognised for what it is, and is recoverable and amenable to meaningful analysis and critical comparison (Ho, 1990).

One type of physical trace evidence which can be found at crime scene is paint. Paint is considered as physical evidence when any liquid, liquefiable, or mastic composition which after application to substrate in a thin layer, is converted to an opaque solid film that may have transferred from one surface of an object to another object during the contact (Nicholas, 2008). These traces can be transferred in the form of chips or visible smears on the clothing of persons or at the scene involved during hit-and-run accident cases, robberies or burglaries.

Paints are generally functioned as a coating that can be placed on porous surface, such as wood or paper, or on non-porous materials, such as metal (Bell, 2006). They are applied commercially today as a household and automotive paints coating. The paints are composed of a polymer, which acts as binder; a pigment to impart colour; a liquid carrier or a solvent and various additives.

Most paint fragments retrieved from the scene have a multilayer structure. Each layer is made from painting material and is a mixture of many chemical compounds (Beckhoff *et al.*, 2006). A typical system of paint coating is consists of three generic layers; primer, colorant and protective layer. The primer mainly is a layer that coats and prepares the substrates, while the other two layers where dyes and pigments are found. In automotive industry, every car produced mainly consist of at least four organic coatings; which are electrocoat primer, the black to grey colour of first layer; primer surface, a highly pigmented layer; basecoat provide the colour of the finish car and clearcoat, an unpigmented layer to provide gloss, durability and appearance (Skenderovska *et al.*, 2008).

1.2 Problem Statement

The examination and identification of paint evidence is crucial in forensic investigation. The paint traces come in the size of chip or as a smear found on the road or on the clothing of the victim involved in hit-and-run accident cases. The limited sample size of paint fragments collected at the crime scene and sample preservation during packaging of evidence and maintaining its chain of custody have become a major challenge to the forensic scientist in solving the road accident cases (Nicholas, 2008).

Furthermore, the fact that these multilayer paint fragments may be produced from different chemical compound mixture but exhibit some features that can exist even in samples known to be from the same source, thus it could provide early conclusion that the paint fragments analysed might have come from the same class (Chang *et al.*, 2003). This fact also become a major challenge to the discriminating power of evidence as this early conclusion may only lead the forensic scientist to assume that there are a contact between the accused to the evidence and/or presence of the accused to the scene, but not conclusively.

The examination and identification of automotive paints can be conducted using a variety of analytical techniques, which are light microscopy, UV-visible microscopy, infrared microspectrophotometry and electron microscopy. This examination and identification are conducted to characterize the physical and chemical features of paint fragments. The physical characteristics may include colour appearance, size, shape, layer sequence, thickness, surface and layer features, contaminants and weathering. Whereas, the chemical characteristics of the paint fragments may include pigments, polymers and additives. In addition, a comparison among the trace of paint samples collected at the crime scene with the paint sample taken from suspected vehicles also must done in order to establish the origin of the paint (Zięba-Palus, 1999).

However, the limited sample size and sample preservation requirements of the paint fragments mandate that the method of analytical techniques must be selective and reasonable in order to maximize the discriminating power of evidence. A knowledge of the use, properties and identification of only most commonly used raw materials in paint formula are rather essential for the forensic scientist as they need fundamental besides logical understanding of paint chemistry (Saferstein, 1982). The physical characteristics of paint fragments such as number and colour of layers in paint fragment can be determined by using optical microscopy, whereas infrared spectroscopy deals with the characterization of chemical compound in the paint (Zięba-Palus, 1999). Both of these techniques are non-destructive which can preserve the integrity of the evidence thus enable the forensic scientist to proceed to another analytical technique. At the end, the year, make and model of the suspected can be revealed by comparing both characteristics of physical and chemical of the known sample from the suspect to the unknown sample from the victim and/or the crime scene.

A study for the development of a database for automotive paints in Malaysia is greatly needed in order to link the vehicle involve in the road accident cases based on the small paint chips or smears left at the crime scene and/or on the victim.

1.3 Objectives of Study

This study embarks on the following objectives:

1.3.1 To examine paint fragments of automotive topcoats using physical and chemical analyses

1.3.2 To characterize paint fragments of automotive topcoats using spectroscopic method

1.3.3 To develop a paint database system of automotive topcoats for forensic purposes

1.4 Scope of Study

In this project, a database of automotive paints based on forensic examination and identification techniques to characterize physical and chemical properties used by local car manufacturer in their paint formula will be developed. The paint database system was designed by using Microsoft Visual Studio as the software. The examination and identification were carried out to 50 of various colours automotive topcoats paints from Perodua car brand manufactured between years 2000 until 2009. The samples are subjected to non-destructive techniques of microscopic examination and Fourier Transform Infrared (FT-IR) spectroscopy in order to characterize its physical and chemical characteristics respectively. The solubility and acrylic properties of paint samples were reflected in a destructive solubility tests.

1.5 Significance of Study

In Malaysia, there is no proper and complete paint database that can help the police to arrest the suspect of road accident cases especially the hit-and-run accident cases. In addition to no eye-witness present during the hit-and-run accident occurred, making it more difficult to trace down the suspect. The police always have to consider the hit-and-run accident cases as the closed case even though there a fatal victim involved. This is maybe due to either no evidence is found at the crime scene or no known sample from the suspect is available to conduct comparison analysis even though the evidence is found at the crime scene. Therefore, it is become complicated and difficult to reduce the road accident case every year.

Within year 2009, the total numbers of road accident are 397, 330 accident cases with average of 1088.6 cases per day. From the total numbers of road accident mentioned, there are 6, 218 (1.6%) cases involved fatal, 6.978 (1.8%) cases involved serious injury, 12, 072 (3%) cases involved minor injury while 372, 062 (93.6%) cases involved no injury but property damaged only (Figure 1.1). Moreover, traffic accident in Malaysia has increased for year 2009 with 24, 259 (6.5%) cases compared to year 2008.

From Figure 1.1, the distribution of injury caused by traffic accident in year 2009 still in a significant number. These injuries may be being contributed by accident cases of hit-and-run. Therefore, the database that will develop can be used to identify the suspect car involved in road accident of hit-and-run cases and thus assist the tracking process.

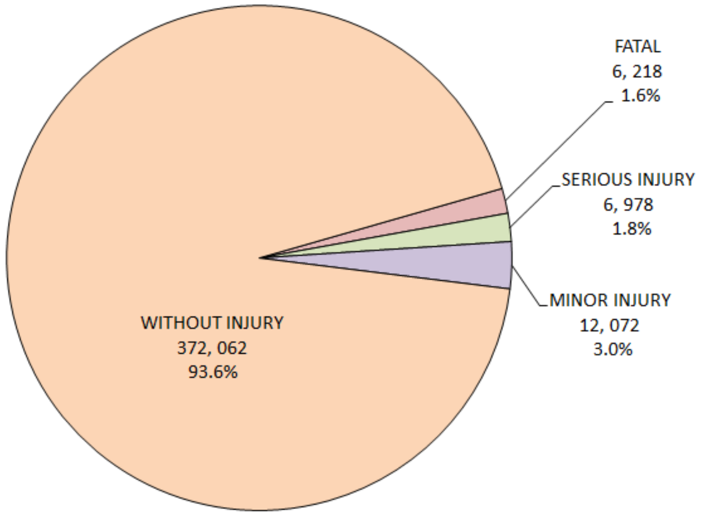

Figure 1.1 Type of accident (Laporan Tahunan PDRM, 2009)

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