Tyre Profiling:
Development and Evolution of
Forensic Methodology

2009

CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Production Note:
Signature removed prior to publication.

Signature of Student

Acknowledgments

I would like to thank a number of people and organisations for their assistance and support in the completion of this research. Firstly and most importantly, I would like to thank my wife Tamar, who not only gave me the mental and emotional support I needed, but who was more than happy to accompany me to wherever my research took me. During this research we were also blessed with our son Luke, who has given me the mental breaks required when dealing with a project for so long. I would also like to thank the rest of my family for all their love and support over the past 6 years.

I would also like to thank my supervisor Brian Reedy who was always there when I needed him, and who gave me the much appreciated feedback and opinions that I needed. Thank you also to my initial supervisor Eric Du Pasquier, who got this research up and running all those years ago, and for arranging my visit to the IRCGN.

Many thanks must go to Jim Keegan whose help with the PyGCMS was invaluable considering the amount of time I spent on the instrument. I would not have been able to complete as much work as I did without Jim's help. Thanks also to Ron Shimmon for his help with the NMR, though in the end I didn't use any of it. Thanks to Katie McBean for her assistance in the examination of samples using the ESEM.

Thank you to Goodyear Castle Hill and Brookvale Tyres for the supply of tyres and sampling of tyres, to the NSW Police Driver Training unit for access to a road for the completion of the skid tests, and to the IRCGN for allowing me to stay on base and use their equipment for 6 weeks.

For their support over the years I would like to thank my fellow PhD students who are going through the same insanity as me, and who were always there not only to share ideas but who made the time spent doing this that much less painful. Thanks to my initial work colleagues who over the years gave me the time off I needed to get into the lab and get my work done, and thanks also to my current work colleagues who have given me a lot of support over the last two years.

Contents

List of Figures

List of Tables

Abstract

The chemical analysis of tyres is not a routine part of forensic investigation. The use of tyres as evidence has been limited to comparison of the tread pattern. However, the tread pattern is not the only evidence that may be left behind by a tyre. When a tyre skids across a hard road surface such as bitumen or concrete, residue from the tyre may be left behind.

It was the aim of this research to develop a method for the analysis of tyres and their residues, understand the amount of chemical variation in tyres, identify suitable methods for the collection of tyre residues from different road surfaces, and to classify tyre samples and identify the source of tyre residues.

A suitable method for analysis was successfully developed using pyrolysis-gas chromatography/mass spectrometry. It was found that pyrolysis was best completed at 450 ^{o}C using a furnace type pyrolyser.

Chemical variation was investigated in a single tyre, in tyres over time, in production batches, and between different models and sizes of tyres from the same manufacturer. Small variations were found within a single tyre and in tyres over time. Greater variation was observed in both the same and different production batches, and between different model tyres and different size tyres.

Three different collection techniques were investigated – picking, adhesive tape, and swabbing. Picking was found to be the most suitable technique to use on a concrete road with gravel aggregate, while a fingerprint lift was found to be the most suitable technique on a bitumen road surface. Swabbing was found to be an unsuitable technique.

Six replicate analyses were used to catalogue changes in the chemical composition between the tyre and the residue. Numerous changes were observed such that only a limited number of signals from the chromatogram could be used for identification purposes. Three different techniques were used for classification and identification – relative polymer content (RPC), target compound identification (TCI), and linear discriminant analysis (LDA). LDA was found to be the most successful technique, correctly classifying 31 of 36 tyre residues.

PyGCMS allows for simple analysis of tyre samples and residues without pre-treatment. A tyre sample was found to have 5-10% variation in the relative polymer content, regardless of when during the life of the tyre the sample was taken. Variation was found between tyres from the same manufacturer. Both similarities and differences were found between tyres from the same production batch and different production batches, suggesting that homogeneity in a single production batch not guaranteed and that manufacturers will also change the composition of a tyre between different production batches. The collection of tyre residues (like the collection of any forensic evidence) may or may not be successful depending specifically on the type of road surface. Collection of tyre residues from a concrete road with gravel aggregate was successfully achieved through picking. Collection of tyre residues from a bitumen road was successfully achieved; however adhesive contamination from both the fingerprint lift and clear adhesive tape interfered with the PyGCMS analysis. Tyre residues were successfully correlated to the source tyre, but the process of collecting sample information from numerous replicate analyses of both the tyre sample and residue for data analysis was a time-consuming one.