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Awareness of the Potential of the EDD Serving as a Source for Transfer of DNA

Diane K. Tolliver[1] and Carl A. Sobieralski[2]

[1]Forensic Document Unit Supervisor and [2]DNA Technical Leader, Indiana State Police Laboratory, 550 West 16th Street, Suite C, Indianapolis, IN 46202-2203

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Electrostatic Detection Devices (EDD) have the potential to collect and transfer DNA[1] during processing. "Touch DNA" can now be detected and interpreted under current DNA processes at the Indiana State Police Laboratory. Analysis is by capillary electrophoresis with the PP16 kit[2] (Promega PowerPlex 16 kit). The EDD bed and humidification chamber were examined for the presence of DNA sources from shed cells. This research examined whether or not EDD processing of documents may be a source of cross-contamination. The 2008 American Society of Questioned Document Examiners (ASQDE) conference theme, "Reasoning with Technology: A Cognitive Approach to Casework," was applied in this research in examining whether or not the forensic document examiner needs to heighten his/her sense of awareness of possible DNA cross-contamination issues when examining documents using the EDD.

Introduction

Forensic laboratories are able to develop complete DNA genetic profiles from an item that was touched. The sensitivity of DNA testing has progressed to the point that DNA is being collected from objects that have been exposed to diploid cells through contact. Most body cells are diploid; they contain 2 sets of chromosomes, 1 set having been donated by each parent. Coughing and the resulting airborne sputum may leave enough DNA for profiling purposes. Folding a sheet of paper and placing it in an envelope, sealing the envelope (either by moisture and/or pressure), and placing a pressure-sensitive stamp on the envelope may also result in the deposit of DNA. This "touch DNA" is detectable from an extremely low sample size.

For perspective, a paper clip weighs approximately 1 gram (g). If cut into a billion equal pieces, each piece would weigh 1 nanogram (ng). If cut into a trillion equal pieces, each piece would weigh 1 picogram (pg). There are 6.0pg of DNA in a diploid cell. An earlier generation of DNA testing, restriction fragment length polymorphism, required 50ng of DNA for genetic analysis, which equates to approximately 83,000 cells. A present method of DNA analysis, STR or short tandem repeats, requires 0.5–1.0ng of DNA for genetic analysis. This equates to approximately 83-167 cells[3] (Phetteplace 2007).

This type of DNA analysis is becoming more common within the United States and is very sensitive to contamination. The Indiana State Police (ISP) Laboratory has been using this type of analysis since 2001.

Background

Research was conducted by an ISP latent print examiner[4] (LPE) on the possibility of cross-contamination occurring from the repeated use of a fingerprint development brush and a container of fingerprint powder. Could these 2 items, used within different places of 1 crime scene or from 1 crime scene to another crime scene be a possible carrier for DNA cross-contamination? The 2007 research by Frances Phetteplace also included an examination of fingerprint lifters. The results showed that the fingerprint lifters were contaminated with DNA; the powder containers did not show the presence of DNA; and the brushes produced partial profiles.

The Phetteplace study supported 1 published article on similar research on this subject of cross-contamination.[4]

If cross-contamination can take place with equipment used by CSIs and LPEs, what impact might the work in a forensic document unit have on cross-contamination of DNA on questioned documents? The answer to this question could determine how cases are triaged when they are received in the laboratory with requests for multiple examinations for different disciplines. Frequently, the forensic document examiner (FDE) has had 1st priority in examining documents before they go to the LPE. Years of research have documented the negative effects chemical processing can have on ink examinations, paper examinations, and the search for indented impressions.

Careful consideration must be given to deciding which unit gets the evidence 1st when requests for biological material and forensic document examination have been made on the same item. Usually the serologist or biologist and the FDE will discuss the possibility of who is likely to have the most potential for producing probative evidence. If a decision cannot be clearly reached, the contributor of the case or the prosecutor is solicited for input.

Experience has shown that swabbing paper documents in an attempt to collect DNA will significantly alter the paper surface and destroy indented impressions on the paper. The swabbing process will also cause water-based inks to run. Should document examinations be conducted before the collection of DNA, or should possible probative evidence such as indented impressions be sacrificed in order not to compromise the search for DNA on documents?

The spotlight of this study was the EDD, a universal instrument the FDE uses in the search and development of indented impressions on paper documents. First, what is the potential of cross-contamination of DNA by using an EDD? Second, can an FDE have an impact on cross-contamination of DNA? This research examined several components of the EDD that could reasonably be a source for cross-contamination. The research was also cognizant of the role the FDE may have in contributing to cross-contamination.

Materials and Methods

The humidification chamber provided with an Electrostatic Detection Apparatus-2[5] used by the ISP Laboratory has 3 shelves. On each shelf, 2 sterile swabs were used to collect the DNA. On the handle of the humidity chamber, only 1 sterile swab was used to collect the DNA. On the corona charging (CC) unit, 2 sterile swabs were used to collect the DNA. The ISP Laboratory Forensic Document Unit (FDU) utilizes both the original ESDA and the ESDA-2. The ESDA-2 was the focus for this study.

Swabs were not suitable to use for collection of DNA from the bed of the ESDA-2.[6] Therefore, 2 pieces of filter paper were used to collect possible DNA. Nuclease-free distilled water was used to moisten the filter paper and the swabs to aid in DNA collection.

The swabs were organically extracted to isolate any DNA present. The extracts were then cleaned utilizing microcon filters to remove any inhibitors that would interfere with subsequent testing. The samples were then concentrated to maximize the concentration of any DNA present. The 2 swabs from the humidification chamber shelves and the CC unit were combined after extraction and before concentration. The samples extracted with filter paper from the ESDA-2 bed were combined after collection and before they were concentrated.

All the samples were then quantitated using an ABI 7500 real-time Polymerase Chain Reaction (PCR) instrument and the Applied Biosystems Human Quantifiler kit. This kit can detect DNA concentrations down to .023ng/microliter (ul) reliably. DNA concentrations below this level are less reliable.

The samples were then analyzed for DNA profiles using the ABI 3130xl and the Promega PowerPlex 16 amplification kit. This kit can develop profiles down to .5ng/5ul consistently and can produce profiles below .023ng/ul (or .115ng/5ul). The ISP Laboratory protocol uses 32 PCR cycles for the Promega PowerPlex 16 amplification kit.

Results

Results of quantitation:

Swabs of humidity chamber shelf 1 resulted in no detectable DNA

Swabs of humidity chamber shelf 2 resulted in no detectable DNA

Swabs of humidity chamber shelf 3 resulted in .00199ng DNA/ul

Swabs of humidity chamber handle resulted in .00258ng DNA/ul

Swabs of CC resulted in .00276ng DNA/ul

Filter paper wipes of the ESDA 2 bed resulted in .00255ng DNA/ul

Results of amplification

All swabs and filter paper wipes used 19.2ul of the quantitated sample in the amplification to maximize the concentration of DNA in the reaction mix. All the samples failed to demonstrate a DNA profile.

Discussion

At the time of sample collection, selected areas of the ESDA-2 that had contact with physical evidence or with the analyst in the FDU did not contain enough DNA to develop a genetic profile. This does not preclude that documents having obvious areas of a biological material on them might leave enough DNA to cross-contaminate another document in the future. It also does not rule out receiving DNA from FDEs who operate the ESDA-2 in an unprotected manner. Normal use of this instrument by a safeguarded FDE does not currently pose a large risk of cross-contamination. Because of the rapid advancements in DNA technology, this will not always be true. The technology now being validated in forensic laboratories will be more likely to detect the low concentrations of DNA contamination found on this instrument.

Many precautions can be taken to protect documents for future DNA testing. Although some may seem extreme, there are some reasonable steps that do not adversely impede the FDE. Weekly cleaning of the instrument and its components and work surface with 70% alcohol or 10% bleach effectively removes DNA and prevent DNA build-up. Use of an ultraviolet light also destroys DNA so that it could not produce genetic profiles.

Cleaning of the instruments (excluding the ESDA-2 bed) with 70% alcohol or 10% bleach before and after examining a document that will be subsequently examined by a DNA unit or after any document that contains a biological fluid greatly reduces the chance of cross-contamination. Cleaning the work bench, using disposable examination paper on the work bench between groups of documents, and not reusing tools such as tweezers or pens without cleaning them will reduce potential cross-contamination.

Changing of gloves each time a different document is handled and the use of a clean barrier paper[7] between the document in question and the bed of the EDD is appropriate. This is compounded when the document is going on to the LPE for processing of latent prints. In these cases, it is recommended that the FDE be double-gloved. This includes changing barrier sheets and gloves between item examinations in the same case. If photocopies or scanned images are made of documents that will be subsequently examined for DNA, cleansing of the glass beds and lids of the photocopier and scanner should be done. Again, changing gloves between contact with each document and awareness of the FDE acting as a potential carrier for cross-contamination is key.

Additional personal protective actions that could be taken by the FDE include the wearing of a surgical-type face mask. Wearing of a disposable or multiple-wear lab coat, oversleeves, and a hat should also be considered for prevention of cross-contamination from the FDE to the document or examination equipment. If someone is observing an FDE during an examination of this type, he or she, too, should be required to wear a lab coat, gloves, and a mask. Individuals should not be permitted to stand near or over opened evidence without the proper attire.

Contamination avoidance procedures should be considered for the EDD platen. Because the ESDA-2 instrument is not designed to allow for routine cleaning with alcohol or bleach, a barrier sheet of paper should be used to prevent the document from direct contact with the instrument bed. The barrier sheet of paper should be prepared under DNA-contamination-avoidance procedures.[8] A limited study was conducted processing documents on the ESDA (original) and the ESDA-2 with and without paper barriers. There was no noticeable change of the developed EDD lift when a smooth sheet of paper (without folds) was used as the barrier sheet. One FDE colleague[9] stated in policy that "a 1-ply layer of towel roll…does not effect the ESDA impression." Further research should be conducted on this aspect of clarity level of EDD lifts with and without using a paper barrier. The trays of the humidification chamber and the chamber handle should be cleaned. The CC unit should also be wiped down.

The triage of multidisciplinary-requested examinations should continue to involve representatives from each discipline and the knowledge of potential hazards 1 analyst's examination may impose on the ability to conduct a thorough examination by another. It is also critical that forensic scientists know that their own genetic profile can impact an examination for DNA.

As caretakers of evidence submitted for document examinations, FDEs should handle, examine, and store the evidence in a manner that

protects its integrity and minimizes the potential for cross-contamination and deleterious change.

Notes

1. DNA: abbreviation for deoxyribonucleic acid.
2. The PowerPlex® 16 System is a multiplex STR system for use in DNA typing.
3. "Combined Fingerprint/DNA Cases; Issues Research and Opinions" in PowerPoint format by Frances Phetteplace, Forensic Scientist, Indiana State Police, 550 West 16th Street, Suite C; Indianapolis, IN 46202 fphetteplace@isp.IN.gov. This study was based on samples run by Maranda Michael and Lisa Robbins, Indiana State Police Forensic Scientists, Biology Unit, as well as previous research articles. The study was conducted under the guidance of DNA Technical Leader Carl A. Sobieralski.
4. *ibid.*, Phetteplace.
5. Electrostatic Detection Apparatus 2 (ESDA-2), Foster + Freeman LTD, 25 Swan Lane, Evesham, Worcestershire, WR11 4PE, UK.
6. E-mail correspondence with Michael J. Zontini, Applications Engineer, Foster + Freeman USA, Manekin Plaza Suite 170, Sterling, VA 20166, Michael.zontini@fosterfreeman.com, March 7, 2008. "It would not be harmful for your DNA analysts to swab the bed of the ESDA-2 as you suggest." After consultation with DNA Technical Leader Carl Sobieralski, it was decided that filter paper was the preferred method to use.
7. *ESDA-2 Instruction Manual and User Guide*, Chapter 3, Operating Procedure, Document handling, Protective measures, Cross-contamination: "Under normal operating procedures, the document is placed directly onto the stainless steel platen. Circumstances where this may not be appropriate include:
   - a document which is known to be heavily contaminated with biological, chemical, or radiological materials;
   - a document which is to be subsequently examined for traces of biological (particularly DNA), chemical or radiological material.

   "In both cases, the placing of a barrier sheet (e.g., standard office copier or printed paper of known and acceptable provenance) between the document and the platen may be adequate as a 1st line of defense against cross-contamination. Such a barrier sheet will not adversely affect the formation of the ESDA image in the document under examination and, according to circumstance, can either be retained as a reference sample (for possible future examination) or discarded.

   "Note that because air is drawn into the platen through the document, a barrier sheet will be more effective at preventing contamination of the document by the platen than vice versa. A platen that has become unacceptably contaminated, for whatever reason, should of course be discarded and renewed."
8. Maxwell, Stephen and Craythorne, Brian. E-mail correspondence dated November 9, 2007, Forensic Science, Northern Ireland, Policy TS5618.1, August 14, 2006, "Joint ESDA-DNA/Examination Conditions."
9. *ibid.*, Forensic Science, Northern Ireland, Policy TS5618.1, Section 6.4: "Contamination avoidance procedures are taken during the ESDA test. The vacuum bed is covered with a one-ply layer of towel roll. The towel roll has been prepared under DNA contamination avoidance conditions and layers are removed from the inside of a towel roll which originates from the manufacturers and has not come into contact with DNA. The one-ply layers of towel roll are stored in a box prior to use. The use of these thin layers of paper does not affect the ESDA impressions."

References

ESDA-2 Instruction Manual and User Guide, Chapter 3, Operating Procedure, Document Handling, Protective Measures, Cross-contamination.

Phetteplace, Frances (2007). Combined Fingerprint/DNA Cases; Issues Research and Opinions (PowerPoint). Indiana State Police, Indianapolis.

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