UNIVERSITI TEKNOLOGI MARA

A STUDY ON THE CONTRIBUTION OF PRIMER LAYER IN CAR PAINT ANALYSIS USING CHEMOMETRICS APPROACHES

RAJA ZUBAIDAH BINTI RAJA SABARADIN

PhD

June 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Raja Zubaidah Binti Raja Sabaradin
Student I.D. No.	:	2013104601
Programme	:	Doctor of Philosophy (Science) – AS950
Faculty	:	Applied Sciences
Thesis Title	:	A Study On The Contribution of Primer Layer in Car Paint Analysis Using Chemometrics Approaches
Signature of Student	:	 ……..
Date	:	June 2020

ABSTRACT

Analysis of car paint is a common practice when involving car road accidents. A car paint system consists of at least 4 layers namely cathodic electro deposition, primer, basecoat and clearcoat. However, not all layers may be present in a car paint sample recovered from the crime scene. Fourier transform infrared spectroscopy (FTIR) has been commonly used for the analysis of car paint as it is a simple and fast analysis. Pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) is gaining popularity as this technique could analyze the chemical composition of a paint sample. This study is conducted in order to evaluate the contribution of car primer layer in the analysis of car paint sample. Fifty car primer samples of two types (1K and 2K) were applied to aluminum sheets. In addition, eight red basecoat were applied on another 10 selected car primers giving a total of eighty red car paint samples. Car primer samples were analyzed using attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR) and Py-GC-MS. The pyrolysis temperature of Py-GC-MS method was optimized. The datasets obtained from the analysis were subjected to chemometric techniques. Principal component analysis (PCA) was able to discriminate 50 car primer samples according to their types (1K and 2K). Using discriminant analysis (DA) with the types of car primer (1K and 2K) was set as independent variables, Py-GC-MS datasets gave 100% correct classification for all three DA modes (standard, forward stepwise and backward stepwise) while ATR-FTIR data sets achieved 100% correct classification for standard and backward modes with 98% correct classification for forward mode. The 80 red car paint samples were also analyzed using ATR-FTIR and Py-GC-MS methods. PCA and cluster analysis showed that the analysis using ATR-FTIR grouped the samples based on the shades of red basecoat. Py-GC-MS analysis revealed that most of the samples were also grouped based on the shades of the red basecoat, but some samples were grouped based on the car primer varieties. This observation showed significant contribution of car primer in car paint analysis using Py-GC-MS. The study on the contribution of car primer was extended by exploiting the dataset from Py-GC-MS analysis using artificial neural network (ANN) prediction model to predict the presence of car primer in a car paint sample. The dataset was split into training (103 data), testing (26 data) and validation (15 data). The developed ANN prediction model gave good performance in predicting the presence of car primer with residual error value less than 0.05 and correct classification rate of more than 95%. Evaluation on the application of ANN was done by analyzing 39 real car paint samples. PCA applied to untreated dataset and dataset treated with developed ANN prediction model. Better discrimination was obtained using treated dataset whereby only samples with car primer were included. Thus, the ANN model constructed may be applied as a pretreatment approach on a Py-GC-MS dataset for forensic car paint analysis.

ACKNOWLEDGEMENT

First of all, Alhamdulillah and thank you Allah S.W.T for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My gratitude and millions of thanks go to my supervisor Prof Dr Norashikin Saim and my co-supervisors Assoc. Prof. Dr Rozita Osman and Dr Hafizan Juahir of Universiti Sultan Zainal Abidin (UniSZA) for their invaluable help of constructive comments and suggestions throughout the experimental and thesis writing also their guidance and valuable advice throughout this study.

I would like to thank Ministry of Higher Education (MOHE) for the financial support for this study (600-RMI/ERGS 5/3 (5/2012)). My gratitude goes to the staff of Centre for Postgraduate Studies, Faculty of Applied Sciences for their help towards my postgraduate affairs. My appreciation goes to the Forensic Laboratory staff, Pn Noor Haida Kamalul Kudzi and En. Dzahir Dzaidanee Bin Nasaruddin for helping me during samples preparation and especially in the operation of the instruments. Special thanks to my friends for lending their hands during lab work, the ideas they shared and for all the ups and downs throughout this journey.

I would never have been able to finish this journey without enormous support, continuous encouragement and understanding from my life partner, Mohd Shah Mohd Zain and my darling children, Hannan Izdihar and Harraz Izdiyad. Millions of thanks goes to my beloved mom, Pn. Hjh. Adibah Hanim for the prayer she made from the day one I started this journey. To my brothers, sisters and in-laws, thank you for the courage for me to complete this journey. This piece of victory is dedicated to all of you. Alhamdullilah.

Finally, not forgotten this piece of work is dedicated to the loving memory of my very dear late father and mother, Allahyarham Raja Sabaradin Raja Abdullah and Allahyarhamah Sarinah Abu Samah. I am here today because of them, Al-Fatihah.

Raja Zubaidah Raja Sabaradin
June 2020

TABLE OF CONTENTS