Original scientific papers UDK 66.017/.018
doi: 10.7251/COM1201100Z

THE ROLE OF CONTEMPORARY MATERIALS IN DETECTION OF MICROTRACES FOUND ON THE CRIME SCENE

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Summary: Having in mind a rapid increase in technological innovations and the use of the materials thus obtained in criminal acts prosecution, it is essential to point out at the importance of the materials as the traces in the presentation of evidence process, since they can be found as micro traces at the crime scene. In all criminal acts perpetrated in the territory of the Republic of Serbia in the past and recent few years, ranging from robberies and heavy thefts and traffic accidents with escaped perpetrators, as well as the criminal acts of rape and murders (attempted murders), micro traces of materials were found at a crime scene. These traces were further analyzed in forensic laboratories of the National Crime-Technical Center of the Republic of Serbia of the Ministry of Interior and thus provided material evidence for the investigation procedure, pre-trial and criminal proceedings. The mentioned microtraces have been examined by ordinary analytical methods, such as Fourier Transform Infrared Spectrophotometry (FT-IR) and Scanning Electron Microscopy with electrodispersive spectrometer of x-rays (SEM/EDS). The new forensic method of probabilistic statistics was applied on the results obtained.

Keywords: contemporary materials, microtraces detection, criminal acts, material evidences, probabilistic statistics.

1. INTRODUCTION

The example that will be presented here is related to a traffic accident in which a pedestrian was killed by a car, after which the perpetrator left the crime scene. The crime scene investigation included the recovering, determination and identification of the traces – the peel of the car paint and polish, plastic, glass, etc. In this case the only relevant element was the red peel of paint. Other elements of the investigation (traces and statements of the witnesses) were used to find a potential perpetrator of the accident. Based on the method of elimination it was concluded that the only two cars that were potential perpetrators could be of red colour (one of the important elements for investigation is that both cars were produced by the same factory "ZASTAVA" in Kragujevac).

Paint samples were taken from all suspected cars for the examination and experimental comparison (forensic expertise) with the samples taken from the crime scene. The experimental expertise was done by the application of Fourier Transform Infrared Spectophotometry FT-IR on one of the most modern devices "Thermo Fisher Corporation" model "Nexus 6700" (low energy domain) and by using Scanning Electron Microscopy with electrodispersive spectrometer – SEM/EDS "JOEL - Tokyo" model "JCM 6460 LV" (high energy domain).

The experimental spectrograms (FT-IR and SEM/EDS) obtained for the suspected cars that have been selected by elimination, were not able to give us any conclusion as to which of the two cars was responsible for that criminal act.

2. PROBABILISTIC METHOD OF EXAMINATION OF PAINT HISTOGRAMS

Having considered the facts above, the theoretical methods of examination were introduced [3,4]. Every experimental graphic (FT-IR spectrograms) contained three curves which are relevant to irrever-

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sible absorption and also one curve related to reversible absorption [1, 2]. This gave the possibility for application of all mentioned theoretical methods in order to determine the perpetrator of the criminal act.

The diagrams (FT-IR spectrograms in the domain of low energy) which are related to the irreversible absorption are processed by the method of minimal square on the basis of the tables constructed in this way. In the following text mark "0" was used to denote the data from the crime scene, while the indexes "1" and "2" denote the suspected cars. The following photos show the FT-IR diagrams which were analyzed:

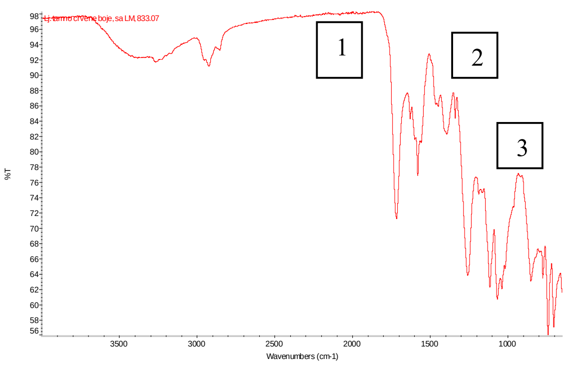

Figure 1. FT-IR spectrograms of the dark-red peel of paint from the crime scene. The spectral regions on which the theoretical method was applied is marked by the numbers 1-3.

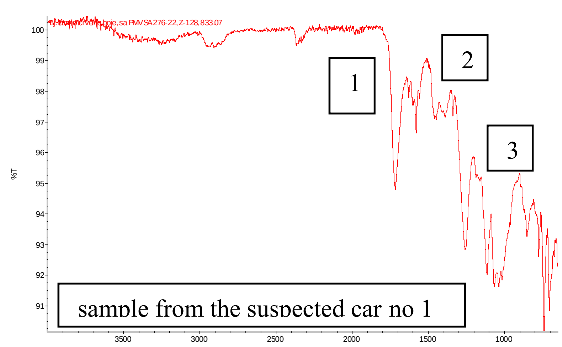

Figure 2. FT-IR spectrograms of dark-red peel from the suspected car number 1. The numbers 1-3 denote the spectral regions on which the theoretical method was applied

From the tables formed according to the data of the presented curves and by the method of minimal square, the coefficients of absorption were determined $\theta_{01}, \theta_{02}, \theta_{03}$:

$\theta_{01} = 2{,}16497$, $\theta_{02} = 1{,}73978$, $\theta_{03} = 14{,}2039$, by which and according to the composition formula

$$D_n(\lambda) = \left[\frac{e^{-\theta_1 \lambda}}{(\theta_2-\theta_1)(\theta_3-\theta_1)\cdots(\theta_n-\theta_1)} + \right.$$
$$+ \frac{e^{-\theta_2 \lambda}}{(\theta_1-\theta_2)(\theta_3-\theta_2)\cdots(\theta_n-\theta_2)} + \qquad (1)$$
$$+ \frac{e^{-\theta_3 \lambda}}{(\theta_1-\theta_2)(\theta_2-\theta_3)\cdots(\theta_n-\theta_3)} +$$
$$\left. + \frac{e^{-\theta_n \lambda}}{(\theta_1-\theta_n)(\theta_2-\theta_n)\cdots(\theta_{n-1}-\theta_n)} \right] \prod_{\mu=1}^{\lambda} N_\mu \, .$$

it is found that the abscissas of the maximum are λ_{0M} and abscissas of the saddle λ_{0P} are given as:

$$\lambda_{0M} = 5{,}58378 \text{ m}^{-1} \quad ; \quad \lambda_{0P} = 9{,}49071 \text{ m}^{-1} \qquad (2)$$

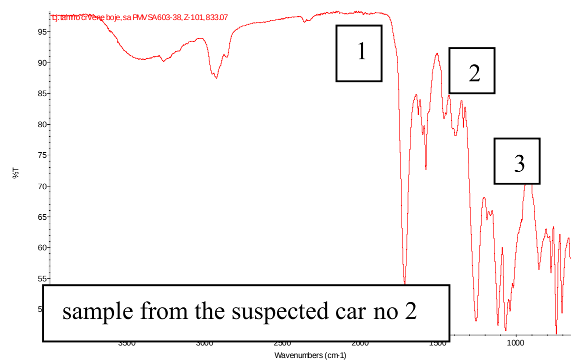

Figure 3. FT-IR spectrograms of the dark-brown peel from the suspected car number 2; the numbers 1-3 signify the spectral region on which the theoretical method was applied

By the application of the formula and mathematical hyphenation (the mean) of the wave length, the following value is obtained:

$$\langle \lambda_0 \rangle = 8{,}31743 \text{ m} \qquad (3)$$

For the paint sample for the car number 1, the tables with the index "1"are obtained. By the method of the minimal square the coefficients of minimum absorption were determined: $\theta_{11}, \theta_{12}, \theta_{13}$: $\theta_{11} = 2{,}16497$, $\theta_{12} = 1{,}73978$, $\theta_{13} = 14{,}2039$, by which and according to the formula of composition (1), it is found that the abscissa of the maximum λ_{1M} and the abscissa of the saddle λ_{1P}, as given:

$$\lambda_{1M} = 10{,}5518 \text{ m}; \quad \lambda_{1P} = 17{,}99 \text{ m} \qquad (4)$$

By the application of the formula and by determining the mathematical hyphenation (the mean) of the wave length λ, the following value is obtained:

$$\langle \lambda_1 \rangle = 15{,}7952 \text{ m} \tag{5}$$

For the paint sample from the car number 2, the tables with index "2" were obtained. From the tables and by using the least square method, the coefficients of absorption were determined $\theta_{21}, \theta_{22}, \theta_{23} : \theta_{21} = 1{,}55174, \theta_{22} = 0{,}50798\ \theta_{23} = 7{,}09774$, by which and according to the composition formula (1), the maximum of abscissa λ_{2M} and the maximum of saddle λ_{2P} are found:

$$\lambda_{2M} = 5{,}09032 \text{ m} \quad ; \quad \lambda_{2P} = 8{,}88347 \text{ m} \tag{6}$$

By the application of the formula and by determination of the mathematical hyphenation (the mean) of the wave length λ, the following value is obtained:

$$\langle \lambda_2 \rangle = 7{,}91257 \text{ m} \tag{7}$$

The absolute values of the differences are formed:
$|\lambda_{0M} - \lambda_{1M}|, |\lambda_{0P} - \lambda_{1P}|, |\lambda_{0M} - \lambda_{2M}|, |\lambda_{0P} - \lambda_{2P}|$.

These differences are:

$$\begin{aligned} |\lambda_{0M} - \lambda_{1M}| &= 4{,}96802\text{m}; \quad |\lambda_{0P} - \lambda_{1P}| = 8{,}49929\text{m}; \\ |\lambda_{0M} - \lambda_{2M}| &= 0{,}49346\text{m}; \quad |\lambda_{0P} - \lambda_{2P}| = 0{,}60724\text{m} \end{aligned} \tag{8}$$

From the formula (8) it is obvious that $|\lambda_{0M} - \lambda_{2M}|$ is less than $|\lambda_{0M} - \lambda_{1M}|$ and $|\lambda_{0P} - \lambda_{2P}|$ is less than $|\lambda_{0P} - \lambda_{1P}|$, so according to this test it can be concluded that the car number "2" is probably the culprit for the accident. In order to check the reality of this conclusion, the obtained results were examined by the method of reversible absorption and the coefficient of the reversible absorption *Φ* was determined by the formula [5-7]:

$$\Phi = \frac{x_1 \cdot x_2}{4\sqrt{\eta_1 \cdot \eta_2}}.$$

On each experimental diagram, one curve was found which is related to reversible absorption and according to them the following values were determined:

$$\begin{aligned} \eta_{01} &= 500 \text{ m}^{-1}, \quad \eta_{02} = 1.000 \text{ m}^{-1}, \quad \Phi_0 = 4{,}69 \cdot 10^{-3} \text{ m} \\ \eta_{11} &= 600 \text{ m}^{-1}, \quad \eta_{12} = 1.050 \text{ m}^{-1}, \quad \Phi_1 = 4{,}18 \cdot 10^{-3} \text{ m} \\ \eta_{21} &= 550 \text{ m}^{-1}, \quad \eta_{22} = 1.050 \text{ m}^{-1}, \quad \Phi_2 = 4{,}34 \cdot 10^{-3} \text{ m} \end{aligned} \tag{9}$$

We are forming the absolute value of the differences $|\Phi_0 - \Phi_1|$, $|\Phi_0 - \Phi_2|$.

$$|\Phi_0 - \Phi_1| = 0{,}51 \text{ m}; \quad |\Phi_0 - \Phi_2| = 0{,}35 \text{ m} \tag{10}$$

Since $|\Phi_0 - \Phi_2|$ is less than $|\Phi_0 - \Phi_1|$ and according to this criterion, it can also be concluded that the most probable culprit is the car number "2".

From each diagram obtained in the area of the high energies (experiment by SEM/EDS) three curves were chosen related to the irreversible absorption. According to them, the tables were made.

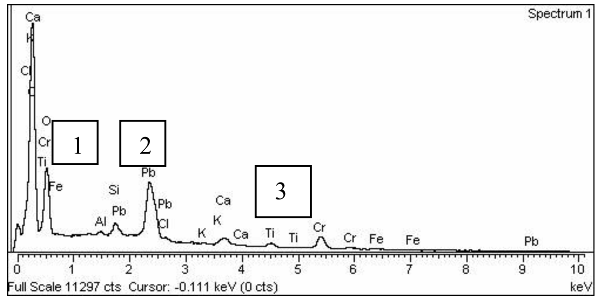

Figure 4.DIAGRAM SEM/EDS of the red acrylic car paint from the crime scene; Numbers 1 – 3 signify the regions of the examination

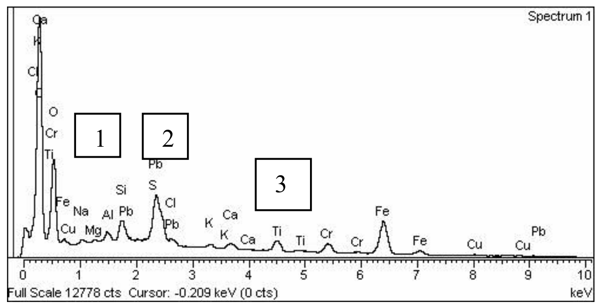

Figure 5.DIAGRAM SEM/EDS of the red acrylic car paint from the suspected car number 1; The numbers 1 – 3 denote the regions of examination

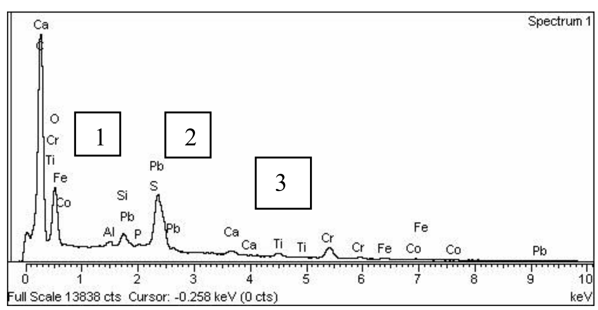

Figure 6. DIAGRAM SEM/EDS of the red acrylic paint from the suspected car number 2; the numbers 1 – 3 signify the region of examination

The tables with index "0" "gave" the following values:
$\theta_{01} = 3{,}882 \text{ m}; \quad \theta_{02} = 1{,}0519 \text{ m}; \quad \theta_{03} = 2{,}9065 \text{ m}$.

The composition formed on the basis of this data has the following values:

$$K_{0M} = 0{,}86891 \text{ m}^{-1}; \quad K_{0P} = 1{,}50025 \text{ m}^{-1} \tag{11}$$

$$\left.\begin{aligned} &\theta_{11} = 1{,}88889 \text{ m}; \theta_{12} = 0{,}73939 \text{ m}; \theta_{13} = 1{,}97475 \text{ m} \\ &K_{1M} = 1{,}41639 \text{ m}^{-1}; \quad K_{1P} = 2{,}43423 \text{ m}^{-1} \end{aligned}\right\} \tag{12}$$

$$\left.\begin{array}{l}\theta_{21} = 5{,}27349\ \text{m};\ \theta_{22} = 1{,}78628\ \text{m};\ \theta_{23} = 2{,}4124\ \text{m}\\ K_{2M} = 0{,}71214\ \text{m}^{-1};\quad K_{2P} = 1{,}23543\ \text{m}^{-1}\end{array}\right\} \tag{13}$$

We are forming the absolute value of the differences:
$|K_{0M} - K_{1M}|, |K_{0P} - K_{1P}|, |K_{0M} - K_{2M}|, |K_{0P} - K_{2P}|$.

These differences are:

$$\begin{array}{l}|K_{0M} - K_{1M}| = 0{,}54748\ \text{m};\quad |K_{0P} - K_{1P}| = 0{,}93398\ \text{m};\\ |K_{0M} - K_{2M}| = 0{,}156806\ \text{m};\quad |K_{0P} - K_{2P}| = 0{,}26482\ \text{m}\end{array} \tag{14}$$

Since $|K_{0M} - K_{2M}|$ is less than $|K_{0M} - K_{1M}|$ and $|K_{0P} - K_{2P}|$ is less than $|K_{0P} - K_{1P}|$, it can be concluded that car number "2" is more likely to be responsible for the accident [8].

At the end, the last conclusion was tested through the process of reversible absorption on the high energies.

On each experimental diagram, one curve was found related to the reversible absorption and according to them the following values were determined:

$$\begin{array}{l}\eta_{01} = 100\ \text{m}^{-1};\quad \eta_{02} = 600\ \text{m}^{-1};\quad \Phi_0 = 1{,}3548\cdot 10^{-2}\ \text{m};\\ \eta_{11} = 150\ \text{m}^{-1};\quad \eta_{12} = 600\ \text{m}^{-1};\quad \Phi_1 = 1{,}106\cdot 10^{-2}\ \text{m};\\ \eta_{21} = 100\ \text{m}^{-1};\quad \eta_{22} = 550\ \text{m}^{-1};\quad \Phi_2 = 1{,}415\cdot 10^{-2}\ \text{m}\end{array} \tag{15}$$

We are forming the absolute value of the differences $|\Phi_0 - \Phi_1|$, $|\Phi_0 - \Phi_2|$.

$$|\Phi_0 - \Phi_1| = 0{,}2488\ \text{m};\quad |\Phi_0 - \Phi_2| = 0{,}06\ \text{m} \tag{16}$$

Since $|\Phi_0 - \Phi_2|$ is less than $|\Phi_0 - \Phi_1|$ even by this criterion it can be concluded that the car number "2" is most probably the culprit for the accident.

If we consider the mathematical hyphenation (the mean) of the wave length: $\langle\lambda_0\rangle = 8{,}31743\ \text{m}$; $\langle\lambda_1\rangle = 15{,}7952\ \text{m}$; $\langle\lambda_2\rangle = 7{,}91257\ \text{m}$, as one of the additional criteria, we also conclude that car number "2" is the most probable culprit of the accident. This means that, if we form the absolute values of the differences: $|\langle\lambda_0\rangle - \langle\lambda_1\rangle|$; $|\langle\lambda_0\rangle - \langle\lambda_2\rangle|$, we see that:

$$|\langle\lambda_0\rangle - \langle\lambda_1\rangle| = 7{,}4777\text{m};\quad |\langle\lambda_0\rangle - \langle\lambda_2\rangle| = 0{,}40486\text{m} \tag{17}$$

If we consider the results of the theoretical analyses of the obtained experimental results, we can conclude with high probability that the car with number "2"is the culprit of the traffic accident, since such results were obtained according to four criteria [9].

3. CONCLUSION

The presented method of determined parameters for irreversible absorption and the results which are obtained can be used to identify the paints. It must be pointed out that this method is not based on the composition of reversible distribution and thus it is more partial than general. It should be emphasized that the convolution of Bessel's functions can be done as well as their composition, but this cannot be performed analytically, only by using the PC and software *mathematica* 5.2.

4. ACKNOWLWDGEMENTS

This paper was done under the project of Ministry of Education and of the Republic of Serbia no. TR34019. The authors express their deepest gratitude to the recently deceased Academician Prof. Dr. Bratislav Tošić for help and support over many years of research.

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УЛОГА САВРЕМЕНИХ МАТЕРИЈАЛА У ДЕТЕКЦИЈИ МИКРОТРАГОВА НА МЕСТУ ИЗВРШЕЊА КРИВИЧНИХ ДЕЛА

Сажетак: Имајући у виду напредак технолошких иновација и употребу тако добијених материјала у кривичним делима, као појавних облика микротрагова на месту извршења кривичних дела, неминовно је издвојити њихову важност као материјалног трага у доказном поступку. Код свих кривичних дела која су била изведена на територији Републике Србије у прошлој и непосредно ранијим годинама, посматрајући од разбојничких и тешких крађа до саобраћајних незгода са одбеглим извршиоцима, као и код кривичних дела силовања и убистава (убистава у покушају), на местима извршења кривичних дела детектовани су микротрагови материјала који су потом накнадно обрађивани у форензичким лабораторијама Националног криминалистичко-техничког центра МУП-а Р. Србије. На тај начин су обезбеђивани материјални докази који су даље коришћени у истражном, преткривичном и кривичном поступку. Поменути микротрагови су обрађивани стандардним лабораторијским методима форензичке науке, као што су: инфрацрвена спектрофотометрија са фуријеовом трансформацијом (FT-IR) и скенирајућа електронска микроскопија са електродисперзивним спектрометром x-зрака (SEM/EDS), на чије је резултате примењиван нови форензички метод пробабилистичке статистике.

Кључне речи: савремени материјали, детекција микротрагова, кривична дела, материјални докази, пробабилистичка статистика.