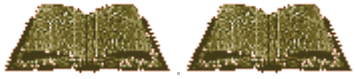
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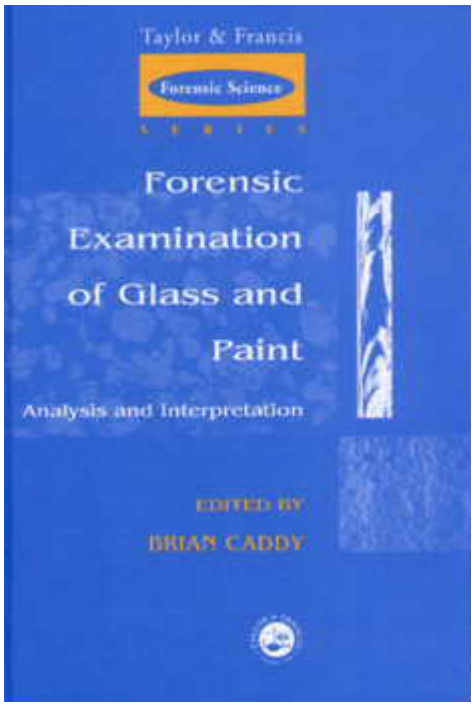
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A VALUABLE BOOK ON GLASS AND PAINT EXAMINATION

Forensic Examination of Glass and Paint: Analysis and Interpretation, 1st Edition *edited by* Brian Caddy, Hard Bound, 246x174 mm.
(A Book from Taylor & Francis Forensic Science Series edited by James Robertson)
Taylor & Francis, 11 New Fetter Lane, London EC4P 4EE; . ; 304 pages; illus. 134 b+w line drawings and photos: ISBN 0-7484-0579-8. Publication Date August 2001: Price, £70.00.

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Brian Caddy

Brian Caddy, the editor of this book, is Emeritus Professor of Forensic Science at the University of Strathclyde, Glasgow, Scotland. He has taught forensic science as an academic discipline for over 34 years.

The value of trace evidence in forensic science can not be underestimated. Edmond Locard, the last century great French pioneer of forensic science underlined the importance of trace evidence more than anything else, when he stated, "every contact leaves a trace". Although we, as forensic scientists keep talking about trace evidence often, but what exactly is trace evidence? We can of course rattle out several examples of trace evidence - hair, fibres, paint, glass, dust. But do all these examples fall under some generic category? Is there some common denominator among all these?

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The book under review explains in detail the importance of two very vital examples of trace evidence - glass and paint. And in the very first chapter all these questions are dealt with in detail. What exactly is trace evidence? In fact the chapter itself is named "What is trace evidence". Written by Peter R. De Forest of John Jay College, New York, this chapter elaborates on trace evidence. The author agrees that "the term *trace evidence* is difficult to circumscribe and define". Nevertheless an attempt is made to define this term. We are told that two very different notions contribute to the concept of trace evidence. One notion is related to size; very small amounts of material such as flakes of paint or chips of glass may be considered trace evidence. On occasions however relatively large amounts of material may be considered as trace evidence. This notion includes the concept of "vestige", something that remains behind after something else has been removed. Fingerprints, foot prints, shoe prints, tire marks etc. may be considered as trace evidence if we go by this concept.

What is the use of trace evidence in forensic science? At page 23, the author tells us that trace evidence is one of the most valuable, misunderstood, misused and underutilized forms of physical evidence. Properly utilized, there could at least be three distinct uses of trace evidence in forensic science. These are (i)investigative aids (ii)associative evidence and (iii) reconstruction. Trace

evidence is most often used as an associative evidence, e.g. it may be used to link a suspect to a scene of crime. Examples of trace evidence being used as an investigative aid are determining the origin of a manufactured material, determining the approximate date of manufacture of a material, providing information to eliminate suspects and suggesting a geographic provenance for an unknown sample. Sometimes trace evidence may be used to reconstruct an event, such as a motor vehicle collision.

A full listing of the Contents of *Forensic Examination of Glass and Paint*

Table of contents

1. What is trace evidence?
2. The composition and manufacture of glass
and its domestic and industrial applications
3. Microscopic techniques of glass examination
4. Elemental analysis of glass fragments
5. Statistical interpretation of glass evidence
6. Interpretation of physical aspects of glass evidence
7. Composition, manufacture and use of paint
8. The role of colour and microscopic techniques
for the characterisation of paint fragments
9. Pyrolysis techniques for the characterisation
and discrimination of paint
10. Use of infrared spectroscopy for the
characterisation of paint fragments
11. Scanning electron microscopy and energy dispersive
X-ray spectrometry (SEM/EDS) for the forensic
examination of paints and coatings
12. The interpretation of glass evidence

The author goes on to give the history of trace evidence. Interestingly wives have always been quite intrigued finding long hair (of a color not matching their own!) on their husbands' coats, and this has possibly resulted in many divorce suits! If even some of these stories are true, they are good examples of trace evidence starting divorce proceedings! The first articulated reference to trace evidence, of course, occurs in Sherlock Holmes' stories written towards the end of 19th Century. Early doyens utilizing trace evidence to the greatest advantage were Edward Oscar Heinrich in the United States, Edmund Locard in France and Georg Popp in Germany. For readers interested in greater details of the history of trace evidence, the author gives three very useful references. These are three papers written by S.J. Palenik, in *Microscope* in the year 1982 (Volume 30: pages 93-100, 163-170, 281-290). They sounded such great fun that I immediately went to the *National Medical Library* and ordered all three of them.

The book has a total of twelve chapters and this chapter sets the stage - so to say - for the rest of the book. Chapters 2-6 (5 chapters) are devoted to "glass evidence" and chapters 7-12 (6 chapters) to "paint". Brian Caddy the editor of this highly informative book has roped in the services of a number of experts (from various countries, including USA, UK, Ireland, Australia, Canada and Germany to name a few) to write different chapters of this book. Each writer has dealt with an area of his own expertise.

The section of glass evidence starts with a chapter on the composition and manufacture of glass. We all seem to know intuitively what glass is, but if asked to define glass, how many of us can actually define it? What exactly is glass? We are given a clear definition of glass in this chapter. It is a product of fusion which has cooled to a rigid state without crystallization. Glass is therefore, by definition, amorphous or non-crystalline.

...Glass is so universal in appeal that it is used almost in every object surrounding us. Car windscreens, beer bottles, spectacle and microscope lenses, mirrors, television and computer screens, window panes, toys, crystal all have glass of one type or other. The composition of all these types of glass differs, but the three most common types of glasses used in forensic casework are soda-lime-silica glasses, borosilicate and leaded glasses...

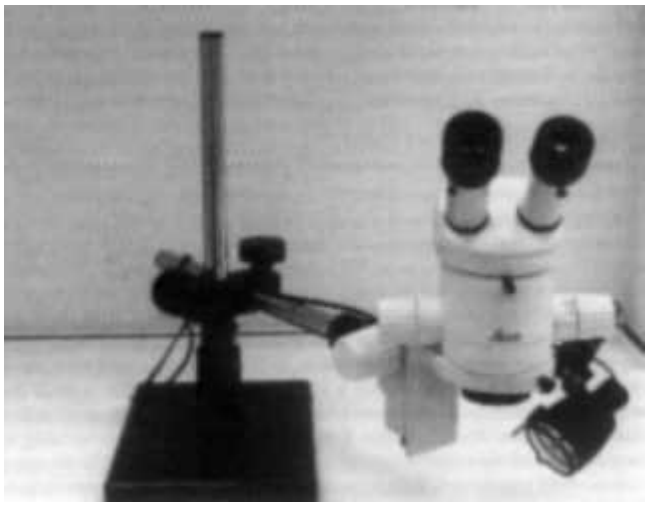
The chapter gives a detailed process describing how glass is manufactured. All the components of glass are well-explained. Components of glass are usually divided into primary formers, intermediate formers, modifiers, stabilizers, colorants and deodorants, accelerating and refining agents, opalisers and cullet. Each of these components are defined. Primary formers, for instance, are those substances which can form glass on their own. Oxides of silica (SiO_2) and boron are primary formers. Intermediate formers usually require another oxide to make a glass, although this other oxide may or may not be a primary glass former. Aluminium oxide (Al_2O_3) usually belongs to this class. Modifiers such as soda (Na_2O) are needed to lower the melting point of primary glass formers. Silica, for instance, melts in excess of 1700^0C, but addition of Sodium oxide can lower this temperature substantially.

Differing compositions of glasses can give rise to different types of glasses. They are used in a wide variety of objects, be they car windscreens, beer bottles, spectacle and microscope lenses, mirrors, television and computer screens, window panes, toys, crystal and so on. The composition of glass would differ, depending on where the glass in intended to be used. Three most common types of glasses used in forensic casework are (i)soda-lime-silica glasses (ii) borosilicate and (iii) leaded glasses.

The chapter goes on to describe in detail the manufacturing process of glass. Although it may not be apparent initially, when one begins to read latter chapters, it is at once clear how important it is to know the manufacturing process of glass.

What microscopic techniques are used to examine glass fragments? Chapter 3 addresses this question. If it is alleged that a suspect broke a glass pane to enter a house, then his clothing would reveal some microscopic glass particles. It is possible to match these microscopic particles, with the remaining pieces of glass on the window, and a perfect match would associate the suspect with the scene of crime.

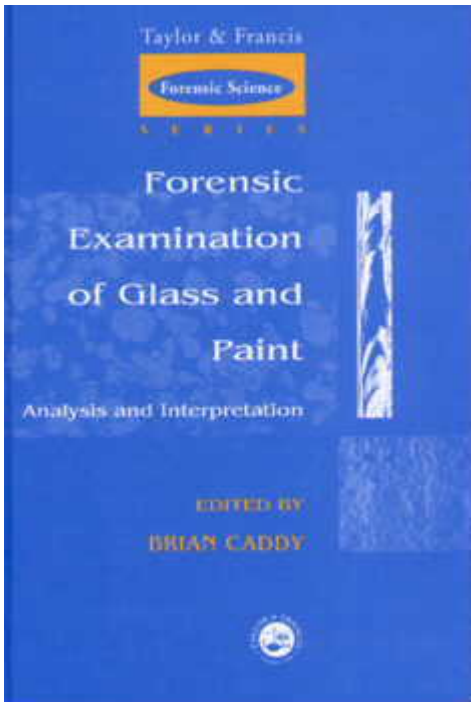
Stereo microscope on a long-arm stand. Such a microscope can be effectively used to search for microscopic glass fragments on the suspects' clothing (the picture appears on page 50 of the book)



The chapter explains in detail, how glass fragments can be recovered from the clothing of these suspects. Two types of stereo microscopes are used for recovery. These are the Greenhough type and the common main objective (CMO) type. The microscope is put on a bench stand or supported on a long arm so it can be swung over clothing. Magnification is usually in the range of x0.63 to x4, which is further enhanced by the eyepiece of the microscope. It gives an additional magnification of x10 or x15. Advantages and disadvantages of several types of lamps are discussed.

Several glass parameters are examined such as surface examination, surface luminescence, surface contour and so on. Refractive index (RI) measurement however provides a very interesting method of comparing glass fragments. The chapter goes on to describe in detail how RI of glass fragments can be measured. Use is made of the fact that when a liquid is heated, its refractive index decreases and vice-versa. Glass fragments can be immersed in some suitable liquid (of a high RI, e.g. clove oil or silicone oils), and the liquid heated gradually. Initially the RI of the liquid is greater than that of the glass, so the glass fragments may be visible through a microscope. But as the liquid is heated, its RI starts decreasing gradually. When the RI of the liquid becomes equal to that of glass fragments they would disappear. This is known as the "match temperature". If the liquid is further heated, the glass fragments would reappear again, because the RI of the liquid would become less than that of the fragments. If the glass is bright in comparison to the surroundings, it is below the match temperature; if it is dark it is above it.

Some major highlights of *Forensic Examination of Glass and Paints* at a glance:



A Bird's eye view

& Each chapter written by an expert in his own field of expertise.
& Richly illustrated.
& Comprehensive coverage of physics and chemistry of glass and paint.
& Manufacturing process of glass and paint explained in great detail, making it possible for forensic scientists to view these pieces of evidence in the right context.
& Reasonably priced so that everyone can have his or her own copy.
& Technical jargon kept at a minimum, so should be useful to even beginners trying to explore this relatively virgin field.
& Separate chapters on the interpretation of glass and paint evidence.
& Useful not only to all forensic scientists, but even to other professionals such as forensic pathologists, physicists, chemists and researchers working in areas of glass and paint analysis.

Although this is an interesting and useful method of RI determination, the examiner may get tired staring at glass fragments through the microscope, through which he may have to "squint" for hours. This difficulty led engineers to develop a far more superior system known as GRIM (Glass Refractive Index Measurement). Initially it was GRIM 1, but now a still superior version GRIM 2 is in vogue, which employs computers, phase contrast microscope, Mettler hot stage (for heating glass fragments), a Video camera with CCD detectors and a single source of monochromatic light of 589 nm wavelength. Scientists can now simply look at a computer monitor, which is far more comfortable that peering through a narrow microscope eye-piece. Rest of the chapters enlarge on several other useful aspects of glass examination.

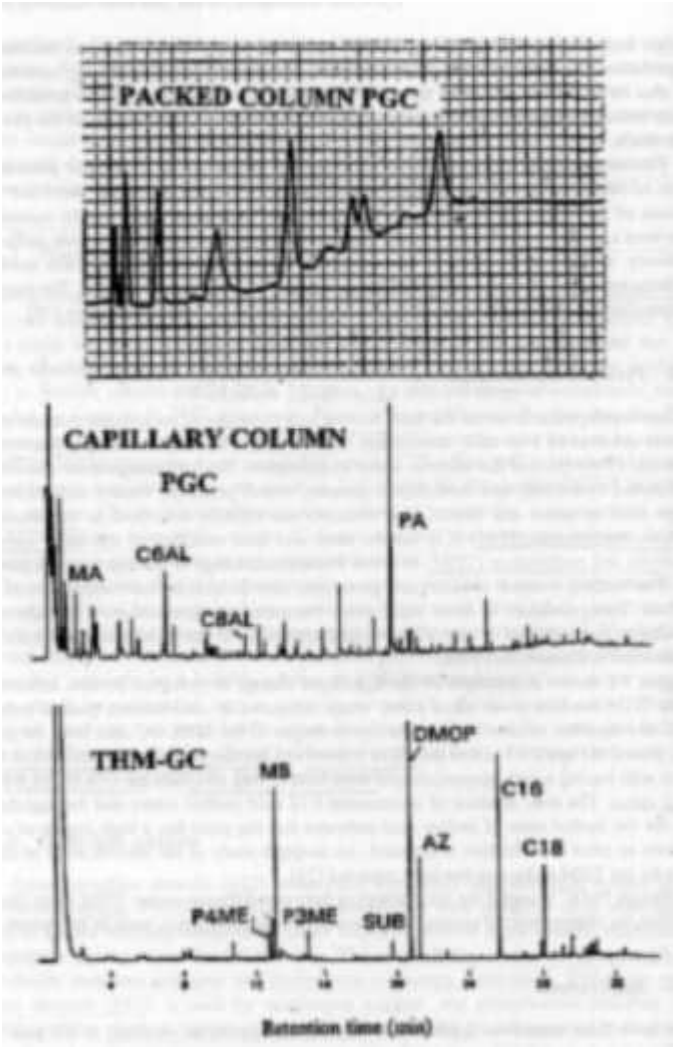
The section on paint examination begins from chapter 7, which is on composition, manufacture and use of paint. In several respects, this chapter is analogous to chapter 2 on glass, and a reference to latter chapters immediately tells us the immense usefulness of this chapter. But first of all, what is paint? Like glass, we all seem to know intuitively what paint is, but may flounder when asked to define it in exact words. Paint - or surface coatings as they are called technically - are materials

applied to substrates, having a dual role of protection and decoration. There may be a third function of paint - to disguise an inferior quality material. Paints may be applied on virtually every kind of surface. These may vary from wood and paper to a variety of metals, plastics and many composite materials. And all paints comprise of three principal components - binder, pigment and solvent.

Next chapter (Chapter 8) enlarges on paint colors and microscopic techniques for paint examination. Detailed techniques are given to recover and prepare trace paint samples for analysis. This includes embedding techniques, microtome sectioning, microscopic examination and microspectrophotometry.

Chapter 9 details a relatively new technique for paint analysis - the pyrolysis technique. In this technique, paint molecules are fragmented thermally, and the resulting molecules are analyzed to derive the composition of the original paint. This technique is known as pyrolysis gas chromatography (PyGC), and it can be combined with Mass Spectrometry (to detect the resulting fragments). The combined technique is known as PyGC/MS.

Pyrograms obtained by packed column PyGC, capillary column PyGC and THM-GC of a pentaerythritol ortho-phthalic alkyd resin paint. It is clear that THM-GC gives better peaks, making the analysis more reliable and detailed (the picture appears on page 170 of the book)



Three different types of pyrolysers are in use - the pulse mode filament, the pulse mode Curie point type and the continuous mode furnace types. All have their own advantages and disadvantages

which are discussed in the chapter. The resulting fragments are detected by various detection systems, most common of which is the flame ionisation detector or FID. There are other specific detectors too. The Alkali Flame Ionisation Detector (AFID) specifically measures nitrogen- and phosphorus-containing compounds. The Flame Photometric Detector (FPD) is used for monitoring sulphur- and phosphorus-containing compounds and the Electron Capture Detector (ECD) is used for halogenated hydroxycarbons and other electron-accepting organic compounds.

Improvements have occurred in this technique, and now use can be made of a very advanced technique - Thermally assisted Hydrolysis and Methylation (THM). In this technique the material to be examined (paint flakes) is intimately mixed with an aqueous solution of a tetraalkylammonium hydroxide (particularly tetramethylammonium hydroxide, abbreviated as TMAH), and heated in a pyrolyzer. This technique gives a better structural information of paint molecules than do other techniques, as can be seen from the adjacent diagram, which appears on page 170 of this book. The chapter ends with a discussion on advantages and disadvantages of pyrolysis gas chromatography and of course the future developments.

Subsequent chapters concentrate upon the use of infrared spectroscopy, scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS) and their current application to the forensic examination of paints and coatings. The last chapter (Chapter 12) discusses how to interpret the paint evidence.

I took about a month to read the book from cover to cover. It was compulsive reading, I must confess. And I learnt a lot from this book. This book would undoubtedly prove valuable to all forensic scientists, but what about forensic professionals working in other areas? Well, I am a forensic pathologist myself, and am not directly involved in the analysis of glass and paint analysis, and yet this book has been very valuable for me. How? While conducting post-mortems, now I know that the clothing of the deceased may have glass fragments on them (even if I don't see them!), and I must search for them (with a microscope, if need be), as they can be very valuable associative evidence. Similarly, in future I will be on the look out for particles of paint on the body of the deceased. Paint flakes are valuable not only in motor vehicle accidents, as I used to believe earlier. Indeed they can be found on most unexpected places. As this book tells us, in one triple murder case at a 'fast food' restaurant, microscopic chips of weathered paint were found on the suspect's boots. And the forensic scientists were smart enough to prove his guilt just by this microscopic piece of evidence.

The details of this case? Well, if I continued like this, you will perhaps all agree, that I might end up summarizing the whole book. The best option would be for one to purchase a copy of this book for himself and read it. Believe me you would not be disappointed.

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