Skin Debris and Gunshot Residue Samplers: II. The Issue of Acceleration Voltage

By Bryan Burnett

ABSTRACT: A sampler was initially loaded with target gunshot residue (GSR) and then was dabbed 30 times on the back of a hand. A number of high-resolution (4096 x 4096 pixel) backscatter images were taken at 20 kV and then at 30 kV of the same areas. Following these images, the sampler was treated to remove skin debris with a sodium/calcium hypochlorite solution and additional high-resolution images were taken at 20 kV of the same areas. Comparison of these images shows that more GSR particles are revealed at 30 kV than at 20 kV. The removal of skin debris evinced even more GSR particles that were not detected on the untreated samplers, regardless of the acceleration voltage used.

INTRODUCTION

Burnett (1) in the previous article introduced a bleach solution to remove skin debris from gunshot residue (GSR) samplers. The bleach-processed samplers reveal GSR particles that were originally hidden or partially obscured by skin debris. Prior to posting that article, a previous version was kindly reviewed by Dr. Jozef Lebiedzik. Dr. Lebiedzik noted that since skin debris obscures GSR particles at 20 kV, then likely the higher the acceleration voltage the better the detection of tissue-obscured GSR particles. An electron beam at an acceleration voltage of 30 kV will penetrate tissue deeper than an acceleration voltage of 20 kV. In addition, backscatter electrons created from a particle at 30 kV would have greater penetration of overlying tissue than backscatter electrons generated at 20 kV.

This author has seen no reports on differences in acceleration voltage affecting particle backscatter signal and thus particle counts in regards to GSR analyses. The likely reason is the notion (e.g., 2) that overlying skin debris is not an issue and that all GSR particles present on a sampler will be detected regardless of the acceleration voltage as long as it is above 20 kV (3,4). The ASTM (4) notes (7.1.2, page 2), " From a practical standpoint, these performance requirements indicate that the SEM/EDS system must be capable of a minimum accelerating voltage of 20 keV; higher accelerating voltages *should* result in improved analytical sensitivity" (italics mine). There is no referenced support by the ASTM for this assertion. DeGantano & Siegal (5) in their survey of GSR analysis procedures of crime labs did not ask about acceleration voltage. Singer et al. (6) in a similar survey also did not inquire about acceleration voltage. A summary of the GSR literature as to the acceleration voltage used in studies is provided in Table 1.

Table 1. *Result of a survey of published works on GSR for the last 25 years for acceleration voltage used.*

35 don't say
1 uses 15 kV
5 use 20 kV
7 use 25 kV
2 use 30 kV

The size of the particle, its density and the thickness and density of the overlying tissue all affect whether that particle is detected by its backscatter signal. Acceleration voltage likely also has an effect – but, how much? As noted above, one would expected that since particles are obscured by skin debris to variable degrees (1,2,8) that the higher the acceleration voltage, the better penetration through tissue and the more energetic the backscatter electrons. Therefore, it is likely more GSR particles on a sampler will be detected at 30 kV than at 20 kV. The question that now needs to be answered: will using an acceleration voltage of 30 kV negate the need to use the digestion procedure to view those particles that are obscured at 20 kV?

This paper examines the backscatter imaging differences of GSR particles between 20 kV and 30 kV when there is overlying skin debris. Images are also provided of the same areas where the skin debris has been removed by bleach treatment.

METHODS

Gunshot residue samplers were constructed of graphite impregnated double-sticky carbon tape applied to standard 13-mm diameter carbon disks that have been attached to SEM stubs.

A sampler was touched to a linen fabric target that had been shot with a .22 Remington at a target distance of 5 cm from the revolver muzzle. The sampler was then dabbed 30 times on the back of a hand and was placed in an ETEC Autoscan scanning electron microscope equipped with an IXRF Systems EDS2000 Microanalysis System. Acceleration voltages were 20 kV and 30 kV and the work distance was 14 mm for all samples. Areas were found on the sampler that had particularly heavy epithelial cell coverage. Backscatter images were taken at 20 kV and 30 kV at 300X with a resolution of 4096 x 4096 pixels. The sampler was removed from the SEM, treated with the bleach solution (1), and rinsed with 0.2 filtered distilled water approximately 35 sec (this proved to be too long a rinse time – see below). The sampler was returned to the SEM, the same locations that previous images were taken were found, and backscatter images taken at 300X again at a resolution of 4096 x 4096 pixels.

The backscatter images were examined carefully. Areas were selected (400 x 400 pixels) from the three 4096 x 4096 pixel backscatter images (20 kV, 30 kV and digestion/ 20 kV) that showed differences in the particle backscatter intensities. Some of the particles were identified with EDS.

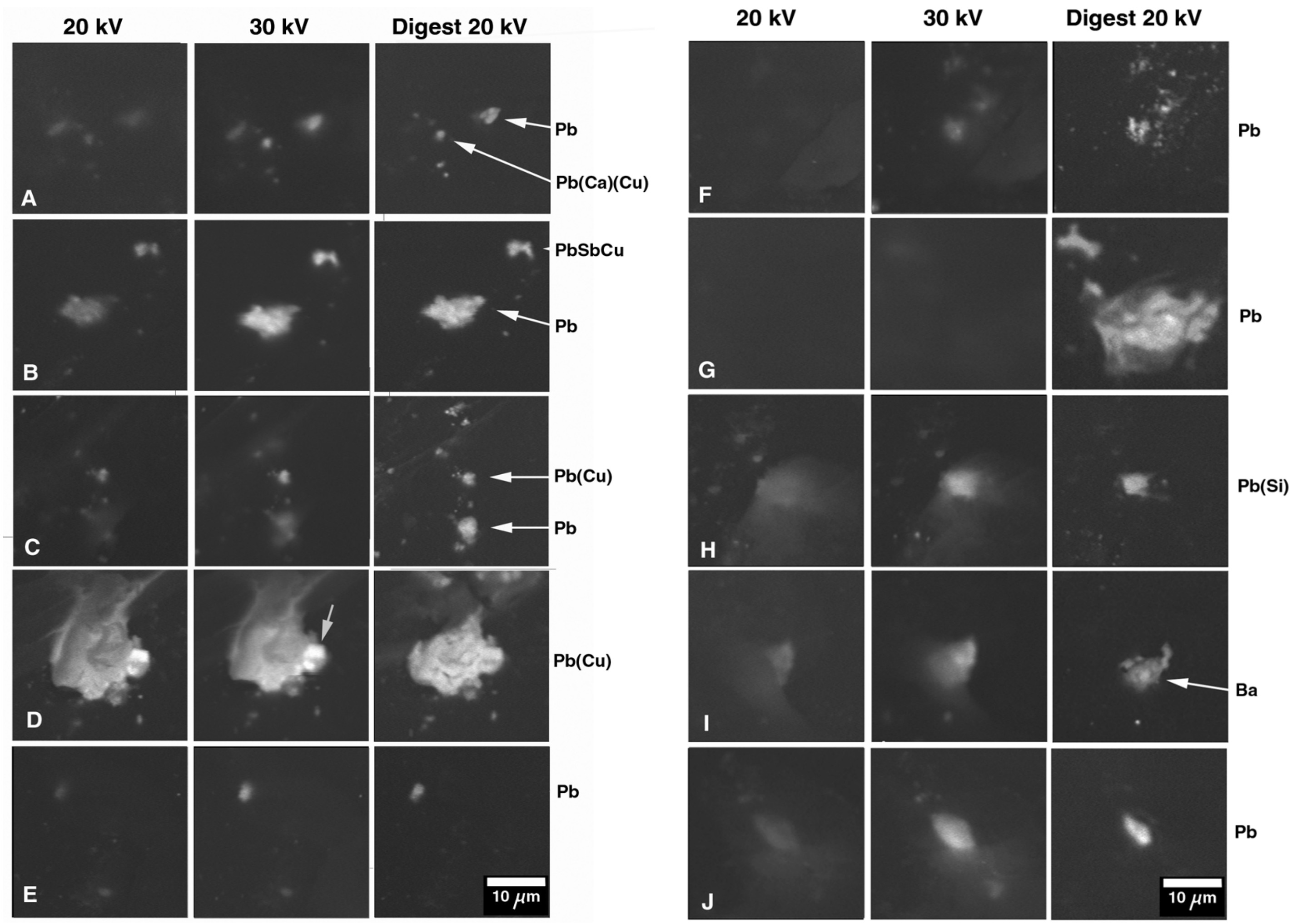

Figure 1. Ten backscatter image series of GSR particles showing the same sampler surfaces at 20 kV, 30 kV and 20 kV after digestion. The compositions of some of the particles are indicated at the right. The gray arrow on D points to a particle that appears to have been partially eroded by too long a rinse time after the digestion solution exposure

RESULTS AND DISCUSSION

Ten image series (20 kV, 30 kV and digestion/20 kV) are shown in Figure 1. Some of the GSR particles in each series were identified by EDS and the composition of these particles are indicated to the right of each image series. The majority of the particles in these images are likely GSR. Figure 1D shows that when there is no organic surface cover on a particle, the 20 kV and 30 kV backscatter electron images of that particle appear nearly equivalent. When there is an organic layer over a particle, the backscatter electrons of that particle generated by a 20 kV electron beam are more attenuated when compared to the backscatter electrons produced at 30 kV

(Figs. 1A, 1B, 1F, 1H, 1I and 1J).

Coverage by skin debris of a GSR particle in some instances does not appear to be remedied by a high acceleration voltage analysis (e.g. Fig. 1G) or the backscatter signal is so attenuated (e.g., Fig. 1C the "Pb" particle) that it is unlikely these particles will be identified as objects of interest in an automated system. Other particles (e.g., Figs. 1A and 1F) also likely would be missed.

Too long a rinse time (35 seconds) was used in the digestion procedure for this study. The excessive rinse time appeared to have caused erosion some particles (e.g., Fig. 1D - heavy BS portion of particle not apparent in the digestion/20 kV image; Fig. 1E - backscatter intensity reduced; Fig. 1J - apparent loss of a portion of the particle). Therefore, it is recommended that the rinse time of a GSR sampler (1) after digestion with the sodium/calcium hypochlorite does not exceed 15 seconds.

CONCLUSION

It is apparent that an automated analysis performed at 30 kV is preferable to 20 kV. Although analyses at 30 kV reveal more GSR particles than at 20 kV, particles still may be undetectable (below threshold) due to an attenuated backscatter signal caused by overlying organic material. The digestion of the GSR sampler has the potential to reveal GSR particles previously undetected, regardless of the acceleration voltage.

REFERENCES

1. Burnett, B.R. 2004. Skin debris and gunshot residue samplers: I. The particle habitus. International Association for MicroAnalysis, submitted and posted at meixatech.com
2. Zeichner A. 2001. Is there a real danger of concealing gunshot residue (GSR) particles by skin debris using the tape-lift method for sampling GSR from hands? J Forensic Sci. **46**:1447-1455.
3. ASTM. 1994. Standard guide for gunshot residue analysis by scanning electron microscopy/energy dispersive spectroscopy. ASTM E 1588-94
4. ASTM. 1995. Standard guide for gunshot residue analysis by scanning electron microscopy/energy dispersive spectroscopy. ASTM E 1588-95
5. DeGaetano, D., Siegel, J.A. and Klomparens, K.L. 1992. A comparison of three techniques developed for sampling and analysis of gunshot residue by scanning electron microscopy/energy dispersive x-ray analysis (SEM-EDX). J Forensic Sci. **37**:281-300.
6. Singer, R.L., Davis, D. and Houck, M.M. 1996. A survey of gunshot residue analysis methods. J Forensic Sci. **41**(2):195-198.
7.Abraham, J.L. and Burnett, B.R. 1983. Quantitative analysis of inorganic particle burden *in situ* in tissue sections. Scanning Electron Microscopy/1983/II pp. 681-696.
8. Lebiedzik, J. 2003. Personal communication.

Bryan R. Burnett
Meixa Tech
1624 Debann Road. Building B
Cardiff, CA 92007
bryan@meixatech.com **COMMENTS APPRECIATED!**