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Techniques of Chemical Analysis in Forensics

Mariana-Alina ŞTEFĂNOAIA[1]

Abstract: The main purpose of the article is the development of knowledge related to finding out and establishing the truth through the technical-scientific interpretation of the traces left on the spot by criminals, aiming at the perfection of the applicable legislation in the field and the nuance of alternative-traceological solutions regarding the ways of establishing the truth through the interpretation of biological traces, respectively: traces of a hairy, odontological, osteological and nail nature, as well as traces of sperm, blood, saliva. The chosen research topic is strictly topical since biological traces represent a very common branch in forensic research. Daily life highlights the fact that the vast majority of criminal acts that were committed by violence leaving material evidence of the events at the scene, but the insufficient training in this field, as well as the lack of certain materials for strict analysis in finding and reporting the traces left behind on the spot, lead to the conclusion that there are situations in which some investigators do not observe in detail all the evidence, which hinders the investigation and finding out the truth, creating irreversible consequences both for the person involved and for the society in which we live. Currently, when we take part in the competition between criminalists and lawyers, as well as criminals, it can be highlighted that the benefits of a system that wants to be democratic benefit, for the most part, the people in the area of delinquency, giving rise to numerous questions regarding the way in which forensic specialists, investigators and magistrates are trained (Stancu, 2010, p. 8). The importance of the chosen theme resides in most of the difficulties encountered in practice due to lacunar legislation and doctrinal opinions, as well as the existence of a non-unitary jurisprudence. The chosen research topic aims at documenting the current state of knowledge and interpretation of biological samples of a biological nature, to perform experiments to be able to conclude investigative reports, as well as to identify uncertainties arising in forensic practice.

Keywords: investigator; forensic; evidence; analysis

[1] Legal adviser, member of the Methodological and Professional Guidance Commission of the Suceava College of Legal Advisers and member of the Methodological and Professional Guidance Commission of the "Romanian Order of Legal Advisers" Federation, Romania. Corresponding author: stefanoaia.mariana@yahoo.com.

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1. Introduction

Forensics came into existence at the end of the 19th century, its founder being Hans Gross. In 1893, the term forensics was used for the first time, through the publication of the Manual of the investigating judge, which was shortly republished under the name of the Manual of the investigating judge in the criminalistics system.

Forensics was known until the end of the Second World War under the name of technical or scientific policing as forensic means, procedures and methods were used specifically by police bodies. This name referred only to the technical-scientific component, not to the methodological and tactical component (Antoniu, Volonciu & Zaharia, 1988, p. 163).

Since its inception, forensics has been considered one of the frontier sciences (Stancu, 2010, p. 27). In specialized literature, different opinions have been expressed regarding the character of forensic science as an independent science, currently there is a consensus on the fact that it has its own object of using existing methods (Colectiv, 1976, p. 15).

Therefore, Criminalistics is a set of procedures applicable in the research and study of crime to arrive at its proof (Ceccaldi, 1962, p. 6).

Forensics is a multidisciplinary science that deals with the development of technical-scientific means, methods and tactical procedures for discovery, fixation, administration, and examination of evidence, in order to investigate and prevent crimes (Anghelescu, 1984, p. 48).

Forensics is the science that is in continuous progress, it puts at the disposal of civil courts, as well as criminal ones, new means for finding the truth and justice uses them to the full (Stoenescu and Zilberstein, 1973, pp. 95-96).

From the analysis of all the expressions in the specialized literature, it can be concluded that forensics is a judicial science, with an autonomous and unitary character, which sums up a set of knowledge about the methods, technical means, and tactical procedures, intended for the discovery, investigation of crimes, identification the people involved in their commission and the prevention of antisocial acts (Stancu, 2010, p. 28).

Forensics is also known as the science against crime (Ionescu & Sandu, 2011, p. 2) because it consists of three complex branches that complement each other, respectively:

- forensic technique that includes all the technical-scientific means and methods aimed at discovering, examining, fixing, and picking up evidence or traces;

- forensic tactics include a set of rules and procedures specific to criminal investigation and trial activities, (for example - on-site investigation, identification of the perpetrator, listening to the defendant, conducting searches);

- forensic methodology aimed at the analysis of certain crimes (for example crimes related to road accidents, crimes related to theft of personal property). Therefore, the forensic methodology determines which are the procedural activities that must be carried out during the forensic investigation of a crime (Cătuna, 2008, p. 4);

Analyzed from a scientific point of view, it can be concluded that the analysis directions of forensics are:

- the development and use of technical-scientific means and methods aimed at the discovery and investigation of traces resulting from the commission of crimes (human traces, traces left using means of transport, traces left by weapons or other instruments);

- adapting the methods used by the exact sciences to the needs of Forensics (for example, the specific methods of chemistry, physics, mathematics);

- elaboration of procedures and tactical rules intended for criminal prosecution, as well as increasing their efficiency, by ensuring the specific scientific foundation of the investigation;

- studying the judicial practice to establish the experience of the criminal investigation bodies on the criminal line;

- analysis of the evolution of the ways of committing criminal acts, to establish the methods and procedures for preventing and combating the commission of criminal offences;

- improving the way of researching the numerous categories of crimes, with applicability to those that harm social values;

- elaboration of methods and foreshadowing of measures intended to prevent antisocial acts.

So, forensics is a legal science that finds its applicability based on four principles:

- the principle of legality regulates the entire activity of a rule of law that is carried out in accordance with the legislative provisions in force at the time of their application;

- the principle of finding the truth assumes that the entire activity of criminal justice can only be carried out by finding the truth;

- the presumption of innocence establishes that any person is presumed innocent until proven otherwise;

- the principle according to which there is no criminal act without the existence of traces.

In conclusion, it can be highlighted to be able to prevent the criminal phenomenon, the competent authorities must resort to effective means and methods because contemporary society is in a continuous evolution, and forensics must take over all the scientific discoveries that have appeared in the key fields in order to be able to prevent criminal phenomena.

2. The Importance of Traces in Criminalistics

Forensic research is part of the scope of the criminal side and represents an element of novelty because biological traces make up one of the most important branches of crime, especially the investigation at the scene.

The latter notion has received several legal connotations over time, which leads to the fact that no exact definition is attributed to it. It is certain that the traces illustrate any modification produced by the human body that can be found on the surfaces identified at the scene of the crime, modifications that can lead, after a thorough analysis, to the identification of the perpetrator.

According to specialists in the matter, there is no deed without traces, and between the perpetrator's deed and the identified traces there is always a causal relationship characterized by the same criteria as the causal relationship present in the structure of the objective side of the crime (Stancu & Manea, 2016, p. 5).

The forensic analysis of the traces identified on the spot by the specialists in the field is a very complex analysis because it involves a mixture of physical and mental processes based on which the analysts in the field must reconstruct the criminal trail, in such a way that it corresponds to the truth. This analysis is carried out at the express request of the criminal investigation bodies, by forensic experts and specialists, with adequate training and experience (Păşescu, 2000, p. 29).

In specialized literature, the phenomenon of traces has been called the principle of exchange or transfer because its interpretation can be understood as any change occurring in the conditions of the commission of a criminal act, between the act and its material reflection, creating a relationship of causality and regardless of expression, the points of view regarding the definition of the trace were relatively close.

2.1. Papillary Marks

The papillary patterns, specific to the skin of the human body, located at the level of the fingers (palm and sole of the foot) are formed by the system of parallel lines of papillary ridges, separated from each other by papillary grooves. The papillary ridges reproduce the irregular relief of the dermal papillae, located at the connection line between the two main layers of the skin, the dermis, and the epidermis (the latter undergoes a permanent flaking process).

By referring to the identification value, the essential element that led to the use of papillary patterns in the identification of people is that not only the papillary pattern, in its entirety, but the papillary ridges themselves and even the pores present elements of specificity, a characteristic point capable of distinguishing a individual by another individual.

Many times, papillary marks are found in the crime scene in a latent state (not detectable with the naked eye), but they are many times of a much better quality than visible marks. Both physical and chemical methods are used to highlight and lift them. The numerous chemical methods of papillary mark removal are carried out under laboratory conditions because the chemicals used are toxic and harmful.

2.2. Biological Traces

The category of biological traces includes most traces of human biological material, especially the products of excretion, secretion and human tissues. The biological traces formed during the commission of a crime are numerous. So, in addition to the traces that are found especially at the crime scene (blood, sperm, saliva), traces of faeces, traces of urine can also be found at the scene, which through a careful analysis it is possible to obtain the necessary data and useful for clarifying the numerous circumstances regarding the nature and manner of committing the act, including elements to identify the perpetrator.

Although biological traces are very common in the case of violent crimes, in traffic accidents, as well as in fires or explosions, they began to gain significant value only in the last decades.

Most of the time, the criminal tries to hide the committed deed through different methods, especially in situations where complex crimes are committed, such as: rape, murder, qualified robbery. He tries to erase or destroy the traces of the crime, using various substances that lead to the difficulty of the investigation or even to his non-identification. Even in these cases, knowledge in the field of biochemistry and chemistry can facilitate the work of investigators and highlight or obtain the

categories of evidence that can be collected from the scene, and later analyzed in laboratory conditions, to identify the guilty person.

3. The Connection of Chemistry with Forensics

The connection between chemistry and forensics consists in the fact that it provides forensics with numerous technical-scientific methods and means, some of which have been specially perfected and adapted to support the criminal investigation process. The improvement of equipment and technical methods in the field of chemistry positively influences the specific activities of forensics, which leads to the conclusion that experts and specialists in the fields can go beyond the classical scope of processing and interpretation of evidence and evidentiary means of identification at the scene of the crime.

Forensic chemistry, as an integral part of forensics, is the one that, through the expertise of the traces left, administers the decisive evidence for the documentation and resolution of criminal cases. In the forensic investigation process of various cases, a very important role in the resolution of the cases is played by the chemical expert who, through the analysis and examination of the evidence provided by the judicial body, can issue relevant and conclusive conclusions for the resolution of the case. Forensic chemistry is applied Alaitic chemistry, and its uniqueness derives from the same considerations that define forensics as a distinct discipline, at the intersection of science and law.

When a forensic scientist examines forensic evidence, he has three main points in mind, namely: identification, classification of the evidence, and individualization or determination of common source.

The classification and identification of forensic evidence is often carried out by the forensic scientist conducting the on-site investigation and these activities require distinct levels of knowledge, depending on the level of knowledge in chemistry, but especially the knowledge of the chemicals used.

3.1. Trace Detection by Treating Objects with Cyanoacrylate Vapors

Cyanoacrylates are chemical compounds derived from esters of cyanoacrylic acid, CH2=C(CN)COOR (where R is an organic residue). These compounds are used for their very strong adhesive properties, generally used in medicine and industry.

The cyanoacrylate chemical compound is intended for forensic use is more fluid than the cyanoacrylate in the superglue composition and polymerizes more difficult when exposed to ambient temperatures.

The treatment with the chemical compound cyanoacrylate is used by analyzing the multitudes of semi-porous or non-porous surfaces (plastic, metal, furniture). When it contracts with the heated surfaces, the liquid cyanoacrylate gives off some vapors that react with the papillary deposit, making the papillary drawing possible. The method of treatment with the chemical compound cyanoacrylate brings numerous benefits regarding the indication of the scene of the crime as biological samples can be collected for DNA identification.

3.1.1. The Principle of Use of Cyanoacrylate Treatment

The cyanoacrylate solution evaporates when it is heated to a temperature of 120 degrees Celsius. The vapors condense and polymerize on the residue left in latent papillary impressions, making the papillary mark visible. At the same time, by using this method, the fingerprint is preserved and protected against all damage.

It is recommended to leave the papillary mark bearing object for at least 10 minutes at 80% humidity to rehydrate older papillary marks so that the salt (NaCl) crystals will absorb the moisture from the surrounding environment.

By taking papillary marks with the chemical compound cyanoacrylate, we mean the exposure of objects bearing papillary marks to cyanoacrylate vapors, by placing them in the oven for a variable duration, where the relative humidity is 80%, and the temperature of the cyanoacrylate heating plate is about 120 Celsius degrees.

In order to improve the trace-substrate contrast, chemical treatment of the papillary traces is resorted to, i.e. color acids. Regarding the use of colored acids after prior highlighting of the papillary ridges with ethyl cyanoacrylate, it was found that basic acids adhere best to the polymer surface, a fact that is explained by the fact that in alcoholic solution they form cations, ions with a positive charge , which adheres to the surface of the ethyl polycyanoacrylate polymer, by forming weak Van der Waals-type electrostatic bonds with the cyan CN - anionic groups contained in the polymer chains.

3.2. Trace Detection by Surface Treatment with 1,8-Diazafluoren-9-One (DFO) and Ninhydrin

3.2.1. Trace Detection by Surface Treatment with 1,8-Diazafluoren-9-One

The solution of 1,8-diazafluoren-9-one (DFO) is recommended to be used to reveal marks on porous surfaces such as: cardboard, paper, matte painted wall, raw wood. DFO solution can be used successfully in revealing papillary blood marks because it reacts like ninhydrin with blood proteins.

The reaction of DFO with the amino acids contained in the papillary deposit is selective, which leads to the further treatment of the sample already examined because with ninhydrin it will be possible to reveal additional papillary traces.

Respecting the order of use of the substances is very important because DFO or indandione can always be used before ninhydrin. DFO is a cheaper substitute for indandione, which can produce papillary marks with similar florescence.

DFO can be purchased as a liquid substance, as a spray or atomizer, or as crystals.

The DFO solution can be used by spraying onto objects, either by dabbing or by immersing the object in the solution for about 10 seconds. If necessary, the drying process of the objects can be resumed. The objects are allowed to dry at room temperature. The process can be accelerated by drying the objects in a drying oven at temperatures of 100 degrees Celsius, without moisture, for about 20 minutes.

DFO reacting with methanol leads to the formation in a first step of hemiketals, which are much more reactive in the reaction with amino acids than DFO treated directly with amino acids. Hemiketals, in reaction with amino acids, more precisely with the amino group, leads to the elimination of a water molecule, linking the double bond nitrogen to the DFO molecule. A chemical decarboxylation reaction takes place, removing a molecule of CO2, resulting in an aromatic imine, which adds water, resulting in formic aldehyde as a byproduct and an aromatic primary amine. The latter reacts with a new molecule of DFO, resulting in the final reaction product, with a structure like Ruheman's purple compound.

3.2.2. Trace Removal by Treatment with Ninhydrin

Ninhydrin (2,2-dihydroxyindan-1,3-dione) is an organic compound used for the identification of ammonia, primary and secondary amines, and amino acids, with which it forms a purple-violet coloration. It is also used for the detection of fingerprints, reacting with the amino groups in the residues belonging to the peptides and proteins that are left with the fingerprints. The compound itself is a white solid soluble in ethanol and acetone.

The ninhydrin solution is recommended to be used for removing traces on porous surfaces such as: cardboard, raw wood, paper.

The final product of the reaction is called "Ruhemann Compound" or "Violet Ruhemann" after Siegfried Ruhemann, who first created the ninhydrin solution.

The solution can be used by spraying on objects, either by dabbing or by immersing the object in the ninhydrin solution for about 5 seconds.

Allow the objects to dry at room temperature. The process can be accelerated by drying the objects in a drying oven with temperatures of 80 degrees Celsius, relative humidity of 65%, for 10 minutes. Temperatures higher than 100 degrees Celsius can lead to the alteration of papillary marks by coloring the background.

Each carbon atom involved in the carbonyl group has a partial positive charge, which is raised by the electron-withdrawing groups, being therefore strongly electrophilic. Therefore, indan-1,2,3-trione reacts very easily with nucleophiles such as water. Due to this, the trione hydration product, i.e. ninhydrin, is much more stable than this, due to the destabilizing effect of the central carbonyl groups.

The ninhydrin reaction occurs in the reaction with alpha-amino acids. In the first step, ninhydrin dehydrates to reform indan-1,2,3-trione, and this reacts with amino acids, forming a Schiff base. Finally, in the aqueous medium, the bound residue (denoted R) cleaves from the imine moiety, forming an aldehyde and a diketohydrindamine. This diketone condenses with a molecule of ninhydrin, forming the imine dimer chromophore derivative, often known as Ruhemann violet, 2-(1,3-dioxoindan-2-yl) iminoindan-1,3-dione.

4. Conclusions

Due to its own object of research, forensics is specific to certain methods of knowledge, some of them typical of the respective science, others common to most sciences, but with applicability, in accordance with its object. At the base of the forensic methodology, as, moreover, of all sciences, there are general ways of knowing such as analysis, synthesis, adapted to the specifics of the object of forensics. In the complex activity of preventing the criminal phenomenon, in the struggle led by the judicial bodies for the discovery of crimes and the identification of the perpetrators, the need to resort to more and more perfect means, methods, and procedures is felt more and more. Ignoring scientific achievements, as well as the incessant improvement of one's own means, would be unthinkable today for a thorough forensic investigation of crime traces or material evidence. Even on a tactical level, the need to add to the rules for the conduct of investigation activities, to some technical procedures to scientifically demonstrate the results obtained during criminal investigations, can be noted. As a consequence, forensics is one of the sciences without which the actions taken by the judicial bodies could not have a result, so that through it, the specialists in the field proceed to reveal a reality that arises as a result of imagination processes regarding the attempt experts to understand the nature of crimes and the ways in which they were committed, human biological traces being among the most accurate, their ability to identify the unique characteristics of the individual perpetrator often remaining indisputable over all other types of evidence.

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