Chemistry and Industry for Teachers in European Schools

# FORENSIC CHEMISTRY - CHEMISTRY AND THE DETECTIVE

An Introduction for Chemistry Lessons

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# FORENSIC CHEMISTRY
# CHEMISTRY AND THE DETECTIVE

## FUNDAMENTALS OF FORENSIC CHEMISTRY

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# FORENSIC SCIENCE

The term "forensic science" describes scientific and technical knowledge that can be applied in the fight against crime (preventing crime and prosecuting it) [3]. In the literature and in everyday language the term forensic technology is also used. In Germany, this definition of forensic science also includes social studies such as linguistic text analysis, language recognition, etc. This can be seen when we look at the different departments of the Federal Criminal Police Office, Germany, (BKA). [4, 5].

The scientific sector comprises the search for evidence and its securing. It must also allow the examination and interpretation of the factual evidence and traces obtained. The traces and evidence can be of a physical, chemical or biological nature. The investigative methods are themselves extremely varied because of the great variety of investigated objects.

Before we discuss the present departments of forensic science of the Federal Criminal Police Office (BKA), we will first introduce forensic science as such. A sharp distinction between the different departments is not possible.

## Forensic biology [6]

Forensic biology is divided into the fields of genetics, serology (detection of blood groups), entomology (knowledge of insects) and botany. It makes use of numerous forensic biological and forensic medical techniques. Out of these the best known are: the investigation of any insects in (or on) a dead body, as well as the taking and analysis of genetic fingerprints. These and other methods have received ever-increasing attention in the media; they have led to the solution of especially interesting crimes. One short example is where insects could convict the murderer (according to Benecke [6]):

"A man contacted the life insurance company of his wife and asked them for the premium after the death of his wife. The wife was only reported as missing for three days and therefore the insurance clerk became suspicious. He told the man that the death of his wife could not been proven until her corpse or part of her clearly identified dead body had been found. Eight days later the man contacted the police. He claimed to have found his wife's severed head in the ditch in front of his house; he did not know how it came to be there, he claimed.

By the appearance of the gash the legal physician determined that the head had only been cut off after the woman had died. For this reason the detectives asked themselves whether the husband had cut off the head himself. He could then show a piece of evidence to the insurance company and at the same time the head did not allow detection of the reason for the woman's death or if the head was already severed from the body before the possible insurance fraud.

The forensic entomologist found maggots of the meat fly Calliphora vomitoria on the exposed cut of the head, but not in the eyes, nose or ears. This meant that the body, together with the head, must have lain in a place which was inaccessible for insects. Otherwise, pregnant meat flies would have laid their eggs in the eyes of the body, which would have caused evidence of feeding to have been created. Only when the head was cut off and put into the open, could the meat flies reach it. At this moment the fresh cut was more attractive for the insects than the eyes. This meant that the maggots could penetrate into the meat more easily than into the eyes and ears.

Finally, the data of the air temperature and the size of the maggots allowed the scientists to conclude that the head must have been severed and put into the open at approximately the time when the husband was talking to the insurance clerk. He was sentenced for life imprisonment; the appeal was not successful and the insurance company refused to pay."

## Forensic medicine

Forensic biology mainly concentrates on direct traces leading to the culprit [6]; while forensic medicine concentrates on the following areas:

(1) Detection of injuries and the cause of death
(2) Identification of poisons and poisonings
(3) Herodobiological investigations (comparable to forensic biology)
(4) Traffic medicine

The question as to whether forensic medicine is part of forensic technology has not yet been satisfactorily answered by forensic scientists. Most authors of the respective technical literature refuse to include forensic medicine within forensic technology [5]. A comparatively exact definition of their tasks has established itself practically and has stood the test of time, especially between the bureaus of criminal investigation and the medico-legal institutes.

## Forensic chemistry and physics

In general, forensic chemistry was defined by Helbig [8] as "the application of chemical knowledge and procedures for the purpose of administering justice". It represents a complex subject area just as all sectors of scientific investigation methods do. Often modern investigation methods are closely linked with physics, so both these areas of science are dealt with together in this context, even though the main emphasis lies on chemistry.

Helbig [8] classifies forensic chemistry as follows:

*1. Forensic toxicology*: This works with the detection and the medical interpretation of poisons and poisonings of all kinds. This area is usually carried out in conjunction with forensic medicine.

*2. Forensic chemistry*: Its tasks are:

(1) General testing of substances by means of chemical, physico-chemical or physical methods; its central task is the identification of substances.

(2) Chemical testing concentrated on an object as part of the work at the site of the crime (e.g. securing dactyloscopic traces, investigating traces on weapons or cartridge cases etc.).

(3) Preparative work: this comprises the production of substances for the practical work of the detective (e.g. materials for casting traces, rapid tests for drugs or explosives, residues etc.). This kind of work is generally done by the manufacturers of chemicals.

The content of this work mainly relates to the following areas: general testing of substances and chemical investigations of objects in forensic chemistry.

# TRACE SCIENCE – ASKING SILENT WITNESSES

Trace information is the core of the scientific criminal investigation and works with physical evidence which can be scientifically interpreted. It comprises the search for traces and the securing, as well as the interpretation of traces. [10].

In this sector those types of traces and their respective investigative methods were selected in which their state-of-the-art applications resemble the questioning of a silent witness.

## Dactyloscopic traces

The origins of the term „Dactyloscopy" can be found in the Greek words δάκτυλος ("dactylos" = finger) and σκοπειν ("scopein" = to inspect). As a verbatim translation it would mean "finger inspection". It is based on the fact that each individual has characteristic traces (skin traces) on the fingers and on the palms, as well as on the toes and the feet. These do not change from the foetal development of the 4th month up to the decomposition of the body after death [11]. The term 'fingerprint traces' can be explained by the verruca-like papilloferous surface with ridges of the dermis (corium), called papillae. Nerve cells, blood vessels and sebaceous as well as perspiratory glands, responsible for the dactyloscopic traces, are found in the dermis. These are connected with the surface of the epidermis by pores and bring about the transfer of the sebaceous secretions (tallow) and sweat in the form of characteristic line patterns.

A fresh dactyloscopic trace consists of approximately 98% water. Additionally, it contains inorganic salts (primarily chlorides) and organic components such as fats, amino acids, peptides and urea. In some cases small amounts of other secretions and excretions coming from other parts of the body which were touched beforehand (e.g scents, pigments, blood or urine) can be detected in a fingerprint. Some substances which stick to the fingers (e.g. paint, oil or dust) can also leave prints on a surface [10].

Dactyloscopy is an important technique for identifying persons and dead bodies as well as for convicting culprits. A historical example is the solving of the case of Clarence Hiller (see L. Strobel [12]).

### History of the dactyloscopy

"It all happened in Hiller's house in Chicago on a dull Saturday afternoon. Clarence Hiller painted the façade of his two-storey house on this afternoon. In the evening he and his wife went to bed early. But what happened afterwards would revolutionise the crime law of the United States.

In the early morning of 19th September, 1910, the Hillers woke up. They became suspicious when they saw that the gas lamp, which stood beside the door to their daughter's room, was not lit. Clarence got up to find out the reason for this. Soon afterwards his wife heard a quick progression of noises: scuffling, two persons falling down the stairs, two shots and the banging of the front door. She ran onto the landing and found Clarence dead at the base of the stairs.

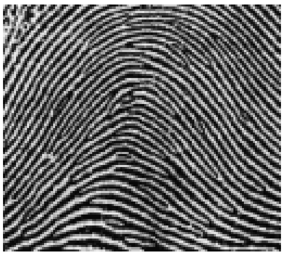
The police arrested Thomas Jennings, a well-known burglar, not far from the scene of the crime. He had blood stains on his clothes and his left arm was hurt. He claimed to have fallen out of the tram. A firearm was found in his pocket. It could have been the one which was fired at Clarence Hiller, but it could not be proved that it was the murder weapon.

The police searched the Hillers' house in the hope of finding evidence which could convict Jennings. Soon it became clear that the murderer entered the house through the back kitchen window. Furthermore, outdoors - directly beside the window –traces from four fingers of someone's left hand were found. These traces were immortalised in the white paint which was freshly applied the day before by the victim.

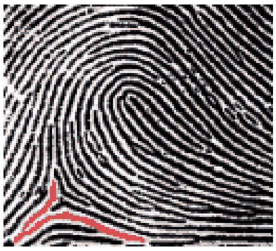
Fingerprints as a means of evidence had finally become a completely new source of evidence which was introduced at a police congress in St. Louis just a short time earlier, but up to this case fingerprints had not been used to convict a murderer.
The defence protested vehemently calling this evidence as unscientific and not admissible, but four policemen gave evidence before the court that the fingerprints in the paint corresponded perfectly to Thomas Jennings' fingerprints - and only to his. The court declared Thomas Jennings guilty, the Supreme Court of the State Illinois affirmed the judgement in a historical trial and Thomas Jennings was hanged soon afterwards."

The considerations of the historical development of dactyloscopy lead us to its beginnings in China and Japan. As early as the 7th and 8th century AD fingerprints were supposedly used on documents and even for court trials. The modern development of dactyloscopy in Europe has its origins in the 1880s when two Englishmen, Herschel and Faulds, published an article on the application of fingerprints for identifying the culprit. Practically, this new court procedure

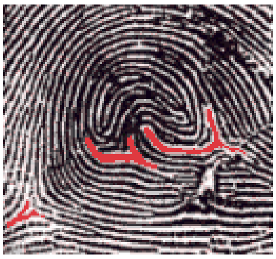
established itself after the publication of "Finger Prints" by the Englishman, Galton, in which he describes the uniqueness and the unchangeability of the ridges and their classification [5]. Henry published an improved classification system in the year 1900. In 1901, this system was introduced as the Galton–Henry system and it is still is the basis of many repositories of fingerprints in Europe, North America and countries of the former British Empire [10].
The following illustration (fig. 1) shows three basic patterns of the fingerprint traces taken from the fingertip which are distinguished in dactyloscopy:

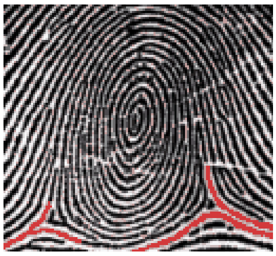


**a** arch ridge flow pattern
(no formation of a delta)



**b** loop ridge flow pattern





**c** whorl ridge flow pattern
(at least two formations of a bifurcation)

**Fig. 1:** Types of basic ridge flow patterns of the fingerprint trace picture of the fingertip (from [13]) (the y-shaped bifurcations areas are marked in red)

A dactyloscopic proof of identity is considered to have been satisfied when the comparison of characteristics conform in at least 12 anatomical parameters of form and position [11]. The amount is reduced to eight, when the basic pattern can be identified.

The Federal Criminal Police Office, Germany (BKA) maintains central institutions and repositories for the purpose of identification. Fingerprints are scanned by special cameras into the Automated Fingerprint Identification System (AFIS) and can then be compared. At present approximately 2.6 million persons are registered with their fingerprint patterns [14].

## Fingerprints at the site of crime – searching and securing them

Dactyloscopic traces are normally inconspicuous and can only be secured successfully after a careful reconstruction of the course of events and a choice of adequate methods at the scene of the crime as well as on the tools used.

This chapter gives an overview of the various methods used to make latent fingerprints visible. For the sake of completeness not only purely chemical but also (chemico-) physical procedures are described here.

**Adhesives**

The term "adhesion" (lat. adhaesio: stick to, adhere) describes the chemico-physical principle which is the basis of the procedures of securing dactyloscopic traces presented in this part. One uses the varying adhesive powers of the trace carrier and the substances transmitted by the fingers. Among these procedures the use of powders, vaporising the trace carrier with iodine, the flame-soot procedure and the so-called micro-particle suspension are all part of criminal investigations.

The procedures vary in the way the adhesives are applied. Common powders are spread or coated by means of a brush (squirrel hair, carbon fibre, magnetic, or Zephyr® [a kind of fibreglass], or marabou feather duster) onto the carrier [15, 16]. Iodine can easily be evaporated because it is highly volatile. This phenomenon is explained by a physical process of adsorption when the iodine vapour (or the iodine dissolved in a liquid) adheres because of the adhesive forces of the trace. The micro-particle suspension is used as a spray or dipping bath.

The most usual method is the application of powders to make latent traces visible [11]. Soot, graphite, (dry paper) toner, aluminium (also called "argentorate"), iron (which essentially matches the so-called "magnetic powder"), iron (III) oxide, copper (II) oxide, manganese (IV) oxide, lycopodium (spores of club mosses) and various special powders [10, 11, 15, 16, 17] are used. Molybdenum (IV) sulfide, which is described in more detail in the Small Particle Reagent, is used in this method as a suspension [15] and can also be recommended following tests by Lipscher [18] and by the author himself.
Fig. 2 shows an overview of the powders mentioned above:

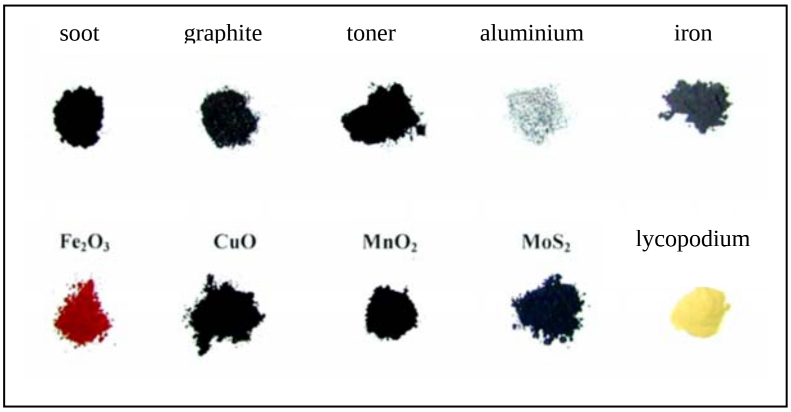



**Fig. 2:** overview of powders.

In practical criminalistic work fingerprints are developed with the help of powders. These are then photographed and secured by adhesive film [2].

The use of iodine is manifold. It is applied as a powder or as a vapour, but it may only be handled under laboratory conditions because it is poisonous and greatly irritates the mucous membranes. This means that it may not be used at the scene of the crime. It is especially suitable for trace carriers on paper. Because of the noticeable volatility of iodine the traces only remain visible for a short time and must therefore be photographed immediately or fixed by a chemical reaction. Starch or $\alpha$-naphthoflavon can be used for fixing the traces [17].

Some trace carriers do not allow conventional dusting because the trace carrier or the trace barely adheres, e.g. on surfaces plated with chromium or nickel. In such a case it is recommended by experts to soot the (heat insensitive) trace carrier directly over the open flame [16, 17].

A microparticle suspension (also called aquaprint, Small Particle Reagent or in short SPR) is used for developing wet or, ideally, extremely fatty traces [15]. The molybdenum (IV) sulfide is applied in the form of a suspension and adheres on the fatty parts of a latent fingerprint which becomes visible as a grey trace.

**Ninhydrin**

A chemical method to make fingerprints visible is the colour reaction between the amino acids of the dactyloscopic trace and a suitable dying reagent.

Specialised manufacturers offer certain agents for this purpose, e.g. the company BVDA International B.V. [19, 20, 21] sells:

(1) 1,8-diaza-9-flurenon (DFO)
(2) 5-methylthioninhydrin (5-MTN)
(3) 1,2-indandion
(4) 1,2,3-indantrion (Ninhydrin).

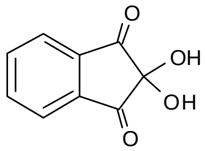
In the framework of this article only ninhydrin was used for the experiments. As there are numerous possible alternatives more details will be described in the following:

Further information on the reagents can be found on the internet under the addresses mentioned above as well as under [22, 23].

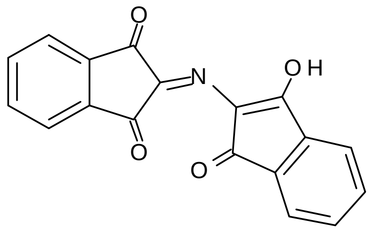
Ninhydrin is used for making latent fingerprints visible in practical police work. As a result mauve or crimson as well as violet or blue traces are obtained. The colours can be changed in a second process to obtain alternative colours.

The ninhydrin procedure is especially recommended for printing paper, newspapers and cardboard as the trace carriers [17]. This method is also useful for large areas of ingrain wallpaper as well as for fingerprints which are several years old. [24].

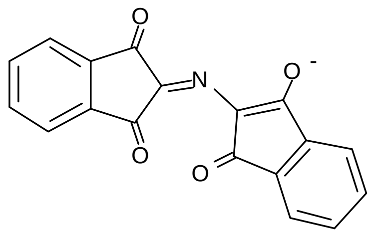
Ninhydrin reacts with amino acids, polypeptides and proteins [25], which are contained in the fingerprint. The underlying mechanism is comparatively complicated. A detailed interpretation can be found under [26].
Fig. 3 shows the structure of ninhydrin and the end products of the ninhydrin reaction:



**a** ninhydrin



**b** mauve/crimson



**c** violet/blue

**Fig. 3:** structural formula of **a** ninhydrin and **b**, **c** the end products of the ninhydrin reaction (after [25, 27]).

Experts suggest as solvents for ninhydrin, methanol [2], ethanol [28], Butan-1-ol [2, 28], acetone [2, 17, 28], or petroleum ether (40-60 °C) [17], for which some add glacial acetic acid, whereas others do not. The solvents acetone and petroleum ether (the NPB-procedure) are generally used in the practical work of the police.

After the application of the reagent solution the development of latent fingerprints to mauve/crimson or violet/blue traces either takes a comparatively long time at room temperature (approximately 72 hours) or approximately 30 minutes after heat treatment (90 - 100 °C), e.g. in the drying oven. A dish containing water provides the necessary air humidity in the oven.

As an alternative to the accelerated procedure in the drying oven, the trace carrier can also be heated with a flat iron [24]. In this case the trace must first be covered with a second sheet of paper (preferably absorbent paper). Should the quality of the trace still not be satisfactory, ninhydrin solution can again be applied onto the trace. The absorbent paper is then moistened with distilled water, put on the trace and ironed again.

As previously mentioned, alternative colours or fluorescent traces can be obtained by a second treatment. When the dactyloscopic trace (which has been treated with ninhydrin) is sprayed with zinc chloride solution (or zinc nitrate solution), then dried in the air and afterwards placed in the drying oven (70-80 °C), the mauve/crimson or violet/blue trace turns orange in the presence of the visible light. In this case it loses contrast.

When light with a wavelength of 480nm is used to irradiate the trace, which must be simultaneously cooled with liquid nitrogen, this improves the contrast because fluorescence occurs (a sensitive and relatively unreliable reaction).

The reason for the change of colour to orange in visible light and the fluorescence at 480 nm is the formation of a zinc complex (compare Fig. 4):

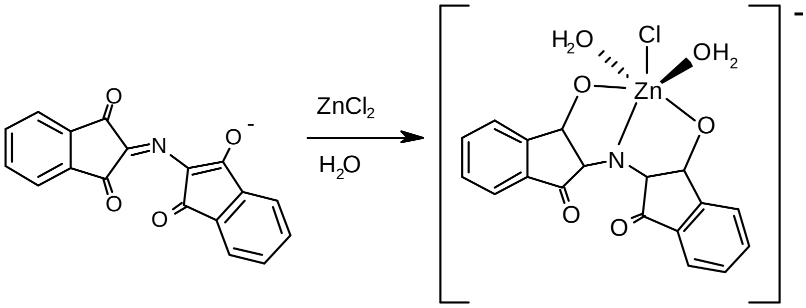



**Fig. 4:** Formation of a complex of the violet/blue colour product of the ninhydrin reaction with zinc chloride (after [29]).

Cadmium ions also form a fluorescent complex with ninhydrin. To achieve this effect the trace carrier must first be treated with cadmium chloride solution (or cadmium nitrate solution), then cooled with liquid nitrogen and irradiated with light of a wavelength of 505nm (sensitive, relatively unreliable reaction) [23].

The treatment with a copper (II) compound leads to a red coloration of the trace in the visible range of light, again this occurs because of a complex formation [2, 28].

**Cyanoacrylate**
It became possible in 1978 to secure latent fingerprints on synthetic fabrics, imitation leather and metals. This decisive advancement was brought about by the discovery that evaporated cyanoacrylate (instant adhesive or Super Glue) polymerises on finger imprints because the moisture contained in the traces [11, 30] stimulates this process. The fingerprints become visible as a greyish-white pattern and are protected against destruction.

Cyanoacrylate adhesives are one-component adhesives based on a monomeric 2-cyanoacrylic acid ester [31]. They cure very quickly with the help of traces of water and become high-molecular mass, uncross-linked polymers (that’s why they are called instant adhesives). Fig. 5 shows a structural part of the 2-cyanoacrylic acid ester polymer:

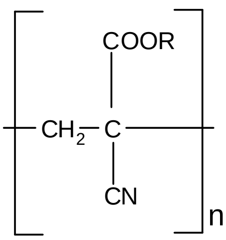


**Fig. 5:** 2-Cyanoacrylate ester-Polymer

When cyanoacrylate adhesive is applied, it forms a precipitate which is not normally desired. For securing traces this "blooming" is produced on purpose by evaporating the monomer. Products which are especially suitable for this purpose (e.g. SICOMET 5040 produced by the company Sichel-Werke GmbH) are stabilised at a higher level, this means they contain certain substances (acidic stabilisers in the ppm range), which provide a delayed polymerisation when the adhesive is evaporated.

The "Modified Super Glue® Technique", first described by J. Almog und A. Gabay [32], takes a polymerised 2-cyanoacrylic acid ester as the basis. This is heated, then decomposes into its monomers and polymerises again on the trace.

For a stronger contrast between the vaporised trace and the trace carrier, procedures for a second treatment are known which are similar to those of the ninhydrin procedure. For a dyeing in the range of visible light common powdery agents and an aqueous crystal-violet solution (also called Gentian Violet or more simply, GV solution) [30, 33] can be used. The traces are dyed blue/violet by the triphenylmethane dyestuff crystal-violet (see Fig. 6).

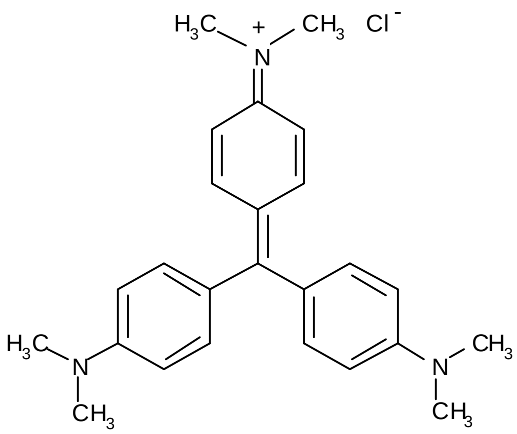


**Fig. 6:** Structural formula of crystal-violet.

By the application of safranin-O solution or a rhodamine-6 G solution, for example, and excitation with green light fluorescent traces are obtained [30, 34].

**Additional Procedures**
Additional methods for the securing of dactyloscopic traces must also be mentioned in this context:

*Gentian violet procedure* [11]: fingerprints can be made visible on the inner sides of adhesive tape (made of paper, textiles or synthetics, adhesive films) by GV solution, as already mentioned above. For this purpose the trace carrier is quickly dipped into or sprayed with the GV solution and then rinsed under running water. The traces turn to a blue colour.

*Detection of fingerprints on brass, e.g. on cartridge cases*, adapted after [2]: first the trace carrier is briefly dipped into an ammoniacal copper(II) salt solution several times. The result is a black colouring on the brass but not on the greasy fingerprints. The reason for the change in colour is the formation of copper (II) oxide.

*Application of acetic acid on trace carriers of copper* [17]: The trace carrier is exposed to acetic acid for several hours whereupon copper acetate (verdigris) is formed on the copper surface, but not on the fingerprints.

*Application of silver nitrate* [2, 18]: In this case the trace carrier (preferably "functional paper" such as printing paper or newspapers) is sprayed with silver nitrate solution. Afterwards the fingerprints are developed to violet, sometimes greyish-black line patterns under the influence of light (comparable with the photographic process).

## Shoe, foot and vehicle traces

"A drowned person was found in a river. It was supposed that he fell into the river by chance and the wounds on his head were caused by stones and other hard objects in the water. But somebody had the idea to draw a sketch of the victim's shoes and to follow the track on the riverbank. He followed it to a spot where there had obviously been a scuffle. The ground had been trampled, twigs of bushes along the riverbank were broken off and the tracks of two other men's shoes were discovered. These men have never been found, but with this discovery it became almost certain that a murder had been committed (see Baden-Powell [43])."

The method of securing these traces does not follow the latest knowledge of forensic science, but the story shows the importance of the actual shoe or footprint as potential evidence. Foot and shoeprints allow valuable information for clarifying a crime. Such examples are the walking pattern or the determination of (anatomical) characteristics of the feet, especially the shoes and their soles [3].

Traces of vehicles can also have individual characteristics in this context. Of importance are, for example, such attributes as damage, repairs or the wear of the tyres [3].

The sketch drawn in our introductory story is, as already mentioned, a historical procedure of securing traces and is a temporary solution only [3]. The state-of-the-art methods are classified according to the kind of trace. Casting traces are distinguished from impression traces.

### Searching and securing casting traces

Casting traces come into existence by a transmission of substances which adhere on a solid, smooth trace carrier by shoes, feet or tyres [44].

Latent casts of naked feet can be made visible by the adhesives already discussed or secured by their haul-off with the help of adhesive tape [3].
A special gelatine film is generally recommended for casting the traces of shoes [45, 53]. This film is placed onto the casting trace and thus the substances of the trace carrier are absorbed.

Special procedures exist for making castings (or latent impressions) on carpets [47]. A physical method of this kind is to use the electrostatic charging of the surface when walking. The traces are then made visible by tiny, light-weight pellets. Another procedure is the so-called interference holography which interprets invisible footprints on a carpet. Two holograms made on the same photographic plate make the footprints visible.

Traces of tyres are made visible by exciting them (actually their softeners) with UV-light to make them fluorescent (see experiment - Lipscher [18]). Good results are obtained on concrete and paving stones. Traces of bitumen or tar cannot be recognised because these trace carriers tend to become fluorescent themselves [47].

**Securing impressions**

Shoe, foot or tyre impressions can be formed in soft, mouldable substances, e.g. in sand or soft soil. A cast of such traces becomes necessary when it is not practically possible to secure the original. A three-dimensional mirror-image is obtained which has the same value of evidence as the original trace [17]. Gypsum is generally used for casting [3].

Before the actual casting the trace must be fixed. Hairspray, clear varnish or an ethanolic shellac solution are used for this purpose [3, 17]. They produce a thin, solid layer and prevent damage when the plaster blend is poured into the trace.
The casting material can either be the so-called "normal" plaster of Paris (anhydrous gypsum) (e.g. "Molto-fill" or similar products) or dental plaster [17]. The latter excels because of its flowability during application, low expansion rate and its property of hardly warming up while setting. A smooth, non-porous surface is obtained after curing [48, 49]. These special properties can also be achieved by the addition of so-called suspending agents. Water-soluble melamine resin, for example, provides an improved flowability if added to the plaster blend [50].

The reaction of calcium sulfate-hemihydrate with water to calcium sulfate-dihydrate is responsible for the curing of all kinds of gypsum.

## Tool traces

Classical burglars often gain access to their objective violently and they use all kinds of tools to achieve this. For forensic science a new complex of traces opens up: tool marks.

According to Pohl [2], tool traces are "impressions or casts of tools which the culprit used at the site of crime and its surroundings."

Their form or appearance allows us to distinguish between:

(1) Traces of impressions and shapes
(2) Traces of sliding, scratching and notches
(3) Traces of pinching and severing
(4) Traces of sawing and drilling
(5) Traces of chopping, chipping and cutting
(6) Special forms: changes of the manufacturer's signs.

In the practical work of the police this area comprises the identification of tools by characteristic shapes, the investigation of safety devices (locks, etc.), machines and instruments as well as the reproduction of manufacturer's numbers on vehicles, firearms, etc. [44].

Casting procedures based on the use silicone and the etching technologies for the reproduction of removed or changed manufacturer's numbers have a special importance for securing traces.

**Casting with silicone**
In case a trace cannot be kept as the original, casting procedures – similar to those of shoe, foot or tyre prints - have to be applied as a general rule. However, instead of gypsum, materials based on silicone rubber have achieved acceptance in securing traces of tools (presumably of solid trace carriers) required [3].

These silicone rubbers essentially consist of polydiorganosiloxanes ($-R_2SiO-$, where R = organic residue), which can be transferred to an elastic state, like rubber, by a cross-linking reaction. The name siloxanes refers to the Si-O-Si bonding. They additionally contain reinforcing agents as fillers (e.g. silicon dioxide) and pigments for an improved photographic documentation. The cross-linking (vulcanisation) occurs at room temperature. For this reason such silicones are also called cold-curing or RTV- (for: room temperature vulcanising) silicone rubber masses. The commercially available products are two-component systems (RTV-2), i.e. vulcanisation only occurs after the addition of a cross-linking agent ("hardener"). These are mixtures of silicic-acid esters (e.g. ethyl silicates) and organotin reagents. The cross-linking reaction proceeds by the formation of Si-O-Si bridges from -Si-O-R and Si-OH and by the elimination of alcohols.

Its chemical property explains the complete name: condensation cross-linking RTV-2 silicone rubbers [31, 51, 52].

**Changes of the manufacturer's number**
Vehicles, firearms and keys for locking systems are typical objects which hold an individual sign in form of letters and numbers and – in the case of firearms – proof marks or strafing signs. They allow the identification of an object and in most cases that of its owner, as well.

If such an object is used in a crime, the culprit often changes this exposing trace. This can be done by filing, drilling, sanding or smashing the original number or by destroying other signs.

Forensic science uses metallographic etching in such cases for the reproduction of the original sign [2] (also called "structural contrasting", see Petzow [53]).
This procedure makes the changes within the structure of the material visible. These changes were produced when the sign was originally put on to the metal. This effect is achieved by working with oxidizing agents which react with different parts of the metal's surface at different rates. This is due to the grain/structure of the surface being different where the metal was altered by embossing/filing and the remaining areas which were not disturbed. The testing of the surface relies on the potential differences which are set up naturally between these different areas [53].

Fig. 7 shows a photograph taken by a scanning electron microscope of an aluminium surface after the application of 10% sodium hydroxide solution as the etching agent.

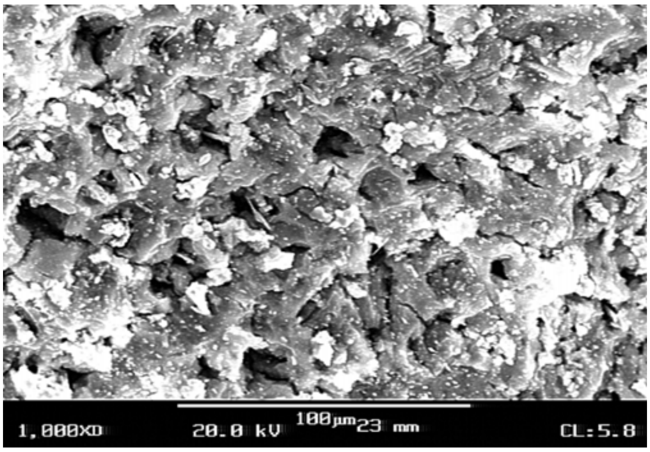



**Fig. 7:** Aluminium surface after application of 10% sodium hydroxide solution.

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