TECHNICAL NOTE

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Is there a Real Danger of Concealing Gunshot Residue (GSR) Particles by Skin Debris Using the Tape-Lift Method for Sampling GSR from Hands?

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ABSTRACT: Experiments were carried out to assess the danger of concealing GSR particles by skin debris using the tape-lift method for sampling GSR from hands. Thirty discrete spherical particles (from GSR and from the debris of oxygen cutting of steel) sized from 8 to 30 microns were mounted on a double-side adhesive coated stubs in known locations using a stereomicroscope. These stubs were then used for dabbing hands 50 times. Some of the particles or parts thereof were covered by skin flakes, however, all particles could be detected using the backscattered electron image (BEI) in the scanning electron microscope (SEM). Also, all could be identified by the energy dispersive X-ray spectroscopy (EDX).

KEYWORDS: forensic science, gunshot residue, collection efficiency, tape-lift

The tape-lift method is the most common technique used for collection of GSR particles for SEM/EDX analysis (1,2). The usual recommended collection procedure from hands by this method has been to dab the adhesive coated stub against the hand until it has lost its stickiness per subjective assessment (3,4). The concern regarding continual dabbing was that skin debris might conceal GSR particles from view (5–7). In contrast to that opinion this author and his associate found in their previous study (8) that 50 to 100 dabbings are necessary to achieve maximum collection efficiency for GSR, while stickiness appeared to be lost after only about 10 to 30 dabbings. It was shown that sampling capability of GSR by a stub covered with skin debris was not significantly decreased, if at all, up to 120 dabbings. Based on that study, the previous operational procedure in Israel for collection of GSR from hands (to dab until stickiness is lost) was amended; the current procedure is to dab the hands of a suspect 50 times.

It should be noted that the study dealt with the collection efficiency by the tape-lift method of quite a large number of GSR particles. Such quantities may be found on a suspect shortly after shooting. In a real life situation, however, very few GSR particles are normally found in samples collected from suspects of shooting; in a high percentage of Israel Police positive casework samples, merely one GSR was detected (9). The previous study (8) cannot provide an explicit answer regarding the "fate" of a particular collected particle on a stub depending on the number of dabbings.

The objective of the present study is to provide some clues to answer this question. Specifically, experiments were conducted to assess the danger of concealing a particular GSR particle by skin debris using the tape-lift method of collection, so that it would be impossible to detect and identify it by BEI and EDX, respectively.

Experimental

The idea was to design the best possible scenario for burying GSR particles by skin debris (the worst conditions for detecting these particles). Such a scenario is as follows: suppose there is a suspect of shooting, and at the time of his sampling there is only one or at best very few GSR particles on one of his hands. Let us further assume that at the first dabbing by a stub all these particles are collected, as the dabbing is continued to complete 50 times (according to our sampling procedure). Such a scenario should provide the highest probability (49 additional dabbings) for concealing the particles by skin debris. In a real life situation, GSR particles are not necessarily sampled at the first dabbing, although one does start to sample from the "proper" areas. In particular this is true after a considerable time lapse between shooting and sampling. As times passes, some particles are lost, and some are redistributed (7).

To simulate such a scenario, the method of choice is to dab a hand of a shooter only once shortly after shooting. The adhesive should be conductive to avoid carbon coating. Then the stub is searched (preferably autosearch) by SEM/EDX for GSR particles. After detection and identification of several GSR particles and the documentation of their exact locations on the stub, additional dabbings should be made to study what happens to previously detected and identified particles. To conduct such an experiment the author first examined by CamScan III SEM the two types of conductive double side adhesive tapes at his disposal (Agar Scientific ltd. and SPI supplies) to check the effect of the electron beam on the adhesive properties of the tapes. It turned out that under absorbed current of about 1nA after several minutes at magnifications of about 200, the tapes lost their stickiness. Similar conditions are used for manual or automated search for the GSR particles. This means that it is not possible to carry out the above described layout of the experiment.

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The following approach was then chosen to conduct the experiment: the smallest possible discrete spherical particles were mounted on stubs in known locations under a stereomicroscope. Then these stubs were used for dabbing the hands of a person and were examined again under the stereomicroscope and by the SEM/EDX.

We used 25 or 15 mm aluminum stubs. A double-side adhesive 3M Scotch Tape No. 465 (used in the Israel Police for standard SEM/EDX examinations including GSR) was chosen to coat the stubs. This tape, although not conductive, is colorless and thus advantageous for localization of particles by optical microscopy. A Zeiss zoom stereomicroscope with a highest magnification of 64 was used to mount particles from a Petri plate on a stub. Sharpened wooden sticks, whose tips were moistened with water, provided considerable success for this tedious task. Spherical particles from oxygen cutting of steel were chosen for the first mounting experiments. The high variability in size of these particles (10) helped determine the smallest possible size of a discrete particle that could be picked up by the author and mounted in a known location on a stub; it turned out to be about 10 microns. It should be noted that GSR particles vary in size from less than 0.5 to more than 200 microns, although in casework the size range is typically 0.5 to 10 microns (5). An additional advantage of using spherical particles from oxygen cutting of steel (iron particles) is that their main metallic elemental composition is iron, having atomic number (Z) considerably lower than the normal average Z of GSR particles. Thus, since their BEI signal is weaker, they are less likely to be detected in the SEM if they are covered by skin flakes. In this way, the experiment becomes more sensitive to the influence of skin debris.

Finally, one stub was prepared with eight mounted spherical iron particles in the size range of 8 to 30 microns (two of them were about 8 microns). The sizes were determined afterwards using SEM. Following the mounting, the stub was used to dab both hands of one individual 50 times. The hands had not been washed prior to sampling. Then the stub was examined under the stereomicroscope. All the particles could be discerned. Some of the particles were photographed before and after dabbing using a Leica DMC comparison microscope equipped with a CCD camera (Fig. 1). On a second stub, 22 spherical GSR particles ranging from 10 to 25 microns (twelve of them having a size of about 15 microns or less) were mounted in the same manner as in the case of iron particles. The particles were collected from a spent 0.38 sp S & W caliber IMI ammunition cartridge case. The hands of a second individual who was not in any contact with firearms or ammunition were dabbed 50 times with this stub (also without prior washing). The stub was then examined under the stereomicroscope where all particles were discerned. Both stubs were carbon coated and examined in the CamScan III SEM combined with a Tracor-Northern 5400 EDX system.

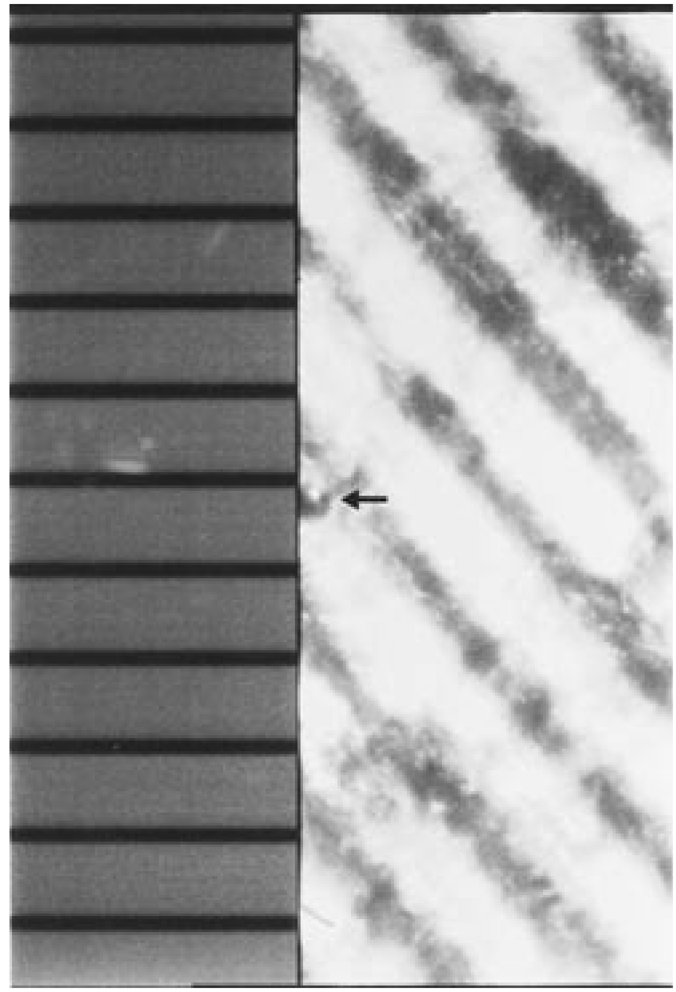

FIG. 1—*Photomicrograph of a spherical iron particle mounted on a stub taken on DMC comparison microscope: the length of every division is 100 microns.*

Results and Discussion

Although after 50 dabbings the stubs appear to be covered completely by skin flakes (Fig. 2) as was shown also in the previous study (8), only two GSR particles and one iron particle out of the 30 iron and GSR mounted particles were found to be covered completely by skin flakes. Fifteen particles were partially covered, and the rest remained uncovered. Nevertheless, all the mounted particles, including those that were totally covered by skin flakes, were detected using the BEI and identified by their characteristic EDX spectra. These results are consistent with the thickness of the skin flakes. As may be estimated from Fig. 2, the thickness of the skin flakes may be of very few microns at most. The flakes are apparently keratinocytes, the cells that comprise the stratum corneum, which is the outermost layer of epidermis (11). Such thickness of mostly organic material should not considerably suppress the backscattered electron signal and the EDX spectra of the materials underneath, having a relatively high average Z (12). Nonetheless, the BEI of two particles among the 15 partially covered particles was suppressed substantially in the covered area of the particles.

Figure 3 shows an EDX spectrum of a skin flake. Figure 4 shows the secondary electron image (SEI) of an iron particle of about 25 microns covered partially by skin. Figure 5 shows the EDX spectrum of an uncovered and covered area of the particle. It may be seen that the skin layer suppresses about 30% of the intensity of the iron X-ray peak (compare the 56 and 74 count time to obtain the same number of counts). The skin elemental contribution in the covered area of the particle is very slight. Figure 6*a* shows the SEI of an area on the stub with an iron particle of about 10 microns completely covered by skin. Based on this image, it is difficult to infer that there is a particle. The BEI (Fig. 6*b*), however, clearly indicates the presence of material with relatively high Z. The EDX spectrum of the particle is shown in Fig. 7. A small contribution of a skin elemental composition is observed. This was the only iron particle that was found to be totally covered by skin.

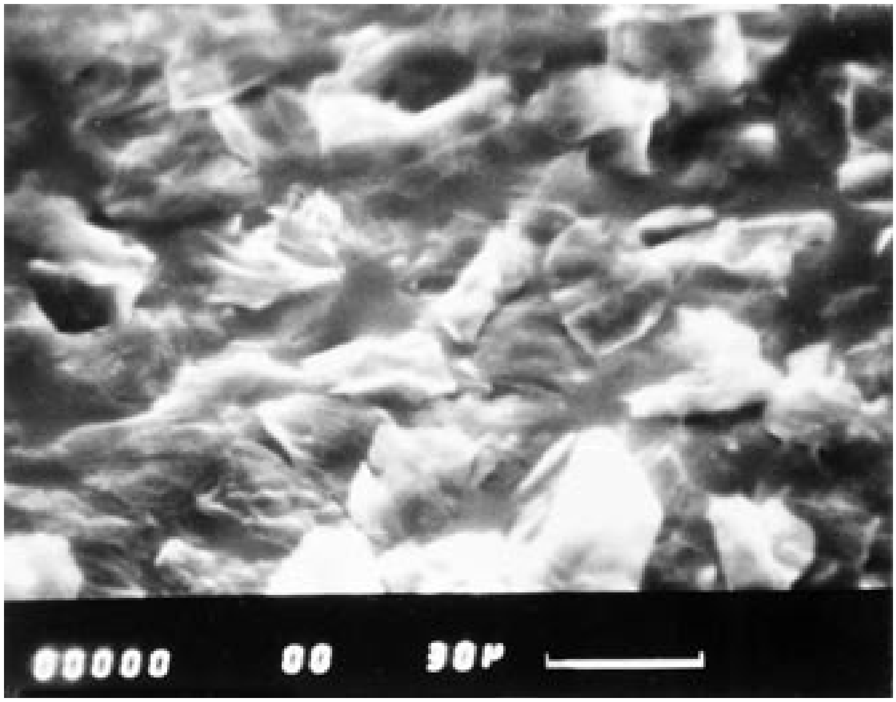

FIG. 2—*SEM micrograph of skin debris on a stub that was used to dab hands 50 times.*

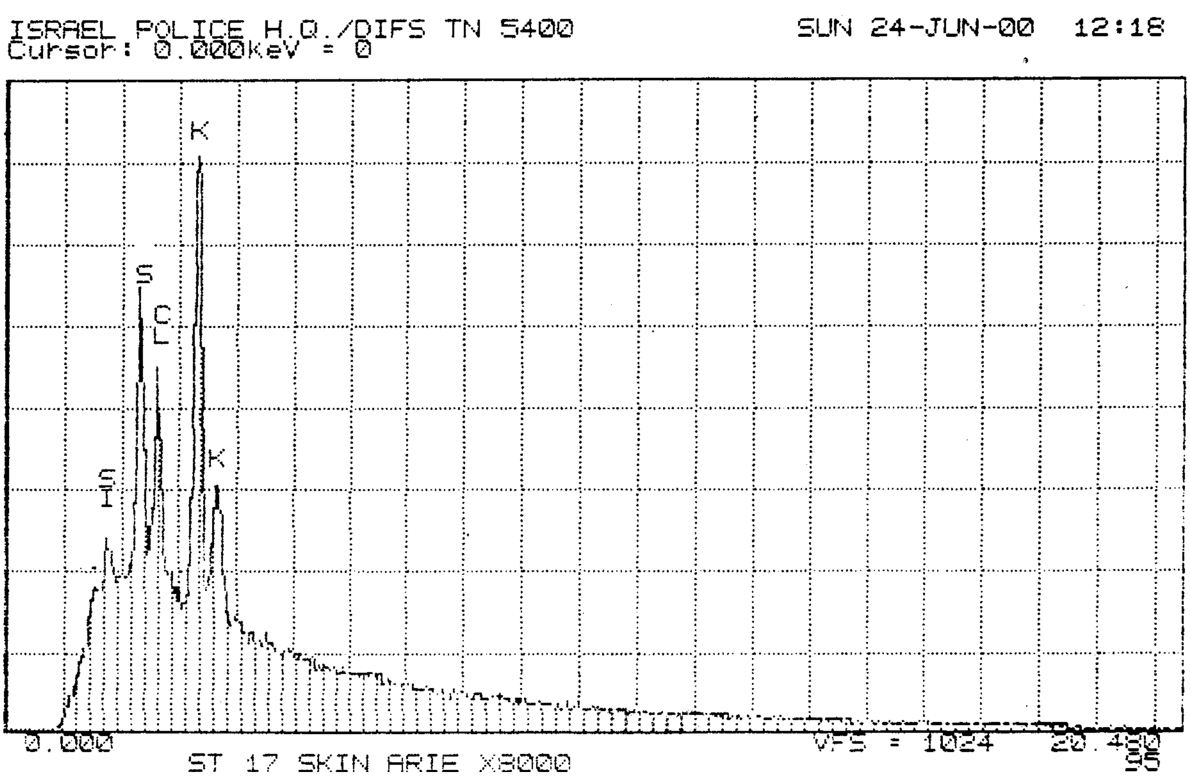

FIG. 3—*SEM/EDX spectrum of skin debris.*

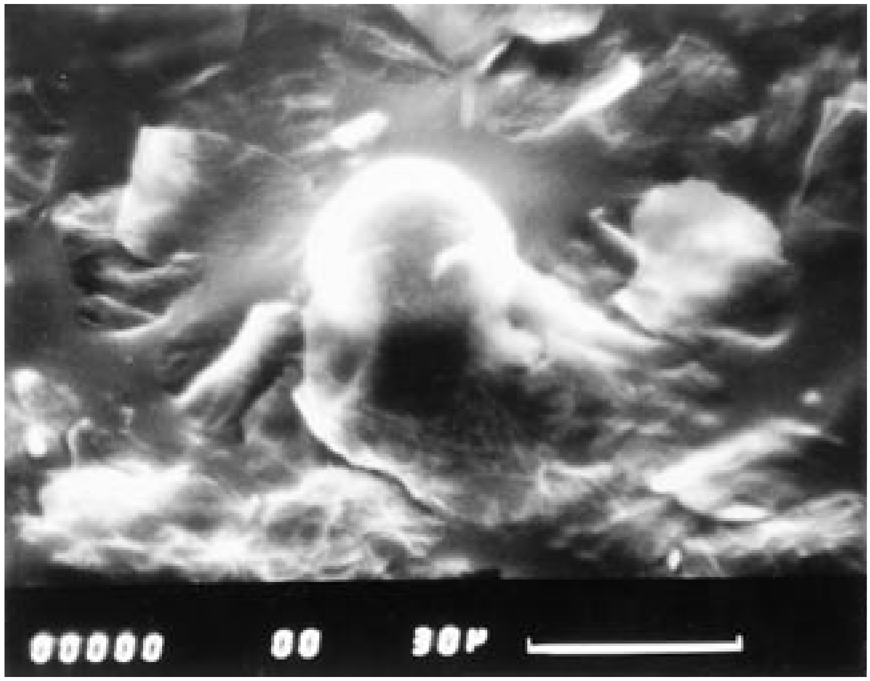

FIG. 4—*SEM micrograph of an iron particle partially covered by skin.*

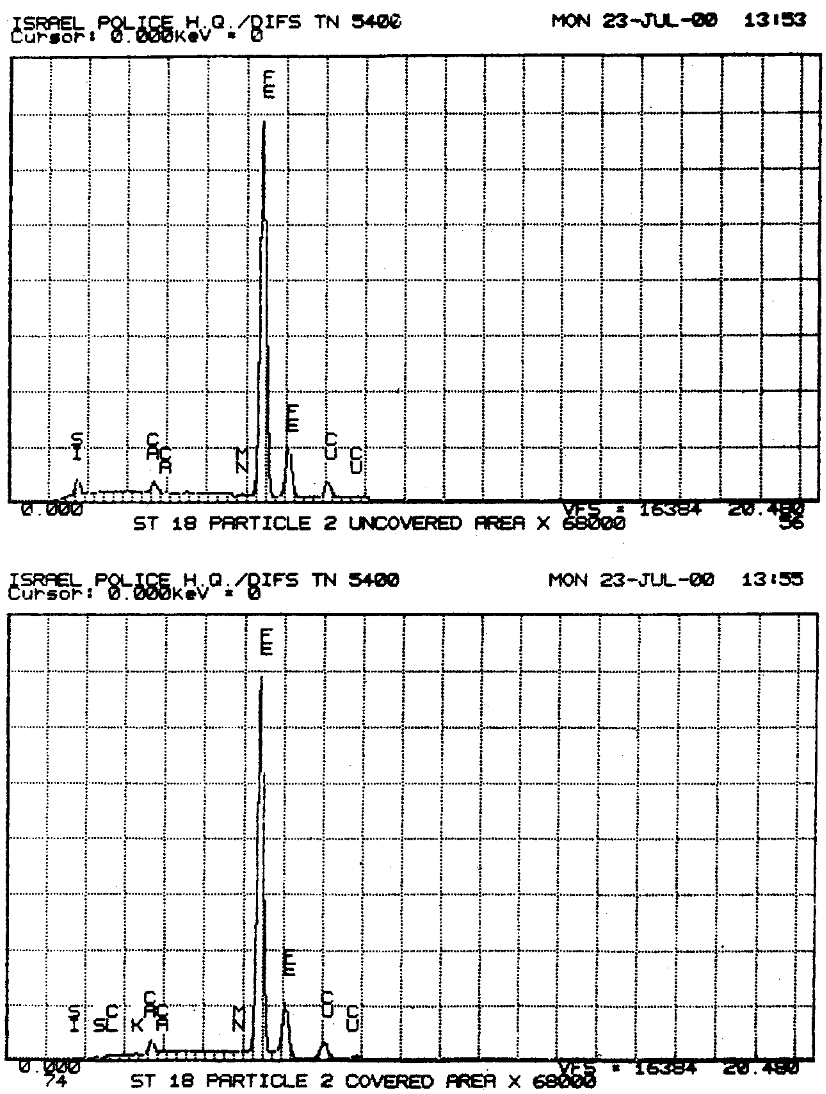

FIG. 5—*SEM/EDX spectra of the uncovered (top) and the covered (bottom) areas of the particle shown in Fig. 4.*

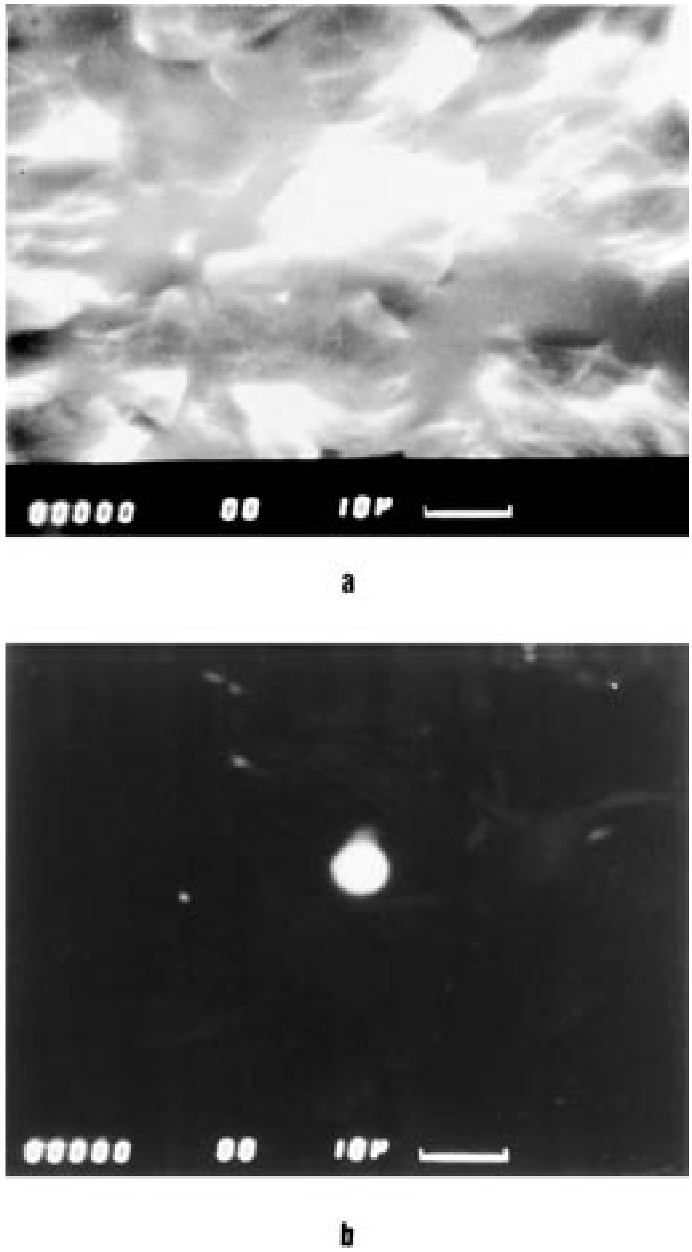

FIG. 6—*SEM micrograph of an iron particle completely covered by skin debris: (a) SEI, (b) BEI.*

Figure 8 shows the SEI of a partially covered GSR particle. Figure 9*a* shows the SEI of the area with a GSR particle of about 10 microns completely covered by skin. As in the case of the iron particle, only the BEI could discern the presence of a high average *Z* particle (Fig. 9*b*). Figure 10 shows the EDX spectrum of a GSR particle uncovered by skin debris. Figure 11 shows the EDX spectrum of the particle in Fig. 9. It may be seen than in addition to the elemental composition of GSR, there is the contribution of the elemental composition of skin. Although when a GSR particle is completely covered by skin flakes the major part of its morphological information is obscured (Fig. 9*a*), some information about its form may be inferred from the BEI (Fig. 9*b*). Though spherical morphology may serve as one of the parameters for identifying GSR particles, it is not mandatory (3). The ASTM Committee on the subject expressed its view as follows: "Since morphology is dependent upon conditions at the time of impact and the distance from point of production to point of impact, it can vary greatly and should be considered only a secondary criterion for identification of GSR; the most accurate method of identifying GSR is by its elemental content" (13). It should be noted that during the mounting of particular iron or GSR particles, occasionally a wooden stick picked considerably smaller iron and GSR particles than about 10 microns that were in the vicinity of the "target" particle and could not be discerned using the stereomicroscope. Such particles were detected and identified in the SEM. They were as small as about 1 micron and some of them were found to be covered by skin flakes. This means that even the smallest size GSR particles encountered in casework should not be necessarily obscured by skin debris after 50 dabbings, so that it would not possible to detect and identify them by SEM/EDX. Thus, the results of this study are consistent

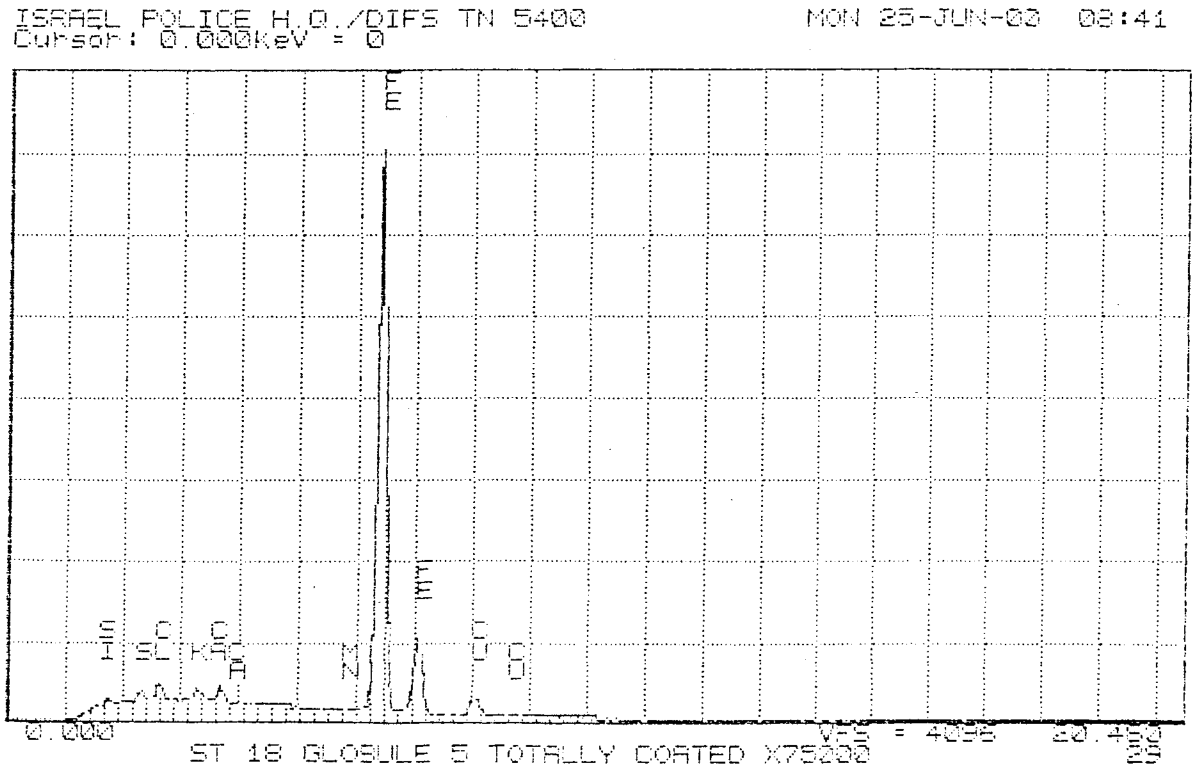

FIG. 7—*SEM/EDX spectrum of the particle shown in Fig. 6.*

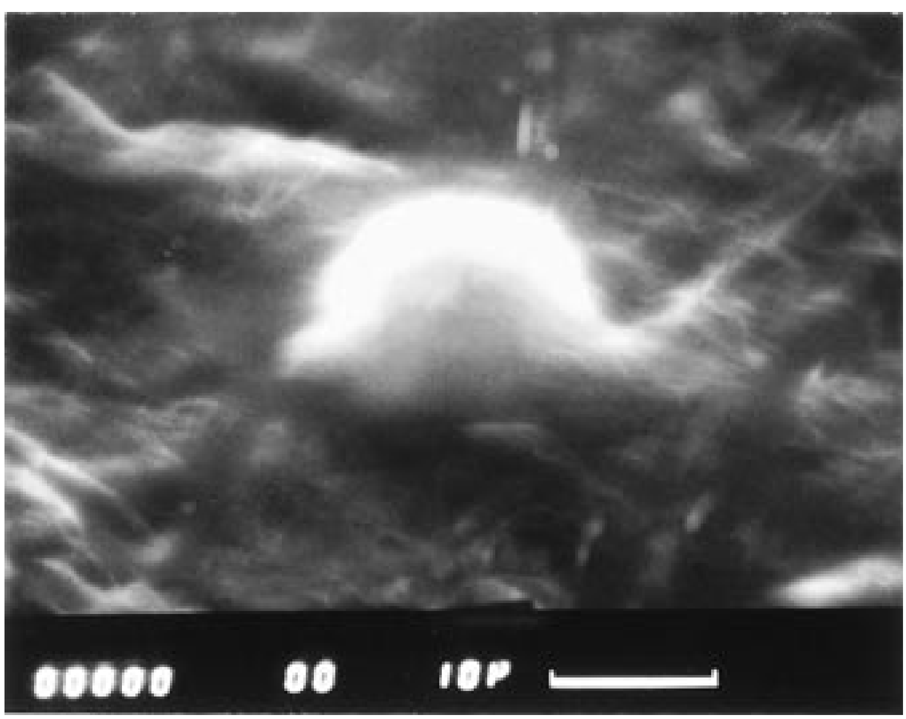

FIG. 8—*SEM micrograph of a GSR particle partially covered by skin debris.*

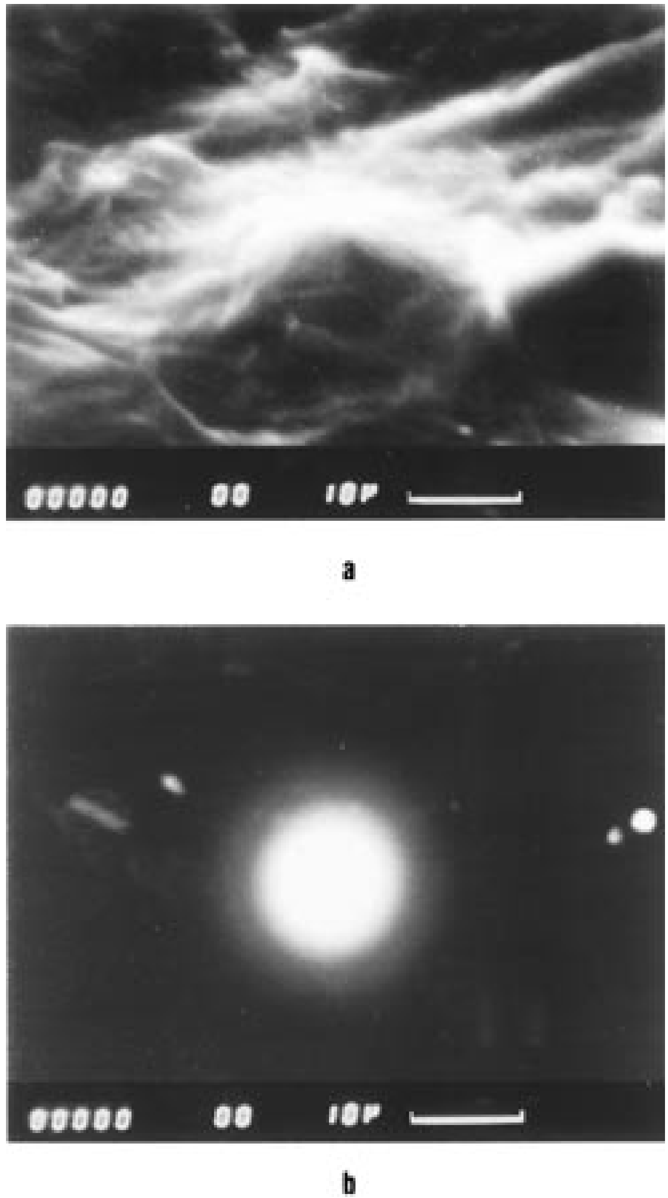

FIG. 9—*SEM micrograph of a GSR particle completely covered by skin debris: (a) SEI, (b) BEI.*

with the results of the previous work on the collection efficiency of GSR (8).

Not all the possibly effecting variables (e.g., the period between washing the hands and sampling) were examined in this study. It is the author's intent to extend the study to smaller GSR particles, various adhesives, and other relevant variables. A study will be conducted also on other types of debris like hair and the debris that may be found on clothing.

Conclusion

It was found that there is no substantial danger of concealing GSR particles by continuous dabbings of hands up to 50 times. This was shown for discrete particles in the size range of 8 to 30 microns that were mounted in a controlled manner on stubs prior to dabbing. Although few of them were covered completely by skin debris and could not be detected by the SEI, they were detected without any problem by the BEI and identified by the EDX. Since GSR particles are lost and redistributed on the hands of a shooter as the time passes, from the operational point of view it means that increasing number of dabbings will increase the probability to collect and detect GSR particles from suspects of shooting.

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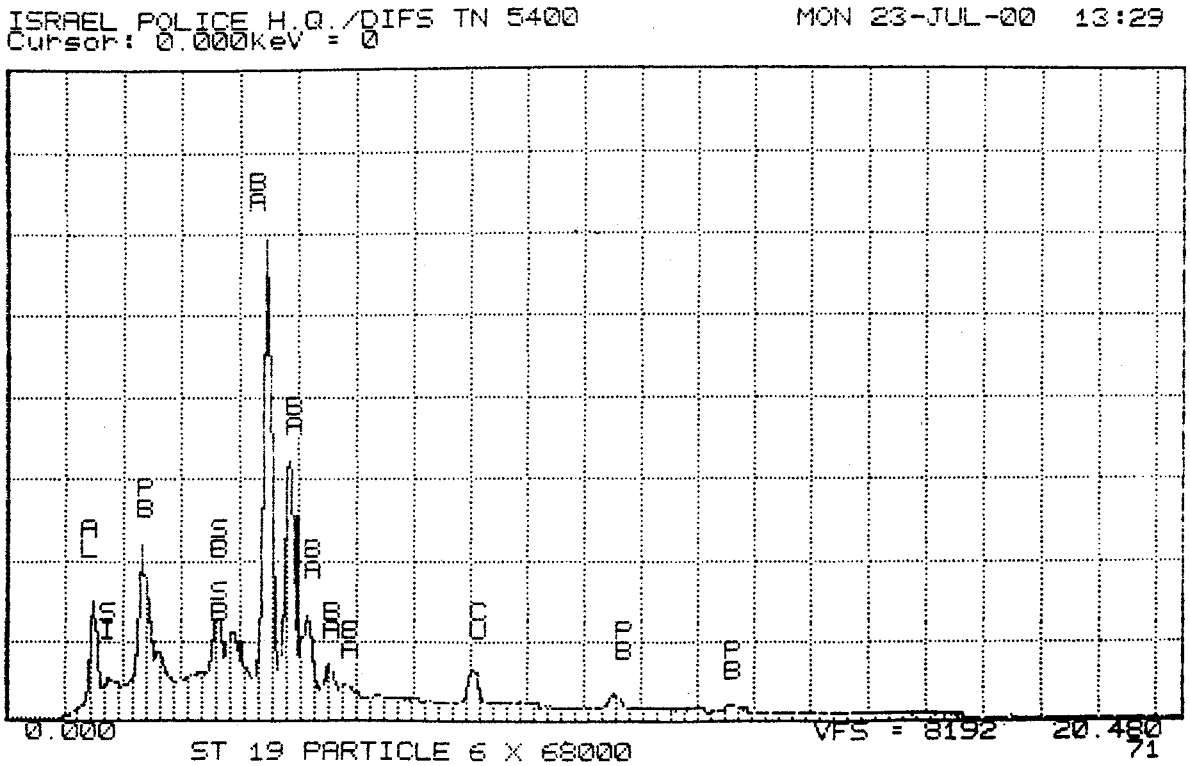

FIG. 10—*SEM/EDX spectrum of a GSR particle uncovered by skin debris.*

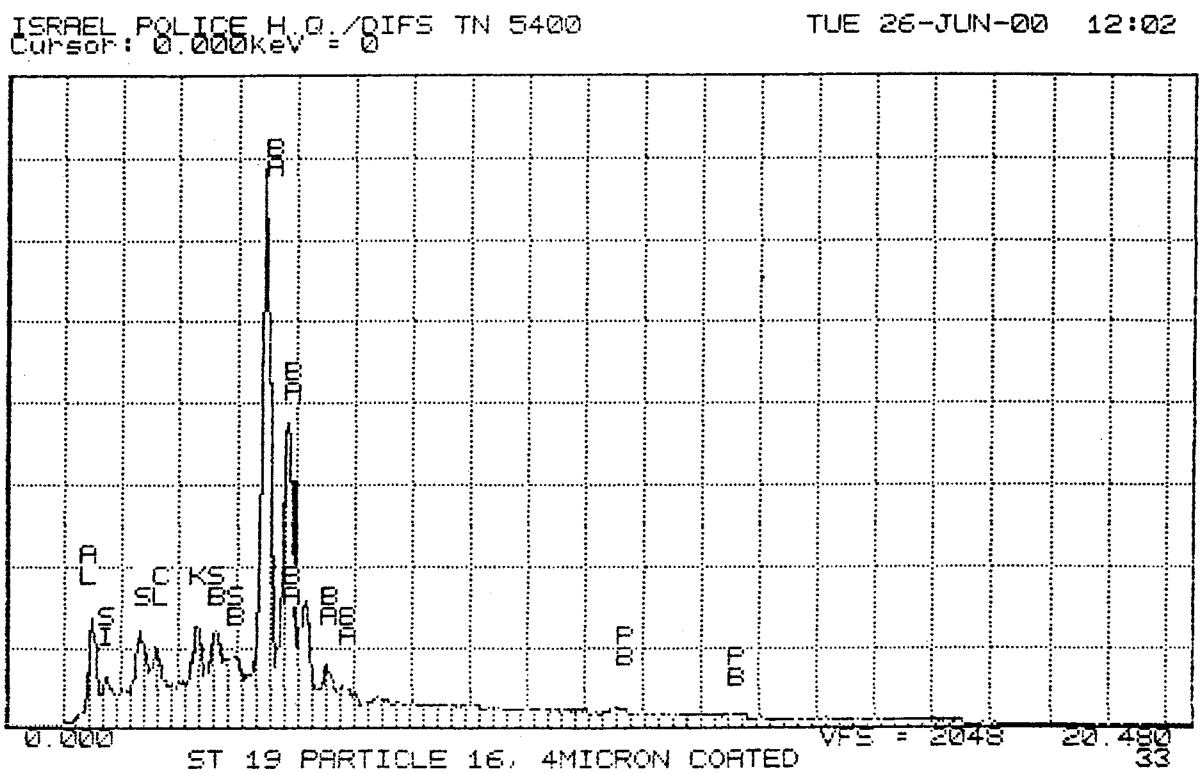

FIG. 11—*SEM/EDX spectrum of the particle shown in Fig. 9.*

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