Editorial



Forensic examinations of micro-traces

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The detection of almost every crime needs the help of forensic specialists. Dr. Locard's exchange principle (Locard's principle) formulated at the beginning of XX century holds that the perpetrator of a crime will bring something into the crime scene and leave with something from it. The examples of evidence traces at the crime scene are the following: single hair, clothing fibers, glass crumbs, chips of paint coatings and plastics, fragments of the epidermis, metal particles or soil. Among all the traces of special interest in forensic science there are micro-traces, not visible to the naked eye, but yet very important for revealing the truth about the event, its course and its participants [1]. They may also contribute to apprehending the perpetrator. A small trace, generally unnoticed by a naked eye, can only be revealed by the use of special magnifying instruments or by illuminating the surface, where it is expected to light of a specific wavelength of electromagnetic radiation. Another way is to use special chemical substances that react with the material making the trace to be visible. However, the disclosure of certain types of evidence material, regardless of their mass, size or volume, may require the use of special equipment or methods to search for narcotic drugs or psychotropic substances or explosives. In revealing the traces, both the knowledge and the ability to search for them depend on the type of event. The imagination and perception of forensic technicians is particularly helpful here. In the examination of the crime scene and the protection of evidence may also be attended by a specialist, such as an expert in forensic physics and chemistry.

Another important issue is to protect the traces properly so that they do not become confused and contaminated since their disclosure to delivery to the laboratory. Moreover, the reference (comparative) material is necessary for the comparative tests. This material should match the evidence in terms of concentration, color, gloss, odor, chemical composition and other characteristics of the substance. At the same time, the principle of representativeness of the collected material should be respected.

Physico-chemical examinations of micro-traces

The revealed and secured traces are identified in the laboratory using modern physicochemical methods that allow traces of milligrams or even micrograms to be investigated and are non-destructive, allowing the materials to be re-examined in the same or another method, often without prior separation from the substrate on which they occur. Establishing the chemical composition and properties of the trace usually makes it possible to determine its type and origin and so, to perform its identification [2]. For example, determining the morphological structure of fibers found under the fingernails of a raped victim and identifying its polymeric composition allows one to determine the type of fiber (natural, synthetic, artificial) and its application (for underwear, clothing, decorative). Comparing their composition and color with the appropriate characteristics of the fibers of the suspect's garment, one can confirm or exclude the possibility of contact between the persons. Another example can be the analysis of the mud on the suspect's shoe (soil trace) and its comparison with the soil sample from the site of the incident, which is helpful in confirming the presence of the suspect at this site. The importance of physicochemical research is therefore not overestimated.

Physicochemical investigations of traces and micro-traces embrace a variety of sensitive analytical methods. The choice of the analytical method is determined by the questions put forward by the contractor of the expert's report. However, the specifics of the research material itself are decisive. This is why an expert with special knowledge can properly evaluate the properties of the evidence material and select the investigative methods. However, this does not mean his full freedom of choice, not to say it's randomness. The expert always pays attention to the frequency of successful identification of similar materials in executed other cases and takes into account the selectivity and sensitivity of the method as well as the probability of an error. He also pays attention to the reliability, with which the findings are made and prefers the methods that guarantee sufficient results. The popularity of the method among the representatives of the trial body is also considered [2].

An indispensable technique in the examinations of traces is microspectrometry. An on-line optical microscope with a spectrometer operating in different electromagnetic radiation ranges allows both the morphology (structure) of the trace to be determined and the spectrometric measurement for the selected fragment. It enables one to determine the structure, color and chemical composition of the trace material [3-7]. The so-called "coupled methods" that are a combination of two different analytical methods, e.g. gas chromatography and mass spectrometry gained the importance over the years. By combining a gas chromatograph with a mass spectrometer and a pyrolyzer, it became possible to investigate the thermal decomposition of solid samples, i.e., plastics, paints, adhesives, gums [8-10]. Thus, a tool has been developed to allow for a more precise determination of the chemical composition of the samples being tested, as well as to distinguish samples belonging to the same product group, but with a slightly different composition, as previously determined by another technique, for example by infrared spectrometry. This method does not require complex preparation of the analyzed sample for testing and is relatively fast.

Combining a measuring device with a computer allows one to store the measurement results, collect them as catalogs and data bases to be used in later comparative research.

Evaluation of the analytical results

It should be noted that due to occurrence of various objects in the

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Received: March 10, 2017; Accepted: April 04, 2017; Published: April 07, 2017

environmental of a human being with lower or higher frequencies, they may have different evidential value. Physicochemical characterisation of an object that became an evidence allows to evaluate the extent of its similarity to the reference sample. Materials such as paint, glass, fibers and plastics are produced in great amounts within production lots and not always they may acquire individual characteristics as a result of use. Therefore, conclusions from physicochemical examinations can only be probable and not categorical. In the absence of reference material the results of physicochemical tests are compared with the databases of the individual groups of materials held by the laboratory, and then the classification of the trace material is possible, i.e. an assignment to the group/ class of materials (articles). The more features are considered in comparison and the more analyzes an expert would perform, the smaller the group/ product class is established.

Often, traces of paints and varnishes are protected during the investigation of a traffic accident or a burglary site. It is then the task of the expert to determine, whether the specimens of the paint producing a trace and a comparative paint obtained, for example, from tool or a vehicle body belonging to the suspect may have come from the same source, i.e. have been parts of one and the same coating. When there is no reference material available, because the perpetrator of the incident is unknown, the examinations are undertaken to attempt the identification of the type and origin of the material, or possibly to find the manufacturer of the coating product. Consequently, it is often possible to determine, for example, the type of vehicle or tool from which the evidence fragment could have been separated. For example, if on the surface of a crowbar being found in the house of a suspect micro-chips of paint consistent in colour and chemical composition with the paint visible on the door that was forced during the burglary, it is very likely that the perpetrator used the crowbar. If on clothing of a pedestrian being hit by a vehicle there is present a smear that reveals a colour, structure and chemical composition compatible with a car paint coating on the suspect's vehicle body [3-5], it is likely that the car was in contact with the injured person. The expert's opinion will always be formulated in terms of probability, since the basic characteristics, such as color and the main components, are the same, and the difference usually concerns ingredients present in small quantities: impurities and additives originating, for example, from raw materials used for production or deliberately introduced for modifying the material properties. The more features will be taken into account, the more precise will be the comparison. On the other hand, the comparison of the paint splinters revealed at the traffic accident site with the data base of the paint coating leads to the establishing of the paint type, and sometimes also to the brand and model of the vehicle that was involved in the collision and drove off the scene. Such a vehicle type information helps the Police to find the vehicle of the offender.

The car paint coating has a layered structure, which is clearly visible on its cross-section. The number, color, thickness and chemical composition of the individual layers depend on the type of coating. The most complex construction has a coating on the body of the vehicle, and the simplest on the surface of the tool such as a crowbar. Preliminary microscopic examinations allow one to observe the stratification of fragments of the paint coating. To determine the chemical composition of each layer, the method of infrared micro-spectrometry and X-ray microspectrometer are firstly used to establish the type of polymers that make up the coating and identify the main pigments and fillers. This makes it possible to determine the type of car varnish (acrylic, nitrocellulose, alkyd, etc.), and so its application.

In addition to the particles, abrasions of this type of material are

also encountered on the substrate, e.g. on clothing, road surfaces, and tools used in the crime. Often, abrasions are clearly visible with the naked eye, for example on the person's clothing hit by the vehicle there are coloured streaks formed by the transfer of particles of polymeric material (varnish, plastic) to the fabric and pressing or mingling between the fibers. Under severe operating conditions at the contact between the two surfaces, e.g. the tool (crowbar) and the door opened by means of it, or for example the clothing of the person being hit by a vehicle and the car body belonging to the perpetrator, local temperature increases, the polymer material is melted and easily transferred to the contact surface. Determining the compatibility of the composition of the transferred material (present in the abrasion) and the material of the contact surface can confirm this contact. Comparative studies always seek to establish a degree of similarity between the material that creates such a trace and the one present at the crime scene as well as the material that is secured from the suspect. To determine whether they may come from objects, tools, or clothing that surrounds us, is important to explain the course of the incident and establish the perpetrator.

At the site of the road accident there are also revealed the traces of rubber, visible in the form of tire marks on the roadway, which consist of the material of the car tire that is transferred to the road surface during a sudden braking of the vehicle. Analysis of the chemical composition of the trace material and comparing it with the material taken from the suspect's vehicle tires can help identify the vehicle being involved in the event. In the rubber tire alongside natural and synthetic rubber, there are additional chemicals to improve mechanical properties such as adhesion and abrasion and chemical resistance, e.g. resistance of finished products to atmospheric agents, fuels and oils. The type of additives used depends on the manufacturer and the type of tire [9].

The analysis of particles of the adhesive material used to seal the envelope or package allows the classification of the adhesive into a specific group of products based on its chemical composition. It also makes it possible to determine if it is a typical adhesive, which is routinely used e.g. to close envelopes / packages. Disclosure of two types of adhesive will lead to the conclusion that the letter was most likely opened and re-glued.

Summary

In the age of dynamic development of nanotechnology the penetration into increasingly deeper levels of structures of the investigated evidence materials create new possibilities for forensic investigation as it involves the use of increasingly sensitive analytical instruments being efficient in examinations of smaller and smaller quantities of materials in forensic laboratories. This in turn provides new opportunities for discovery and clarification, as well as the proof of crimes that recently could not have been unraveled.

Although the size of the disclosed trace is small, it provides valuable information about the criminal event. Each case must be analyzed individually and answering the questions of the contracting authority depends not only on the knowledge and experience of the expert, but also on what kind of evidence will be made available to the research and how well secured. An expert opinion is an evidence in the preparatory proceedings. There are no perfect methods or infallible experts. There are only methods that are better and experts, who mistake less frequently than others. However, the expert is always responsible for honesty and diligence in carrying out the tasks entrusted to him. The court as the highest expert may reject even the most faithful opinion.

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