UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF NEW SCREENING REAGENT, PATTERN DISTRIBUTION AND CHEMOMETRIC APPLICATION OF GUNSHOT RESIDUE (GSR) AS EVIDENCE RECOVERY USING FOURIER TRANSFORM INFRARED (FTIR) TECHNIQUE

SITI NURHAZLIN BINTI JALUDDIN

PhD

September 2022

ABSTRACT

The innovation of chemographic reagent, Rapid Griess Test (RGT) was successfully developed as a rapid and portable screening test kit in detecting GSR at crime scenes. There different chemicals consist of amino group namely, 1,4-phenylenediamine, 1,8-napthalenediamine and 3-aminophenol were tested as substitution of alpha-naphtol in Modified Griess Test (MGT). It was proven that 3-aminophenol has highest efficiency as chemographic reagent. This chemical reagent formed a colour solution upon reacting with nitrite (NO_2^-). Furthermore, the effectiveness of 3-aminophenol as a substitution of alpha-naphthol in RGT prevented the addition of acid and heat for the reaction to occur. In order to determine the pattern distribution and particles dispersion of GSR, the shooting test was performed. The findings showed various firearms produced different pattern distributions and particles dispersion at a closed shooting distance. Specifically, the revolver produced larger soot of GSR pattern distribution at 3 cm of shooting distance compared to the pistol. However, pistol produced more particles dispersion at target materials as compared to the revolver. The factors that affect the various size of soot and particles dispersion is including the barrel length, internal pressure of firearms and the weight of propellants. In the meantime, the morphological structure and chemical composition of GSR from different brands of ammunition were analysed using Scanning Electron Microscope (SEM) and Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR), respectively. The findings revealed that each ammunition consists of unique characteristics with the propellant's shape determined by its chemical composition as well as the manufacture. Furthermore, the spherical or round shape of the propellant consists of a single-base propellant and is made up of nitrocellulose and nitro-glycerine. On the other hand, the thin flake propellant consists of a double-base propellant and its components include nitrocellulose, nitro-glycerine and other mixtures. The ATR-FTIR spectrum showed that all the samples consist of main peaks of nitrocellulose, but the percentage transmission of each ammunition was different. This is because the chemical composition of ammunition is different within the manufacture. Due to the huge and complex data set of the ATR-FTIR, chemometric analysis was implemented in the last part of the analysis. Principal Components Analysis (PCA) and Hierarchical Cluster Analysis (HCA) were used as a technique of unsupervised chemometric. From PCA analysis, propellant and GSR can be differentiated and grouped according to the types of calibres and brands of ammunition.

ACKNOWLEDGEMENT

بسم الله الرحمن الرحيم

Assalammualaikum w.b.t

Alhamdulillah and praise to Allah, the Almighty God for His mercy has given me strength, patience and blessings to complete this study. Here, I would like to express my sincere to every single person for their effort and support that contributed to help me in completing all the process of the research and development activities.

First and foremost, I would like to express my sincere gratitude to my advisors and my PhD research committee; Assoc. Prof Dr Zainiharyati Mohd Zain, Assoc Prof Dr Muhd Fauzi Safian, Supt Mohamed Sazif Mohamed Subri and Dr Mohamed Izzharif Abdul Halim for their patience, supervision, encouragements and thoughtful guidance towards the completion of this thesis.

My sincere thanks also extend to ACP Dato’ Narenasegaran a/l Thangaveloo for the brilliant comments and ideas. His prompt inspirations, timely suggestions with kindness have helped me to accomplish this task.

I sincerely acknowledge all the laboratory assistants and staff from the Department of Chemistry, Research Department of IPSIS and Faculty of Applied Sciences Universiti Teknologi MARA for assistance in handling instrument and also supplying relevant literature and information.

I also place on record, a very warm thank you to my friends who directly or indirectly have lent their helping hand in this venture. I also wish to express my special appreciation and gratitude to Malaysian Crime Scene Investigation (CSI) team, and Ballistic Department of Forensic Laboratory RMC, Cheras for valuable guidance and motivation extended to me.

Last but not least, heartfelt appreciation is given to my beloved family especially to my mother, Mrs Kamsiah binti Alias for her supports, endless love, prayers and most precious care. The greatest challenge that I faced during my PhD journey was losing the pillar of my strength, the respectful man who always quote me as independent and superwomen. With the blessing of Almighty, I dedicate this PhD thesis to my beloved father, Jaluddin Mohd Ali the cancer fighter.

Siti Nurhazlin Jaluddin

TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Research Background

"Physical evidence cannot be intimidated. It does not forget. Its sits there and waits to be detected, preserved, evaluated and explained". This famous quote by Herbert Leon MacDonnell explained the importance of evidence in criminalistics. Evidence can be defined as the object availability and/or information that indicates whether a belief or proposition is true or valid (Oxford Online Dictionary, 2010). In forensic science, evidence can be differentiated into circumstantial evidence or direct evidence. Based on the Locard's Exchange Principle by Edward Locard, physical evidence or material evidence can be defined as any object that is established to confirm a crime has been committed. Evidence also links a crime to its victim or between a crime and its perpetrator (Petherick *et al.,* 2009)**.** This evidence can play several roles in ballistic investigation, such as shooting distance, types of firearms and ammunition used in shootings, as well as the chemical composition of gunshot residue (GSR). Subsequently, it can be stated that evidence recovery is an action or process of regaining data and information of evidence using scientific methods. However, suitable techniques are required in order to obtain the information from the evidence.

GSR or firearm discharge residues consist of burned and unburned particles from the propellant, primer components, and metal contained in the projectile, as well as in the gun barrel when a gun is fired (Dalby *et al.,* 2010). During firing, a considerable amount of material in the gaseous or solid aerosol phase is produced and expelled along with projectile, leading to the production of GSR (Vanini *et al.,* 2015). GSR evidence that provides clues of the individuals that fired a gun has been of substantial help in investigations. It has been used to estimate the firing distances, to identify bullet holes, to differentiate entry and exit wounds, to establish the kind of ammunition used, to trace the trajectory of a projectile, and to determine whether or not a person has discharged a firearm (Andrasko *et al.,* 1998, Glattstein *et al.,* 2000, and Brozek-Mucha *et al.,* 2001). Normally, only trace amounts of GSR are deposited on the back of the hand, face, hair and clothing of the shooter and this material can be used to determine if a person has discharged a weapon. On the other hand, the amount