The Hazard of Benzidine to Criminal Justice Personnel

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The Hazard of Benzidine to Criminal Justice Personnel

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FOREWORD

The Law Enforcement Standards Laboratory (LESL) of the National Bureau of Standards (NBS) furnishes technical support to the National Institute of Law Enforcement and Criminal Justice (NILECJ) program to strengthen law enforcement and criminal justice in the United States. LESL's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

LESL is: (1) Subjecting existing equipment to laboratory and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guidelines, state-of-the-art surveys and other reports.

This document is a law enforcement equipment report developed by LESL under the sponsorship of NILECJ. Additional reports as well as other documents are being issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles and clothing.

Technical comments and suggestions concerning the subject matter of this report are invited from all interested parties. Comments should be addressed to the Law Enforcement Standards Laboratory, National Bureau of Standards, Washington, D.C. 20234.

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THE HAZARD OF BENZIDINE TO CRIMINAL JUSTICE PERSONNEL

ABSTRACT

Benzidine is a hazardous material which can cause bladder cancer in man. Yet it is used by criminalists and by investigative personnel in the detection of blood and in the preparation for photography of fingerprints found on bloody substrates; significant benzidine uptake by these personnel is possible. The forensic techniques which utilize benzidine, and the most likely routes by which contamination of personnel may occur, are described. Recommendations regarding its handling and use are presented.

Key words: Benzidine hazard; blood testing; carcinogen; fingerprints; forensic science; hazardous materials.

1. INTRODUCTION

Benzidine has been identified as a carcinogenic compound hazardous to man. The Occupational Safety and Health Administration (OSHA) has classified benzidine as a hazardous substance and has promulgated rules and regulations (OSHA Standard 1910.93j) regarding its use and handling.

Benzidine has been used by criminalists and law enforcement personnel for over half a century. A mini-study, requested by the National Institute of Law Enforcement and Criminal Justice and performed by the Hazard Analysis Section of the National Bureau of Standards, under the direction of the Law Enforcement Standards Laboratory (LESL), has confirmed that the use of benzidine by various law enforcement personnel does indeed pose a hazard to them. The purpose of this report is to document the findings of this mini-study and to present the conclusions and recommendations. The report deals basically with two areas of benzidine use by law enforcement personnel: (1) as a presumptive blood-test reagent, (2) to prepare fingerprints made in a blood base for subsequent photography.

2. THE BENZIDINE HAZARD

Benzidine (4, 4′-diaminobiphenyl) is a white crystalline powder that darkens to a reddish, tan or brown color upon oxidation. Benzidine reagent is typically prepared from the pure compound rather than from one of its salts. The production of benzidine in the USA amounts to millions of pounds annually. It is widely used in the manufacture of azo dyes; according to the Color Index [14],[1] more than 25 dyes are made from it. In addition, it is used as an analytical reagent in many industries (ref. 15, p. 81). Benzidine melts at 128 °C, possesses a significant vapor pressure and can be sublimed [15]. It is readily absorbed through the skin. Although its salts exert no significant vapor pressure, skin absorption can occur [7].

Both experimentation on animals and epidemiological evidence [8] indicate that benzidine and its salts are systemic carcinogens causing an increased (but frequently delayed) incidence of bladder cancer in man. Other chemicals used in the manufacture of dyes, such as 4-aminobiphenyl and 2-aminonaphthylene, are also dangerous carcinogens [20]. In many of the epidemiologic studies involving workers in various industrial plants and occupations, these substances may have interfered with the deductions made regarding the carcinogenicity of benzidine. Nevertheless, the evidence is sufficiently

[1] Figures in brackets indicate the literature references at the end of this paper.

strong for OSHA to have promulgated specific rules and regulations regarding the handling (use, transport, etc.) of benzidine [9].

Another commonly used blood-test reagent, *o*-tolidine (3, 3′-dimethylbenzidine), has also been identified as a possible carcinogen [4, 10, 15]. Purified *o*-tolidine has been found to be a systemic carcinogen to rats when injected under the skin [21], but other animal data are either negative or inconclusive. No epidemiological studies on the effects of *o*-tolidine on man were available as of 1972 [15], but Culliford [4] has branded *o*-tolidine as a "reported" carcinogen. The evidence for its hazard to man was not sufficient for OSHA to issue rules and regulations for its use. However, it is a regulated substance in Great Britain [22, 23].

3. BENZIDINE IN CRIMINAL INVESTIGATION

3.1 Blood Testing

3.1.1 Background

Presumptive blood testing (tests to determine if suspect stains or crusts are blood) may be performed at the scene of the crime or in the crime laboratory. Field tests may be performed by a medical examiner, law officer, coroner or criminalist. In the crime laboratory, evidential materials containing possible blood stains are tested by either a forensic serologist or a criminalist.

Table 1 lists the eleven most commonly used presumptive blood tests. Tests b, c, d, e, h, i, j, and k utilize reagents that produce a distinctive color change (or fluorescence, in the case of luminol) in the presence of small traces of blood. Chemical oxidants, vegetable peroxidases and some other contaminants can produce false positives in each of these eight tests. Tests a, f, and g can also be used as presumptive blood tests. However, since these do not produce false positives in the presence of the above interferences, one of them is frequently used as a confirmatory test. These tests (a, f, and g) are either more complex, time consuming and/or less sensitive than the eight others. The benzidine test is considered to be the most sensitive of the tests listed in table 1 and as specific as any of those tests that depend on peroxidase activity to produce a positive reaction. Crystal tests (e.g., Takayama or Teichmann) do not work well on old or weak stains. The luminol test is exceedingly sensitive but will likely destroy the ability of the stain to be typed. In general, high sensitivity is more desirable than high specificity, since stains giving false positives can be discarded during the precipitin or blood-typing stages. An insensitive test may require so much sample as to eliminate the possibility of additional classification or testing.

Since its documentation seventy years ago [2], benzidine has remained the standard blood-test reagent throughout the world. That this is so is evident from the fact that almost all forensic science text books that describe blood testing [4] methodology include the benzidine and one or two other tests. Brian Culliford, in his monograph on blood testing, classifies all presumptive blood tests as "benzidine tests." That benzidine is widely used in the U.S. is evident from the results of a nationwide survey conducted in the fall of 1974 [1]. This survey was directed at forensic serologists in various Federal, State, county and metropolitan crime laboratories as well as university forensic science departments. The first part of the survey questionnaire asked each respondent to list all

TABLE 1. *Laboratory familiarity with various presumptive blood tests**

Test #	Blood test	Number of labs reporting: Familiarity with test	Number of labs reporting: Former use of test
a	Microscopic examination of stain or smear made from stain extract, including cytological stain	56	
b	Benzidine	54	1
c	*o*-Tolidine	10	
d	Benzylidine dimethylaniline	2	
e	Phenolphthalein	48	1
f	Crystal (Takayama or other)	54	1
g	Spectrophotometric methods (absorption spectrum of hemoglobin, etc.)	10	
h	Luminol	15	
i	Leucomalachite green	10	
j	Hemaiest**	9	
k	Hemastix**	8	1
Totals		276	4

* This table summarizes a portion of the data presented in Reference #1.

** Both Hematest and Hemastix are trade names of products sold by Ames Co., a subdivision of Miles Laboratories, Elkhart, Indiana. Hemastix may be discontinued. Both are impregnated with *o*-tolidine reagent.

It was necessary to identify commercial products by manufacturer's name and label. In no instances does such identification imply endorsement by the National Bureau of Standards.

the presumptive blood tests with which he/she was familiar. Of the 126 surveyed, 116 responded to this question. The 116 responses gave a total of 276 indications for the eleven tests listed, as is shown in table 1. On the average, therefore, each respondent was familiar with 2.4 presumptive blood tests. Almost half of them listed the benzidine test; it was the most widely known of the chemical reagent tests. Several factors, including the three listed below, affect the interpretation of these results:

(1) Did the 56 laboratories performing microscopic examinations (test a) do so initially, as a matter of routine, or as a confirmatory test (ref. 5, p. 455)?

(2) One California forensic serologist claimed that he, and most other California forensic scientists, had stopped using benzidine since that state adopted strict regulations regarding its handling. A serologist in a Michigan crime laboratory claimed to have stopped using benzidine in March 1975. The U.S. Army Criminal Investigations Laboratory at Ft. Gordon, Georgia, switched from benzidine to phenolphthalein in the fall of 1974. Thus, the level of benzidine usage appears to be on the decline.

(3) The questionnaire did not ask each laboratory to give its method of preference. Nevertheless, it is clear that the use of benzidine in the crime laboratory, as of late 1974, was widespread. This is probably also true of field investigators who routinely examine

crime scenes and gather evidence. As already noted, tests a, f, and g of table 1 cannot readily be performed outside a laboratory, while the potential for typing of blood stains may be destroyed by the use of luminol.

3.1.2 Potential for Benzidine Contamination

There are several routes by which crime laboratory, crime scene or other personnel connected with law enforcement may come in contact with benzidine intended for use in blood testing.

(a) *During the Preparation of the Benzidine Reagent*: In some laboratories, the benzidine reagent (usually 0.1 to 0.5 percent benzidine in alcohol-acetic acid or glacial acetic acid) [4] may be prepared daily. More frequently, however, a master batch of reagent solution is made up at intervals ranging from weeks to six months or longer. This master batch is used to refill a small dropper bottle. The efficacy of the benzidine reagent solution is checked periodically. In most laboratories contacted, benzidine reagent preparation took place in the open; however, one laboratory (of eight contacted) used a hood. In most cases, benzidine compound, master reagent solution and dropper bottle were all stored in the open; in a few, refrigerator storage was used.

The greatest danger of benzidine contamination probably occurs during preparation of the reagent. Contamination may occur if the pure compound becomes airborne for a sufficient time to be inhaled by or to land on the user or a nearby surface. Spillage can also lead to direct or indirect ingestion.

(b) *During the Blood Testing:* The testing of stains frequently involves the transfer of a small amount of the stain onto the corner of a twice-folded filter paper. A cotton swab or applicator stick may be substituted for the filter paper. If the filter paper, swab or stick is used dry, then transfer is effected by mechanical rubbing. The filter paper or swab may be moistened with distilled water or saline solution, in which case transfer is by elution. One or two drops (0.05-0.1 mL) of benzidine reagent is then added to the transferred stain, followed by a few drops of a developer or activator solution, which brings out the characteristic deep blue coloration of this test. If sufficient stain is available, a small piece of the stain or stained material may be cut out and placed in one of the depressions on a porcelain spot-test plate. The benzidine and developer solutions are then added and, once the test is completed, the plate is rinsed off and cleaned in chromic acid cleaning solution. Few if any criminalists wear disposable plastic gloves when performing the benzidine test, and some criminalists do not wash their hands after each such test. Contact is possible either from careless handling or volatilization of the benzidine from the test solutions. In any case, the contamination possible during a test is much less severe than that possible during reagent preparation. Note, however, that the laboratories contacted indicated that they performed as many as 200 blood tests per month. Therefore, the opportunities for contamination during testing are many times more frequent than during the production of master solution.

(c) *During Disposal or Cleanup:* The test swab, applicator stick, or filter paper is usually discarded in a waste basket. This basket may or may not be lined with a disposable plastic bag, and the basket is invariably left in the open and not in a negative pressure environment. If a spot test plate is used, contamination may occur during cleaning. The law officer who must perform presumptive blood tests in the field is, typically, in greater jeopardy than the criminalist in the laboratory. The reasons are:

(1) While essentially all crime laboratory serologists are aware of the hazards of benzidine, the average field worker may have neither the time nor the opportunity to keep abreast of such facts.

(2) The field investigator does not have access to hooded (negative pressure) areas.

(3) The environment in which a field investigator must operate is frequently not conducive to the taking of safety precautions. The investigator, typically, will rush his examination of the crime scene to preclude interference by other law officials, residents, etc. Thus, the investigator may not put on plastic gloves, may not wash after his examination and may not give the reagent bottles, etc., the careful handling they deserve. Also, since he carries his reagents with him, the opportunities for breakage and/or spillage are present and his equipment case may become contaminated with benzidine.

3.2 Blood Print Development

3.2.1 Background

When fingerprints occur on a blood substrate (i.e., "blood prints"), a benzidine reagent is used to enhance their visibility. One such reagent is a 0.5 percent solution of benzidine in glacial acetic acid and collodion ethyl ether. Another is a one percent solution of benzidine in ethanol-acetic acid. Hydrogen peroxide solution (3 to 30%) is added to the benzidine solution just prior to its use.

There are two methods of using these benzidine reagents. Usually, the solution is used as an aerosol mist. However, at least one of the laboratories contacted prefers to pour the benzidine solution over the blood prints.

Latent blood print enhancement may be performed by fingerprint technicians, questioned document examiners or criminalists.

3.2.2. Potential for Benzidine Contamination

The opportunities for benzidine contamination related to blood print development are basically the same as those described in 3.1.2. There are, however, several significant differences.

(a) In some cases, the benzidine reagent used with blood prints is of about the same concentration as that used in blood testing (i.e., between 0.1 and 0.5% benzidine). Some laboratories, however, use a reagent solution that contains, as indicated, about 1 percent benzidine.

(b) Although the routes for benzidine contamination during preparation, storage, use and disposal of reagent solutions are similar in blood testing and blood print development, the latter task may involve the use of an aerosol spray. If not performed in a negative pressure environment, benzidine reagent spray may present a substantial opportunity for inhalation as well as absorption through the skin.

(c) Most (if not all) crime laboratory serologists have some scientific background and a knowledge of the carcinogenic nature of benzidine. On the other hand, most fingerprint technicians have little, if any, chemistry laboratory training, and are not likely to be aware of the hazard of benzidine.

(d) In blood testing, the object receiving benzidine reagent is, typically, disposed of or cleaned. In blood print testing, the object onto which benzidine reagent is sprayed or poured is usually retained as evidential material. As such, total removal of benzidine reagent may be proscribed. Later handling of this evidence might inadvertently contaminate the handler.

4. CONCLUSIONS

(a) Benzidine is strongly suspect as a cause of human bladder cancer.

(b) Most forensic serologists and criminalists are aware of the hazard of benzidine contamination, but this knowledge is frequently ignored in daily practice. Field investigators, fingerprint technicians and questioned document examiners are, generally, less aware of benzidine's hazard. Furthermore, whereas the former group has the requisite training that should enable them to effectively minimize the hazard to themselves and their co-workers, the latter group is, for the most part, ill-equipped to do so.

(c) There is widespread use of benzidine in the crime laboratory and at the crime scene. Benzidine is mostly used for blood testing, but it is occasionally used for blood print enhancement. The level of use of benzidine in both areas is on the decline.

(d) Some laboratories routinely use the benzidine test in preference to the other available techniques. They do so because the benzidine test is the most sensitive and one of the simplest and most specific tests for blood. All other known tests are inferior to it in one or more ways. Similarly, benzidine is claimed, by some, to be superior to ninhydrin for the enhancement of blood prints, especially on solid substrates.

(e) The opportunities for contamination during benzidine reagent preparation, storage, transportation and post-test disposal are similar for both blood testing and blood print development. The reagents used in both tests are about 0.1 percent benzidine by weight. This is the concentration level above which the OSHA standard applies. One formula used in blood print enhancement calls for a benzidine concentration of approximately 1 percent. It is assumed that relatively few workers use this higher strength formula. The spraying or pouring of benzidine reagent for blood print development certainly involves a much higher exposure than that due to the one drop of reagent used in presumptive blood testing.

(f) In the typical laboratory, there are ample opportunities for absorption through the skin or inhalation of the spray, pure powder or sublimate, or of evaporated material from solution or test residues. Ingestion of benzidine by means of contaminated food is also possible. Since benzidine is a systemic carcinogen, inhalation, absorption and ingestion routes are all potentially hazardous. In the field, these opportunities for contamination may be magnified.

(g) The OSHA rules and regulations governing the handling of benzidine, if strictly applied, would preclude its use in most crime labs. This is essentially the reason why the U.S. Army Crime Lab at Ft. Gordon, Ga., switched to phenolphthalein reagent in the fall of 1974 after many years of using benzidine for blood testing. The California Occupational Safety and Health Administration has adopted rules which are at least as stringent as the OSHA regulations.

5. RECOMMENDATIONS

5.1. Recommendations Regarding the Handling and Use of Benzidine

(a) Until a safe and satisfactory substitute for benzidine is developed and made available, [12, 13] use of this reagent should not be proscribed.

(b) Where sufficient sample exists so that the sensitivity of the blood test is not crucial and where a confirmatory test is possible, one of the other test reagents (test c, d, e, h, i, j, or k of table 1) should be substituted for benzidine. This is certainly true if the presumptive test is to be followed by precipitin, electrophoretic, or blood typing tests. Thus, the use of benzidine should be reserved for those cases where other reagents will not suffice. Similarly, benzidine reagent should be used to enhance blood prints only when photographs of the original print prove unsatisfactory.

(c) Benzidine reagent solution should be made up in a negative pressure area as infrequently as reagent stability and caseload permit. The use of a filter-type respirator when handling benzidine powder should be encouraged.

(d) Disposable plastic or surgeon-type latex gloves should be worn whenever benzidine or its solutions are handled. This also covers the handling of all containers, droppers, applicators, plates, etc., that contact them. Note that ninhydrin reagent has been shown to pass through latex and polyethylene gloves [19], and it would not be surprising if benzidine is also capable of transmission through them. It is best to use disposable gloves when handling benzidine, but to assume that this compound can permeate them.

(e) Solid residues including once-used plastic gloves, should be placed in a closed receptacle which is lined with a disposable plastic, airtight bag. At the end of each work day, this bag should be closed shut and properly disposed of.

(f) Soap-and-water hand washing should follow each usage of benzidine.

(g) If spot-test plates are used for blood testing, they should be washed afterwards. Washing should be done wearing disposable gloves and the sink rinsed well after each such washing. Unless several tests are to be performed in short succession, the plate should be washed immediately after its use. A subsequent soak in chromic acid cleaning solution should remove all traces of benzidine.

(h) Use the lowest concentration of benzidine solution that gives satisfactory performance.

(i) The spraying of benzidine reagent in the laboratory should be done in a designated negative pressure area (i.e., a hood), while wearing mask and gloves. If the pouring technique is used, it should be performed over a sink and the sink washed after use. Again, gloves are to be worn. Whether spraying or pouring, the amount of reagent used should be the minimum quantity required to give satisfactory results. When spraying a small object in the hood, the backing material, which may become contaminated with benzidine, should be properly cleaned or disposed of. The spraying of blood prints with benzidine solution should not be done at a crime scene unless it is in the open and at a safe distance from other people. After photography, the evidence should be placed in a plastic bag or other suitable container and brought to the crime lab or evidence storage area. If this is not possible, the sprayed area should be wiped clean after photography is completed and the wipes disposed of properly.

(j) Benzidine reagent should never be prepared in the field. When a new solution is required, it should be obtained from the base laboratory or a substitute reagent (e.g., d. e, h, i, j, or k of table 1) used. The reagent solution should be stored in tightly stoppered bottles and kept in a second container so that, if the dropper bottle should break or leak during transport, contamination of the entire field kit would not occur. At no time should more than 5 or 10 cc of benzidine reagent be carried in a field kit; at one drop per test, 10 cc of reagent should be sufficient for up to 200 tests.

(k) Laboratory work areas, surfaces, reagent bottles, etc. should always be considered as contaminated. Under this assumption, food should never be brought into or eaten in the laboratory. Hands and face should be thoroughly washed when leaving the laboratory. A field investigator should wash his hands after handling his field kit. If no sink is available, a disposable towlette should be used.

(l) Crime laboratories should have or install adequate negative pressure or well ventilated work areas.

(m) Every worker who comes in contact with benzidine should periodically be given a urinary cytogical examination.

5.2. Recommendations Regarding Research

(a) There are references [12, 13] to blood-test reagents that are at least as specific and sensitive as benzidine and which, at present, are not considered hazardous to humans. Either through insufficient research or documentation, unavailability, or high costs, these alternative test methods are not widely used. Funding should be made available to explore the alternative presumptive blood tests and/or to remove the blockages to their general use. Each candidate reagent should be evaluated as to its sensitivity, specificity, stability, availability, and potential hazard to man. The effects of humidity, temperature, age, substrate material, and state of putrefaction of the blood stains on the use of the candidate reagent should also be studied.

(b) Assuming that benzidine is determined to be or perceived as being indispensable to certain areas of blood testing or blood print enhancement, then a program should be funded to ascertain the minimum benzidine concentration (and associated reagent formulation that is capable of providing, respectively, the minimum acceptable sensitivity or contrast.

(c) A study of the permeability of various available rubber and plastic gloves to benzidine should be considered. As long as benzidine continues to be used, workers should be aware of which gloves (if any) are not satisfactory and which gloves are most impervious to this reagent.

5.3. Recommendations Regarding Warning Notices

Warnings and safety precautions regarding the use of benzidine should be disseminated to both criminalists and field workers. For those workers engaged in blood testing, articles in the publications listed in table 2 are suggested.

To obtain coverage for those workers who may, upon occasion, use benzidine to enhance blood prints, the five periodicals listed in table 3 (which include two periodicals from table 2) should be considered.

TABLE 2. *Periodicals likely to be read by criminal investigators involved in blood testing*

#	Name of periodical	Published by	Editor	Frequency of publication	Total circulation	Coverage	Comments
1	Forensic Serology Newsletter	John Jay College of Criminal Justice	Dr. Jon Gaenssler	Bimonthly	200	Most U.S. crime labs and universities with forensic science programs	To put in July issue, submit article by mid-June.
2	Crime Laboratory Digest	Federal Bureau of Investigation, Wash., D.C.		Monthly	200	U.S. and Canadian law enforcement crime labs	Newsletter-type periodical
3	Information	I.A.C.P., Gaithersburg, Md.	Robert Angrisani, (Asst. Director, Public Affairs Section)	At least monthly, more often as news occurs	11,000	Lab and field workers	
4	The Police Chief	I.A.C.P., Gaithersburg, Md.	Robert Angrisani	Monthly	20,000	Senior law enforcement management personnel (+5000 lower rank police officers)	
5	The National Sheriff	National Sheriffs' Association, Wash., D.C.	Truman Walrop	Bimonthly	32,000	Police officers and, therefore, some field investigators	To put in Aug.-Sept. issue, submit article by Aug. 1.

TABLE 3. *Periodicals likely to be read by criminal investigators involved in blood examination*

#	Name of periodical	Published by	Editor	Frequency of publication	Total circulation	Coverage	Comments
1	Identification News	International Association for Identification, Utica, N .Y.	Walter Hoetzer	Monthly	~2,000	Fingerprint Technicians and QDE's	No obstacles to article being inserted.
2	Fingerprint and Identification Magazine	Institute of Applied Science, Chicago, Ill.	T. Dickerson Cooke	Monthly	~7,000	Every known fingerprint group	No obstacles to article being inserted.
3	Law Enforcement Bulletin	Federal Bureau of Investigation, Wash., D.C.	Mr. Campbell	Monthly	~90,000	Mostly regular subscribers but some upon request. All crime labs.	
4	The Police Chief	I.A.C.P., Gaithersburg, Md.	Robert Angrisani	Monthly	~20,000	Senior law enforcement management personnel (+5000 lower rank police officers).	
5	The National Sheriff	National Sheriffs' Association, Wash., D.C.	Truman Walrop	Bimonthly	~32,000	Police officers and, therefore, some field investigators	To put in Aug.-Sept. issue, submit article by Aug. 1.

Of these five, it would appear that an article appearing in the first two and either the fourth or fifth should provide essentially complete coverage of the target population.

Possibly the articles should be supplemented by the dissemination of a poster stating recommended procedures for benzidine use. This poster should be designed for visibility and legibility when posted in laboratories that handle benzidine.

5.4. Proposed Study of Morbidity Statistics for Criminalists

Epidemiological studies of the effects of benzidine on man are based on statistics from workers exposed to extremely high concentrations of the compound. Criminalists, forensic serologists, fingerprint technicians, etc., have had, on the other hand, relatively nominal exposures. This probably holds true even for those involved in high levels of blood testing for ten or more years. A study of morbidity levels among long term blood-test personnel may shed some light on the low-level hazards of benzidine. This study could involve the comparison of abnormality levels observed from urinary cytologies on both laboratory personnel and a control group. Where abnormalities are observed in either group, they can be followed up by cystoscopies and/or intravenous pylograms or other examinations that will assist in determining the source of the problem. Benzidine is a specific carcinogen, and this should simplify the interpretation of results. This type of program is in progress at the U.S. Army Criminal Investigations Laboratory at Ft. Gordon, Ga. Some abnormalities observed in this study cleared up soon after the workers stopped using benzidine. Such a study could draw on both active and retired criminalists and those with both long and short term exposures to benzidine.

The above study could be supplemented by an examination of the causes-of-death of long term forensic serologists.

Both studies should involve active and control groups of at least 100 subjects. If the target sample sizes cannot be achieved with available criminalist/forensic serologist data, then medical laboratory technicians who have used benzidine to test for blood traces in feces, or other groups of workers using benzidine at nominal levels, could supplement the active group.

This project might receive support from NIOSH, OSHA or NILECJ.

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yields for producing this compound, low yields being stated as the reason this derivative of benzidine is not now available or in use. He claims, furthermore, that 3,3′, 5,5′-tetramethylbenzidine will not be a carcinogenic hazard.

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