JASTEE, March 2017
Vol. 7, Issue 1, pp. 4-9

David A. Stoney,[1] Ph.D. and Paul L Stoney,[1] M.B.A.

Differential Sampling of Contact Surfaces of Footwear to Separate Fractions of Loosely, Moderately and Tightly Held Particles

ABSTRACT

A method of differential sampling is described that is suitable for separation of loosely, moderately and tightly held particles on footwear. Separation and study of these fractions can help in the investigation of fundamental aspects of particle adhesion, retention and loss on contact surfaces. Loosely held particles were removed by walking on paper, moderately held particles were removed by electrostatic lifting, and the most tightly held particles were removed by moist swabbing. Clear divisions among these fractions were achieved by repeating each sampling step (walking or electrostatic lifting) until virtually no additional particles were collected by that method. Twelve walking steps on butcher paper were found to be sufficient to remove the most loosely held particles and six subsequent steps on an electrostatic lifter were found to be sufficient to remove moderately held particles. Particles from each of these fractions were collected using a moistened swab (applied to the butcher paper and electrostatic lifting film, respectively).

Keywords: Differential Sampling, Footwear, Contact Surfaces, Particles

INTRODUCTION

Research focused on the persistence of trace evidence generally,[1-5] and on footwear specifically,[6,7] strongly supports the hypothesis that, after transfer to an item, some particles are tightly held (and retained longer), while others are loosely held (and more rapidly lost). There is a "trend of two/three stage decay…, with subsequently less rapid loss…, followed by a period of much lower decay."[8] To better study possible differences among populations of loosely, moderately and tightly held particles, we needed to develop methods for differential sampling of the contact surfaces of footwear.

Staged, alternative sampling methods are often employed in trace evidence analysis.[9-12] One purpose is to employ an initial method (such as picking individual fibers or paint chips) to collect loosely held traces as they are recognized, and that might

[1] Stoney Forensic, Inc., 14101-G Willard Road, Chantilly, VA 20151

otherwise be lost or redistributed as the examination proceeds. Another purpose is to preserve and document the location from which trace evidence was recovered (as in the regional taping of clothing in the recovery of fibers). Again, different methods may be used for alternative particle types (such as taping for fibers, followed by vacuuming to recover fine particles, or washing to recover pollen). However, there has not been a protocol for *differential sampling* and recovery of trace evidence with the express intention to fractionate loosely and tightly held particles, so that these populations can be compared and contrasted.

This paper presents methods and parameters for an effective differential sampling of the contact surfaces of footwear, separating loosely, moderately and tightly held particles.

MATERIALS AND METHODS

Three methods were used for sampling. The more loosely adhering particles were removed by walking with firm steps on butcher paper (92 kg individual, shoe size US mens10.5). The number of steps was increased while monitoring the paper surface with oblique lighting to determine when further steps yielded no perceptible additional particles. Particles were removed from the paper by (1) folding the paper and tapping loose particles into the fold, (2) collection of particles within the fold by moist swabbing, and (3) moist swabbing of any footwear impressions visible using oblique lighting. Swabbing was conducted using 3% ethanol in distilled water. Beginning with approximately 1 mL solution in a 1.5 mL microcentrifuge tube, paddle-shaped polyester clean room swabs (Absorbond Cleanroom Polyester Swab #TX782) were moistened, used to swab the paper surface and washed/pressed onto the side of the microcentrifuge tube. Additional solution was added as needed. (See Figure 1.)

Moderately adhering particles were removed using an electrostatic lifter (Sirche Electrostatic Dust Print Lifter Kit ESP900). Electrostatic lifting was conducted using a reverse procedure (foil side of lifting film down) and employing a piece of foil taped to the floor as a conductor.[13] The full voltage setting was used and particles were removed by smooth full steps onto the charged foil (92 kg individual, shoe size US mens10.5). The number of steps was increased while monitoring the reflective electrostatic film surface with oblique lighting to determine when further steps yielded no perceptible additional particles. Particles were removed from the electrostatic film by moist swabbing using 3% ethanol in distilled water, as described above for the paper. (See Figure 2.)

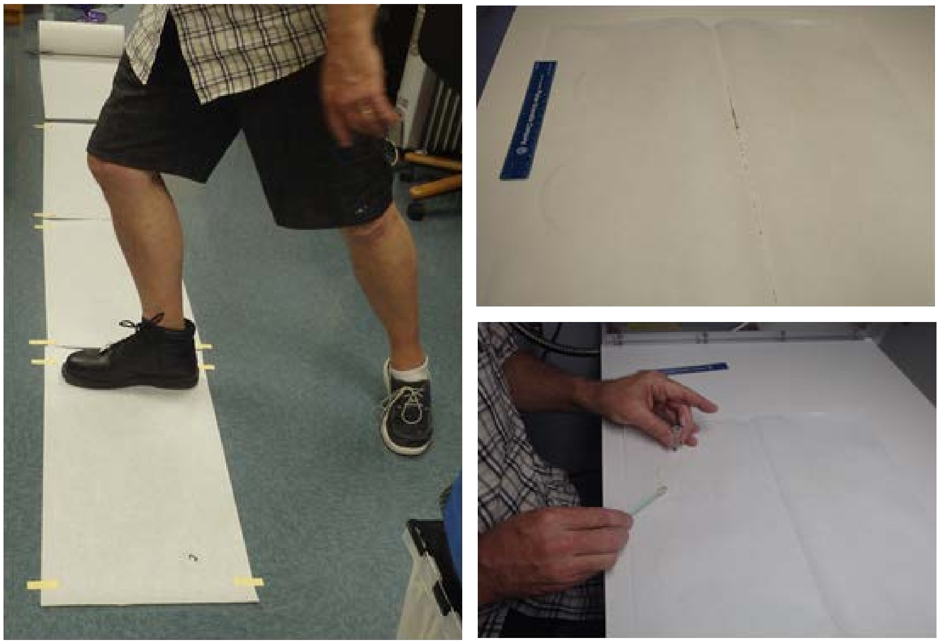

Figure 1: Removal of the most loosely held particles by walking on paper.

Figure 2: Removal of moderately held particles using an electrostatic lifter.

Direct moist swabbing of the contact surfaces of the footwear soles was conducted to remove and collect the most tightly held particles (Figure 3).

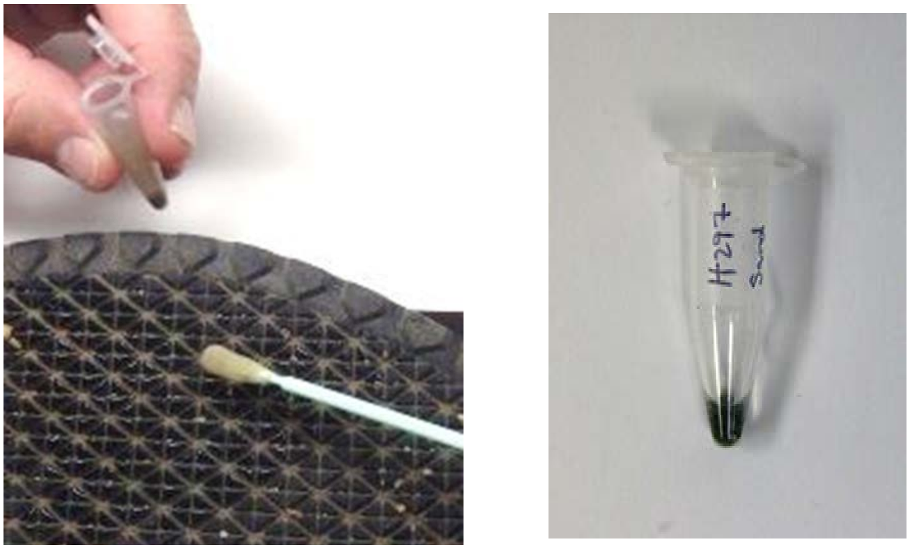

Figure 3: Removal of the most tightly held particles by direct swabbing of contact surfaces of the sole.

Each of the three sampling methods resulted in particle suspensions in 3% ethanol within 1.5 mL microcentrifuge tubes. Additional ethanol was added to the suspensions to inhibit the formation of mold.

The differential sampling methods were applied to two types of footwear: athletic shoes with flexible rubber soles (Kirkland Signature™ Men's Athletic Shoes) and work boots with hard rubber soles (Grabbers Black Steel Toe EH Non-Slip Work Boots). Three pairs of each type of footwear were used, exposing one pair of each type to each of three different dry, dusty environments by walking a distance of 250 m along a route, achieved by ten transects of 25 m (five round trips).

RESULTS AND DISCUSSION

For both types of footwear and each of the three environments tested, twelve firm, smooth walking steps (92 kg individual, shoe size US mens 10.5) were found to be sufficient to remove the most loosely held particles, as further steps recovered no perceptible additional particles.

Likewise, for both types of footwear and each of the three environments tested six smooth steps (92 kg individual, shoe size US mens 10.5) were found to be sufficient to remove the moderately held particles, as further steps recovered no perceptible additional particles.

Whereas these specific numbers of steps were found to be sufficient within the described experimental parameters, they cannot necessarily be extended to other types of footwear, other pressures (as a result of varying the weight of the individual or the contact area), or to other environments and exposure conditions. However, the sufficiency of any number of steps is easily monitored by inspecting the paper or electrostatic film surface for adhering particles, which are easily visible with oblique lighting.

The process of moist swabbing was applied as a collection step in each of the sampling methods and cannot be considered as strictly non-destructive: water soluble particles can be lost entirely, altered or formed by crystallization upon drying. Dry swabbing could be employed as an alternative or as a part of a modified method to test for such particles. A swabbing step would also disrupt any physical structure of accumulated deposits (such as layered clumps). Direct removal by picking clumps off of the outsole would be the preferred method to preserve any potential structure within these deposits.

CONCLUSIONS

The described three-staged sampling process provides a means to separate loosely, moderately and tightly held particles from the contact surfaces of footwear providing a means of studying the different fractions. Comparing and contrasting the populations of particles in these fractions is one approach to better understanding fundamental aspects of particle adhesion and loss from these surfaces and provides one possible means of separating particles which may have been acquired at different times and locations.

ACKNOWLEDGEMENTS

This project was supported by Award 2014-DN-BX-K011 awarded by the National Institute of Justice, Office of Justice Programs, U.S. Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this paper do not necessarily reflect those of the Department of Justice.

REFERENCES

1. Bull PA, Morgan RM, Sagovsky A, Hughes GJ. The transfer and persistence of trace particulates: experimental studies using clothing fabrics. Science & Justice. 2006;46:185-195.

2. Robertson J, Roux C. Transfer and persistence. In: Siegel JA, Saukko PJ, Knupfer GC, editors. Encyclopedia of Forensic Sciences. London: Academic Press; 2000. p. 834-838.
3. Pounds CA, Smalldon KW. The transfer of fibres between clothing materials during simulated contacts and their persistence during wear: part I — fibre transference. Journal of the Forensic Science Society. 1975;15:17-27.
4. Pounds CA, Smalldon KW. The transfer of fibres between clothing materials during simulated contacts and their persistence during wear: part II — fibre persistence. Journal of the Forensic Science Society. 1975;15:29-37.
5. Pounds CA, Smalldon KW. The transfer of fibres between clothing materials during simulated contacts and their persistence during wear: part III — a preliminary investigation of the mechanisms involved. Journal of the Forensic Science Society. 1975;15:197-207.
6. Morgan RM, Freudiger-Bonzon J, Nichols KH, Jellis T, Dunkerley S, Zelazowski P, Bull PA. The forensic analysis of sediments recovered from footwear. In: Ritz K, Dawson L, Miller D, editors. Criminal and Environmental Soil Forensics. New York: Springer; 2009. p. 253-269.
7. Morgan RM, Ainley J, Scott K, Bull PA. Trace materials on footwear - science or ichnomancy?. Presented at: NIJ/FBI Trace Evidence Symposium; 2011 August 8-11; Kansas, MO.
8. Morgan RM, Freudiger-Bonzon J, Nichols KH, Jellis T, Dunkerley S, Zelazowski P, Bull PA. The forensic analysis of sediments recovered from footwear. In: Ritz K, Dawson L, Miller D, editors. Criminal and Environmental Soil Forensics. New York: Springer; 2009. p. 264.
9. Scientific Working Group for Materials Analysis (SWGMAT). Trace evidence recovery guidelines. Forensic Science Communications. 1999; 1(3). Now available from www.asteetrace.org, under the Resources Tab, in the SWGMAT file, under the Trace subgroup.
10. Robertson J. Forensic examination of fibres: protocols and approaches - an overview. In: Robertson J, editor. Forensic Examination of Fibres. Chichester, UK: Elllis Horwood; 1992. p. 41-98.
11. Koons RD, Buscaglia J, Bottrell M, Miller ET. Forensic glass comparisons. In: Saferstein R, editor. Forensic Science Handbook, Vol. I. 2nd ed. Upper Saddle River (NJ): Prentice Hall; 2002. p. 161-213.
12. Petraco N, De Forest PR, Petraco NDK. A guide to the analysis of forensic dust specimens. In: Saferstein R, editor. Forensic Science Handbook, Vol. III. 2nd ed. Upper Saddle River (NJ): Prentice Hall; 2010. p. 31-74.
13. Adair TW, Tewes R. Lifting shoe impressions from cylindrical objects: a simple method. The Information Bulletin for Shoeprint/Toolmark Examiners. 2006;12(1):7-13.