

Invisible Ink: A Refresher for Document Examiners

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With recent publicity concerning imprisoned gang members using invisible ink to communicate instructions for murdering rival gang members, it is anticipated that other inmates will “copy-cat” this “secret communication” technique. This paper reviews the history of invisible ink, discusses materials most commonly used in correctional facilities to produce invisible inks, and explains the various methods for identifying and developing the writing produced by these substances.

Introduction

The art and science of secret written communications or hidden messages is called *steganography*. The word is derived from the Greek words *steganos*, meaning “covered” and *graphein* meaning “to write” (Singh 1999). Invisible inks are substances which are invisible, either on application or soon thereafter, that can later be made visible by some other means (Wikipedia 2006). Invisible ink, or sympathetic ink, as defined by Webster (1994), is colorless and invisible until treated by a chemical, heat, or special light.

One of the earliest accounts of secret writing dates back to the 5th century B.C. when Demeratus, an exiled Greek, wrote a warning about a forthcoming attack on the wooden backing panel of a wax tablet. He then hid the message under a fresh layer of wax. Ancient Chinese wrote messages on fine silk which were subsequently rolled into tiny balls and covered in wax. A messenger would then swallow a ball of wax and deliver it to its intended recipient. In the 1st century A.D., a Roman, Pliny the Elder, explained in his treatise “Natural History” how the milk of the thithymallus plant could be used as an invisible ink to write secret messages on parchment. The milk would become transparent after it dried and could be read after carefully being held over a candle flame. The heat of the flame would oxidize the “ink” and turn it brown.

In the 20th century, military and intelligence (spy) organizations throughout the world used invisible inks as their concealment choice when passing letters and messages past censors. Invisible

inks became more and more sophisticated as literally thousands of chemical combinations were utilized to produce and reveal latent images. The “war of invisible inks” raged during World Wars I and II and the Cold War when Russian and German scientists battled to find more exclusive inks and the Americans attempted to find more general revealing agents (Abrams 1999). The invisible ink wars came to an end as spies began to rely more on microfilm, machine cryptology, and digital steganography. What was once considered one of the most sophisticated forms of secret communications is now being used by many children as a “spy game” toy.

Invisible Ink Update

In March 2006, information came to light that imprisoned members of the Aryan Brotherhood, a white supremacist gang, had for several years forwarded hidden messages written in invisible ink to fellow gang members. The messages directed gang members inside and outside the prison to commit murder and other crimes. One secret message forwarded from gang members imprisoned in California directed 2 inmates in a Pennsylvania prison to embark on a nationwide war with DC Blacks, a black prison gang. Twelve hours after receipt of this message, 2 black inmates were dead and 2 others injured in the Pennsylvania prison. It was later learned that the invisible ink used to create these secret messages was urine. The use of this organic substance as an invisible ink thus moved this secret communication technique out of the “child’s play” mentality.

The authors of this paper, through experience gained in their law enforcement and penal careers, believe that this highly publicized means of concealing communications will certainly be utilized on a more frequent basis. With this in mind, it is important that those responsible for monitoring written communications in correctional facilities and members of the questioned document community become more familiar with the use and means of identifying the materials used in producing invisible or secret messages.

Invisible Ink Types

A "war of invisible inks" raged during the World Wars I and II and the Cold War. Many extremely sophisticated compounds and formulas were developed and used. Some of these formulas are so secret that in 1999 the United States District Court for the District of Columbia ruled against plaintiffs who had filed a lawsuit requiring the Central Intelligence Agency (CIA) to reveal the invisible ink substances used during World War I. The CIA has stated that these ink formulas were a matter of national security and that releasing them could prove quite useful to hostile governments and terrorist groups (Pfleger 1999). Although recognizing there are numerous types of invisible ink formulations, this paper addresses 2 of the more common types:

1. Organic ink that is developed by heat and readily available to inmates in correctional facilities. Some of these substances that can be used as sympathetic inks are lemon juice, apple or orange juice, urine, onion juice, milk, saliva, vinegar, diluted cola beverages, and soapy water. These substances oxidize and usually turn brown when heated. Some methods or heat sources utilized by the message recipient

(or the examiner) include the following: heat lamps, standard pressing iron, hair dryer, heating/cooking ovens, standard light bulbs, and candles.

2. Inks developed by chemical reaction are not generally available in correctional facilities, but the substances used to produce them are readily available to the public. Some of these substances (Table 1) change color when developed with an acid or base (Wikipedia Contributors 2006).

Writing Substrates and Instruments

The particular type of writing instrument and substrate used in the application of invisible inks contribute to their secrecy. The base material of the substrate directly affects the absorption of the ink into said material. A more porous substrate will permit more absorption of the ink than a nonporous material. Thus, low quality notepad paper or even newspaper is ideal for such application. On the other hand, glossy paper (such as that used in magazines) is not conducive for application of a secret ink. Unfortunately, most correctional facilities provide inmates with a low-grade notepad type paper for their personal use.

The color of the paper may also contribute to masking the presence of the ink. If the writing substance is clear, a white background may be the paper of choice. If the substance has a slight yellow or brown color, yellow paper may be the choice to use. Ideally, the use of some type of a pen quill or pen nib similar to those found on fountain pens would be the instrument to use in the application of the sympathetic ink onto the substrate. However, again thinking of the availability of these materials in a correctional facility, it is unlikely that such instruments would

Substance	Developer
Ammonia	Red cabbage water
Copper sulfate	Sodium iodide, sodium carbonate, or ammonium hydroxide
Iron sulfate	Sodium carbonate or potassium ferricyanate
Lead nitrate	Sodium iodide
Cobalt chloride	Potassium ferricyanide
Sodium chloride (table salt)	Silver nitrate
Phenolphthalein	Ammonia fumes or sodium carbonate
Vinegar	Red cabbage water
Starch	Iodine solution
Lemon juice	Iodine solution

Table 1. Substances used as invisible ink and the agents used to develop them.

be employed. It is feasible that homemade writing tools such as toothpicks, the reverse end of a ballpoint pen ink reservoir tube, Q-tips, or swizzle sticks may be more appropriate and available writing instruments. The type of instrument which could be employed by inmates is left to the imagination of the person applying the invisible ink.

Initial Examination and Detection

Although there is little discussion relating to the subject invisible/secret/sympathetic ink in the various reference books in questioned documents libraries and reference material, most of the leading authorities in the field agree that there is no "cookbook" of procedures and/or protocols to apply when dealing with these inks. Generally, it is difficult to follow a standard examination process without some knowledge or suspicion that a sympathetic substance was applied and, more importantly, what that particular substance was. Ames (1900) wrote, "To understand these [sympathetic] inks it is necessary to know the constituents of the inks and know the proper reagent to use to produce the desired result."

In 1958, Harrison stated, "The problem posed by secret writing is not that it cannot be deciphered by a thorough and systematic investigation, but that its presence may be unsuspected." Later, Conway (1978) wrote, "The criminal or subversive who dispatches secret messages through a suspected, possible, or actual censorship may at times pose complex problems because of the variety of media which could conceivably be utilized is almost endless." Finally, Hilton (1993) opined, "When the writing material is known to the recipient, the particular method of development or order of applying reagents may then be employed. When secret inks of unknown composition are suspected, this cannot be done, yet it may become important to know whether a suspected document contains secret ink writing and, if so, what the message is."

Examination and detection techniques discussed below apply to the most common organic substances used as sympathetic inks. However, these same procedures and techniques can also be utilized in identifying and developing invisible inks produced from other materials and substances. First, the examiner must be aware of the hazards attributed to the examination of documents suspected of containing invisible writing. There are numerous reports of the use of various body fluids such as saliva, semen, blood serum, and especially urine. Because of

possible biological hazards associated with these materials, examiners should take the appropriate safeguards and wear the appropriate protective equipment when handling documents suspected of containing these materials.

Second, the examiner should obtain background information by asking these questions:

1. Has information been received indicating the possible presence or application of invisible ink in a particular document (e.g., informant, personal [witnessed] observations, etc.)?
2. Is there any history of the use of invisible ink by the individual who prepared the document in question or by any group to which he or she may be connected?
3. Are the circumstances at the time of preparation of the document conducive to the use of invisible inks (e.g., gang or personal disputes, need to relay confidential information, etc.)?
4. Has anyone reported observing any obvious or suspected (physical) indicators of the application of invisible ink present on the document?

Third, the examiner needs to be aware of the possible indicators that some type of invisible ink may have been applied to a document. Each of these should be included during the initial examination process of the questioned document(s). Many of these processes may be conducted physically, while others may require microscopic examination:

1. Discoloration and/or slight color differences in the base material of the substrate, specifically the areas on the document previously mentioned.
2. Disruption of paper fiber(s) possibly caused by the application of the invisible ink material using a crude or nontraditional writing instrument; e.g., toothpick, swizzle stick, etc.
3. The presence of impressions and/or indentations in the substrate material.
4. Running/bleeding of the inks in the writing on the document and/or any preprinted lines on the substrate.
5. The presence of an odor produced by the material used as the invisible ink; e.g., urine, lemon, onion, etc.
6. Unexplained presence of stains possibly caused by improper or careless application of the invisible ink onto the document.
7. The presence of moisture indicating liquid material has not completely dried.

8. Unexplained wrinkling and/or warping of the substrate causes shrinkage of base material after an excessive amount of liquid has been applied and dried to the substrate.
9. Partially developed portions of invisible inks.

Finally, physical examination of the document should include the most common areas on document(s) where invisible ink messages can be found. These areas are the bare spaces/blank areas between words, the end of written lines, and the margins (left, right, upper, and lower). Another common technique is to write the "secret" invisible ink message and then cover or overwrite the message using a ballpoint pen. During the examination, the examiner should consider the use of various heat sources listed earlier in the paper and/or light sources to assist in visually inspecting a document for the presence of a foreign substance. Some of these sources include direct lighting, transmitted light, oblique lighting, ultraviolet, infrared, and alternate light sources with variable wave lengths.

Conclusions

The Connecticut Department of Public Safety's Forensic Science Laboratory, Questioned Document Section, has undertaken a research study to determine the most efficient procedures for correctional personnel in screening documents for the presence of secret invisible ink communications. At the same time the research study also attempted to identify the most proficient methodology to be utilized by forensic document examiners for identifying and visualizing invisible inks on suspect documents.

Preliminary experimentation involving the various examination processes discussed in this report reflect that a) subjecting a substrate containing a urine base sympathetic ink to various heat sources is an effective means of developing and visualizing that particular organic substance; and b) scanning substrates containing milk or citric base sympathetic inks with ultraviolet light is an effective means of visualizing those particular organic substances.

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