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FORENSIC ANALYSIS OF COLORED MATERIALS IN THE FIELD OF LOW ENERGIES

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INTRODUCTION

In this paper, the application of scanning electron microscopy methods with energy dispersive spectrometer (SEM / EDS) in the processing of experimental samples of colored materials is presented. In order to ensure better electrical conductivity of samples of colored materials, the samples were prepared with an ultrathin layer of gold by a nanotechnological process in a vacuum chamber (which is an integral part of a scanning electron microscope), and only then recorded and analyzed under different magnifications. Electron microscopy uses beams of very high energy electrons that cause changes in the nuclei of atoms that make up the color molecules. The results of the intensity measurement "landed" in the area of wave vectors between (10-7-10-9) cm-1, which equals energies of (2 - 6.5) 10-16 J, and means that the measurement results are the result of characteristic X-ray radiations. Here, the functions Cn (k) are found for all colors of the ranbow and their maximum abscissas are determined, which are marked with λm. In this case of color analysis at high energies, it was found that there is a law of magnitude λm of the type of paint. Legality can be formulated with the following statement: the red color has the largest abscissa of the maximum and it decreases towards purple, where its value is the smallest.

COLORED MATERIALS IN THE HIGH ENERGY FIELDS

Experimental analysis of the obtained samples was performed by the method of scanning electron microscopy with energy dispersive spectrometer (SEM / EDS), using the instrument of the brand "JOEL - Tokyo" model "JSM 6460 LV". In order to ensure better electrical conductivity of the paint samples, the samples were prepared with an ultra-thin layer of gold by a nanotechnological process in a vacuum chamber (which is an integral part of the device), and only then recorded under different magnifications. Diagrams obtained by recording samples using a scanning electron microscope with an electrodispersive spectrometer (SEM / EDS) are attached, while an example of one is given here in order to specifically show the method used in this paper. Figure 1 shows an SEM diagram of a red acrylic paint sample:

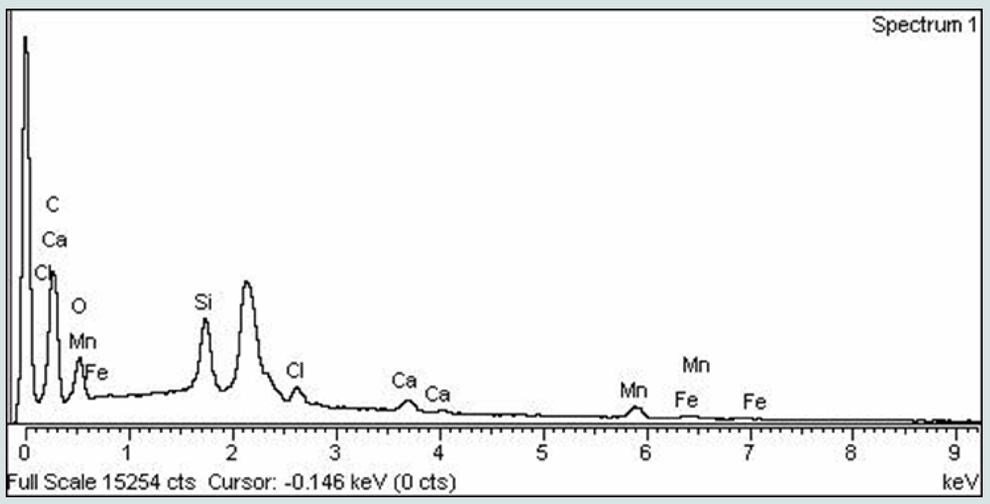

Figure 1. SEM / EDS diagram of red acrylic car paint. Numbers 1 – 3 indicate the test regions

After reading the values from the diagram, the corresponding tables (1, 2 and 3) are formed:

Table 1: Values from the ordinate and abscissa for the first region (1) of the spectrogram

$k = x_i$ $[10^{10}]m^{-1}$	N	$\ln N = y_i$
0,99	26	3,26
1,19	15	2,71
1,38	5	1,61
1,58	4	1,38

Table 2: Values from the ordinate and abscissa for the first region (2) of the spectrogram

$k = x_i$ $[10^{10}]m^{-1}$	N	$\ln N = y_i$
6,039	18	2,89
6,237	11	2,398
6,435	7	1,94
6,633	6	1,792
6,831	5,5	1,705

Table 3: Values from the ordinate and abscissa for the first region (3) of the spectrogram

$k = x_i$ $[10^{10}]m^{-1}$	N	$\ln N = y_i$
7,425	35	3,55
7,623	20,5	3,02
7,821	12	2,485
8,019	9	2,197
8,217	7	1,946
8,415	5,5	1,705
8,613	4	1,386
8,811	3,5	1,253

STATISTICAL PROCESSING OF RESULTS OF EXPERIMENTAL ANALYSIS OF COLORED MATERIALS

The obtained coefficients of directions in the sample of red acrylic car paint on microscopic glass are:

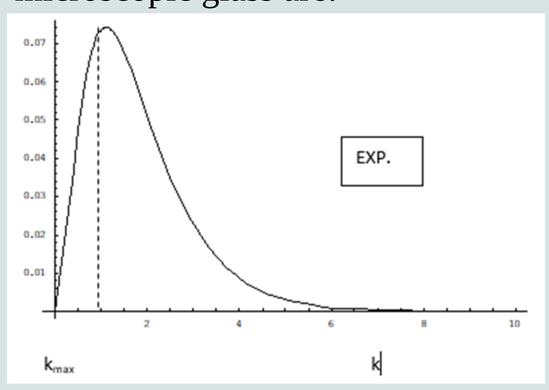

Fig 2. Composite curve formed on the basis of experimental results

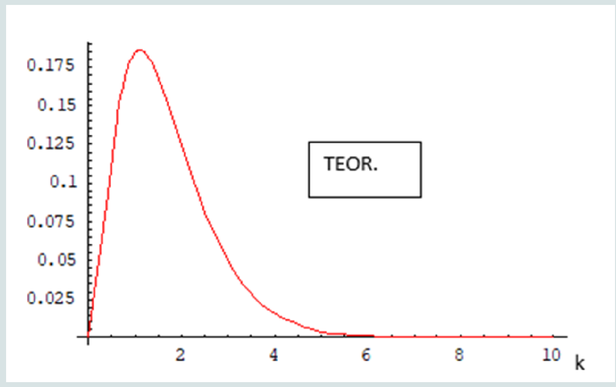

Fig 3. Composite curve formed on the basis of theoretical results

After comparing the experimental curve with the theoretical one, an exceptional agreement is found, which is shown in Fig. 4.

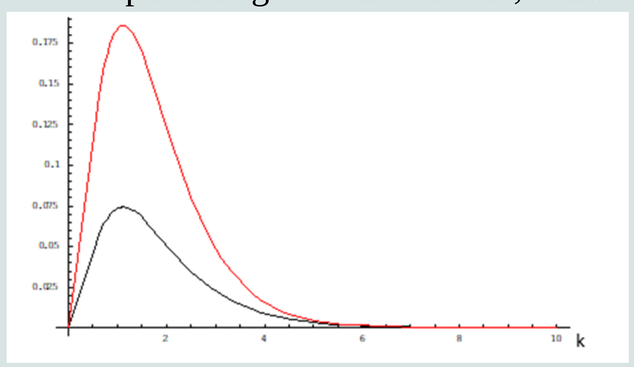

Fig. 4. Comparison of composite curves: experimental and theoretical

$$D_n(\lambda) = \left[\frac{e^{-\theta_1 \lambda}}{(\theta_2-\theta_1)(\theta_3-\theta_1)\cdots(\theta_n-\theta_1)} + \right.$$

$$+ \frac{e^{-\theta_2 \lambda}}{(\theta_1-\theta_2)(\theta_3-\theta_2)\cdots(\theta_n-\theta_2)} +$$

$$+ \frac{e^{-\theta_3 \lambda}}{(\theta_1-\theta_2)(\theta_2-\theta_3)\cdots(\theta_n-\theta_3)} +$$

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

CONCLUSION

Direct experimental methods such as the method of infrared spectrophotometry (FT-IR) and the method of scanning electron microscopy (SEM/EDS) give diagrams that are very complex and difficult to interpret, and it's even more difficult to make a forensic up-to-date conclusion. In this situation, the only way out is to apply the methods of mathematical statistics and use an analogy with the physical characteristics of absorption. Since the aim of this paper was to present a new method of color identification, the basic trend of the work was to find some specifics and adequate analogies with some phenomena that can expand the range of forensic color research.

REFERENCES

[1] F. Manhas, V. Pereira, M. Izabel, M. Silveira Bueno, Analytic Chemical Act 588 184-191 (2007).

[2] L.D. Landau, E. M. Lifshitz, Mechanics, Butterworth Heinemann, Oxford (2000)

[3] V.M. Agranovich, Theory of Excitons, Nauka, Moscow (1968)

[4] S. Knox, Theory of Excitons, Academic Press, Inc., New York (1963)

[5] H. Goldstein, C. Poole, J. Safko, Classical Mechanics, Adison Wesley, San Francisco, Boston (2002)

[6] V.M. Agranovich and V.L. Ginzburg, Crystaloptics with Spatial Dispersion and Theory of Excitons, Nauka, Moscow (1979).

[7] Zorić, V.M.: Analysis of mechanical oscillations in the colored coating and method of application of results in forensic research, Dr. thesis, TF M. Pupin, Zrenjanin, University of Novi Sad, 2009.

[8] V.M.Zorić: Forensic Investigation of colored layers, Zadužbina Andrejević, ISSN 1450-801X ; 366, Beograd, 2014.

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