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# JOINT EXAMINATION OF HAIR FRAGMENTS, SPORES AND URANIUM PARTICLES USING REM-PMA

Introduction

The increase in the number of incidents with NRM [1] and the resonance of some crimes, as well as some ambiguous results of the investigation [2, 3, 4], are the cause of increased attention for the prospect of investigating such crimes and incidents. In the 1990s and 2000s, in the investigation of incidents and crimes with NRM, all attention was focused on determining the characteristics of NRM. But for the last few years, there was a growing need to jointly investigate confiscated radioactive evidence by nuclear forensics specialists and experts in traditional forensics. This trend was also reflected in the exercises organized by the international nuclear forensic community, primarily in the exercises of the CMX series. If the previous exercises, CMX 4 and CMX 5, were focused on determining the nuclear-physical characteristics of samples [5, 6], the last CMX 6, already included the definition of traces that are the subject of traditional forensic disciplines: (fingerprint examination) and traceology [7].

A conflict of interest may arise when examining samples with both nuclear forensic evidence and traditional forensic evidence. Also, preparing the specimen for testing or examining evidence by certain methods may damage or destroy other evidence that other experts will later examine. In this context, the task is to develop the operating regime of the equipment and to establish the sequence of analysis of evidence in the forensic examination, which will allow obtaining the information useful for the investigation, as much as possible. Such tasks are successfully performed under the IAEA Residential Assignment Programs, for example, on the application of SEM-EDX methods for the purposes of nuclear forensic examination at the Laboratory for Microparticles Analysis, Moscow, Russia, 2021.

Formulation of the problem

One of the widely used methods in forensic examinations is a combination of scanning electron microscopy and X-ray microanalysis (SEM-RMA). Using SEM-RMA, in traditional forensic examinations, the characteristics of shot products, explosion products and explosives, precious metals, various organic fibers, morphological characteristics of human and animal hair, spores and others are determined [8]. At the same time, SEM-RMA is successfully applied in the nuclear industry to study of a number of NRM characteristics. Electron microscopy makes it possible to study the morphological characteristics of NRM samples: geometric parameters of products, grain sizes, fracturing and surface porosity. X-ray microanalysis makes it possible to establish the elemental composition of a material even if only its microparticles are found at the scene of the incident [5, 6].

SEM-RMA is considered a non-destructive method. However, it is non-destructive in the case of analysis of samples traditionally studied by this method. At the same time, the effect of the electron beam on all types of traces that can be found on the samples taken from the incident site, and, first of all, having an organic nature, has not been studied. In turn, the study of traditional forensic traces, for example, fingerprints by the method of cyanoacrylate fumigation, may lead to the impossibility of subsequent determination of NRM characteristics that are essential for the investigation. Thus, examining one piece of evidence on the surface of a test sample may damage or destroy other evidence.

The purpose of this work was to prepare samples containing objects characteristic of research in a traditional forensic laboratory as well as in a laboratory investigating NRM and to determine the effect of subsequent research procedures on the safety of various types of evidence. As a result, the optimal research sequence for this type of sample should be determined and the optimal modes of operation of the electron microscope should be established.

The experimental part

To solve the problem, were prepared the samples that contained hair fragments and pollen particles (spores of various trees: pine, birch and cedar), typical for traditional forensics, as well as uranium particles - the subject of research by NRM specialists. Microparticles of uranium (for contamination) were taken from samples previously examined in the CMX-5 exercise [6] at the "Microparticle Analysis Laboratory", Moscow, Russia. All objects were deposited together on carbon substrates.

In fig. 1 shows a picture of a hair fragment (a) with a cedar spore (b) on its surface. On the surface of the spore, in turn, a particle of uranium was found. The study of this and other samples, without providing a drain of electricity from it, showed that spores and hairs are charged with an electron beam and become

“invisible” to SEM. Therefore, to remove the charge, a thin, approximately 30Å, layer of gold was deposited on the surface of the samples. However, when studying even gold-deposited samples at an accelerating voltage of 20-30 kV and beam currents typical for the analysis of uranium microparticles, the surface of the hair and spores is destroyed. Therefore, the study of such samples should begin with an analysis of the morphological characteristics of hair and pollen at an accelerating voltage of 5 kV and beam currents of 10-11-10-10A. It is expedient to investigate uranium particles at an accelerating voltage of 20 kV and beam currents of about 1 nA. In this case, hair and spores are destroyed, but the necessary information about them has already been obtained.

Conclusion

It this work, it is shown that for the effective study of samples containing both hair, pollen particles, and uranium microparticles, it is necessary to spray a thin layer of conductive material on the sample. On the sprayed sample, it is necessary, first of all, to investigate the morphological characteristics of the hair and spores. These characteristics are determined at an accelerating voltage of 5 kV and beam currents of the order of tens of Picoamperes. Then it is possible to analyze uranium microparticles, as well as other NRM fragments at accelerating voltages up to 30 kV and beam currents up to units of Nanoamperes.

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