

health hazard alert

OSHA
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Benzidine-, o-Tolidine-,
and o-Dianisidine- Based Dyes



U.S. Department of Labor
Occupational Safety and
Health Administration

U.S. Department of
Health and Human Services
Public Health Service
Centers for Disease Control
National Institute for
Occupational Safety and Health



Health Hazard Alert:

Benzidine-, o-Tolidine-, and o-Dianisidine-Based Dyes

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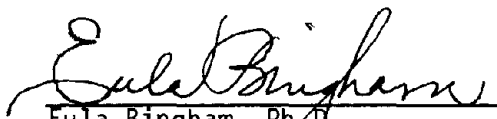
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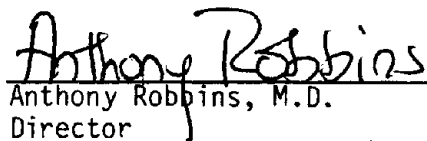
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Recent data from animal tests, case reports, and other sources about the carcinogenic effects and metabolism of benzidine-, o-tolidine-, and o-dianisidine-based dyes have come to the attention of OSHA and NIOSH. Both agencies have reviewed the data and conclude that the findings establish the potential of these dyes to cause cancer in humans.

OSHA and NIOSH conclude that persons working with these dyes should be aware of the potential health hazards that could result from excessive exposure to them. The intent of this document is to summarize the information available on the carcinogenic effects and metabolism of benzidine-, o-tolidine-, and o-dianisidine-based dyes and to provide guidance so that employers, employees, and physicians may work together to reduce potential health hazards that could result from excessive exposure to these dyes.



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BENZIDINE-, o-TOLIDINE-, AND o-DIANISIDINE-BASED DYES

Health Hazard Alert

SUMMARY

OSHA and NIOSH have reviewed the literature on benzidine-based dyes. Available studies indicate that some benzidine-based dyes cause cancer in experimental animals and are converted in animals and humans to benzidine. From the accumulated evidence, OSHA and NIOSH conclude that benzidine-based dyes are potential human carcinogens. In a Special Hazard Review, NIOSH has recommended that the commercial use of benzidine-based dyes be discontinued and appropriate substitutes be utilized. OSHA has concluded that exposure of workers to the dyes should be reduced to the lowest feasible levels. This should include discontinuing use of the dyes where possible.

There is evidence from animal studies that o-tolidine, o-dianisidine, and the two dyes based on o-tolidine are carcinogenic. There is preliminary evidence that dyes based on o-tolidine and o-dianisidine, except for metalized dyes based on o-dianisidine, may be metabolically converted to the parent compounds. Benzidine-based dyes may contain residual amounts of benzidine as well as other substances such as 4-aminobiphenyl, an OSHA-regulated carcinogen. Dyes manufactured from o-dianisidine and o-tolidine may also contain residual amounts of the respective parent compounds. Therefore, there may be a problem of contamination with carcinogenic materials in addition to concern for the metabolism of these dyes to carcinogenic substances. Dyes derived from o-tolidine and o-dianisidine should be handled with great care in the workplace, and exposure to them should be strictly limited. This Health Hazard Alert summarizes these biological effects and presents actions that should be taken to reduce worker exposure to these substances.

BACKGROUND

Benzidine-based dyes are defined as dyes that contain benzidine attached to other substituents by diazo linkages. Dyes based on o-tolidine contain o-tolidine (3,3'-dimethylbenzidine) attached to other substituents by diazo linkages. Dyes based on o-dianisidine (3,3'-dimethoxybenzidine) contain o-dianisidine attached to other substituents by diazo linkages. At least 16 benzidine-based, 8 o-tolidine-based, and 9 o-dianisidine-based dyes are produced currently in the United States. (1) The appendices contain a list of the dyes and a summary of major producers and importers of the dyes.

Estimates of the production and importation of these dyes by major companies are shown in Table 1. These estimates do not include importation or production by at least seven other companies.

Table 1

1978 Production and Importation of Dyes Made
From Benzidine, o-Tolidine, and o-Dianisidine

Dyes From	Pounds (Presscake Basis)
Benzidine	1-2 million
o-Tolidine	800,000
o-Dianisidine	1,329,000

Source: Written communication from Dyes Environmental and Toxicology Organization, Inc. (DETO), Scarsdale, New York, September 24, 1979.

Thousands of workers involved in the production of dyes, textile, paper, and leather goods potentially are exposed to dyes based on benzidine, o-tolidine, and o-dianisidine. Because more than one of these dyes may be found concurrently in the same industry, it is difficult to count exposed workers and to define the extent of exposure to any specific dye.

The textile dyeing and finishing industry employed an estimated 75,400 production workers in July 1979; of these, about 7% were potentially exposed to these dyes. (2,3) In July 1979, the leather tanning and finishing industry employed 19,800 production workers of which 1,000 spray machine operators or colorers had the opportunity for exposure to the dyes. (3,4) NIOSH has estimated that about 79,200 workers in 63 occupations potentially are exposed to benzidine-based dyes. (5) The number of directly exposed workers is estimated by DETO to be less than 20,000. (6) Exposure to these compounds may occur by inhalation, ingestion, and skin absorption. (7,8,9) Definitive studies establishing the primary route of exposure have not been carried out.

Many of these dyes are complex mixtures, difficult to analyze, and may contain impurities that are carcinogenic. (10) For example, 4-aminobiphenyl, an OSHA-regulated carcinogen, and 2,4-diaminoazobenzene, an International Agency for Research on Cancer (IARC) documented carcinogen, (11) were found as impurities in a batch of C.I. Direct Black 38. (12) [See Note 1]

BENZIDINE-BASED DYES

Evidence of Carcinogenicity

In 1978, the National Cancer Institute (NCI) published the results of a 13-week subchronic feeding study of C.I. Direct Blue 6, C.I. Direct Black 38 and C.I. Direct Brown 95. (13,14) Two of these benzidine-based dyes induced both hepatic neoplastic nodules and hepatocellular carcinomas in male and female Fischer 344 rats; C.I. Direct Brown 95 induced tumors in female rats. (13,14) All of these dyes induced tumors within 5 weeks of the initial exposure. This is reported to be the shortest latency period for tumor development of any chemical studied in the NCI bioassay program. (5) Tumors did not develop in the control animals.

Korosteleva et al. studied the effects of benzidine-based dyes fed to rats and mice. (15) Violet C 100% [See Note 2], a dye with a benzidine group in the molecule, induced microcholangiomas of the liver and other rare tumors in male rats; spontaneous tumors of this type were not observed in untreated rats.

Okajima et al. administered Direct Deep Black EX (C.I. Direct Black 38) in drinking water to male Wistar strain rats. This benzidine-based dye induced papillomas and carcinomas in the urinary bladder and carcinomas in the urinary bladder and carcinomas in the liver and colon. These lesions did not occur in control rats. (16)

An epidemiologic study by Yoshida et al. reported an association between employment in the dye industry and urinary bladder cancer in humans. Their review of the work histories of 200 male patients with bladder cancer revealed that 8.5% had worked in the dye industry and had been exposed to benzidine-based dyes. A review of the work histories of the 148 persons in the control group (randomly selected patients with urinary disease other than cancer) revealed that 1.4% had worked in dye industries. (17)

Note 1: C.I. indicates that the name is listed in the Colour Index, 3rd. ed., Society of Dyers and Colourists and the American Association of Textile Chemists and Colourists, Bradford, England, Vol. 1-6, 1971.

Note 2: Translation from the Russian. The 100% does not indicate that it was 100% active ingredient but that it was 100% of commercial dye strength. This is probably C.I. Direct Red 13.

Metabolism of Benzidine-Based Dyes to Benzidine

Evidence exists to indicate that benzidine-based dyes are converted to the carcinogen benzidine in laboratory animals and in humans.(10) The NCI bioassay of C.I. Direct Blue 6, C.I. Direct Black 38, and C.I. Direct Brown 95 for carcinogenicity included analyses of urine samples for benzidine from treated animals.(14) Urine samples from Fischer 344 rats were collected over 24-hour periods during weeks 4 and 12. Benzidine was detected in the urine of rats given benzidine-based dyes but not in the urine of the untreated control rats. As the amount of the dye fed to the rats increased, so did the amount of benzidine excreted in the urine. Analyses of the dyes prior to mixing in feed demonstrated no residual or contaminating benzidine. The data indicate that the benzidine in the urine resulted from the bio-transformation of the dyes. Similar results were found by analyses of urine from $B_6C_3F_1$ mice.(14)

Rinde and Troll studied the metabolism of the benzidine-based dyes C.I. Direct Blue 6, C.I. Direct Black 38, C.I. Direct Brown 95, and C.I. Direct Red 28 in Rhesus monkeys.(18) Each monkey was gavaged with a single dose of one dye dissolved in dimethyl sulfoxide. Each of the dyes was administered in two different dose levels in separate experiments, except for C.I. Direct Red 28, which was given at only one level. Purified benzidine was administered at two levels in the same manner. Urine was collected over a 72-hour period from all the animals and pooled for assay. Urine collected from the monkeys before dosing was used to establish the control values. The authors found benzidine and a metabolite, monoacetyl benzidine, in the urine of the monkeys receiving the dyes. The control values were negative. They concluded that the dyes were converted to benzidine in vivo.(18) Korosteleva et al. found benzidine in the blood serum and tissues of rats fed Direct Red 13.(15) This indicated that the dye had been converted to benzidine.

Lynn et al. reported on the metabolism of the benzidine-based dyes C.I. Direct Blue 2, C.I. Direct Black 4, C.I. Direct Brown 2, C.I. Direct Orange 1, C.I. Direct Red 28, C.I. Direct Orange 8, and C.I. Direct Green 1 in female mongrel dogs and rats. (19) Each of five mongrel dogs was administered a dye orally and urine was collected at 24 hour intervals for 3 days. No trace of benzidine was detected in the dogs' urine 3 days after exposure. Some dogs were used more than once with a minimum of 1 week between dye exposures. Benzidine was recovered in the urine of each treated dog following the oral administration of the 7 dyes. Although some residual benzidine in each of the dyes had been detected prior to administration according to the authors, the amount of benzidine recovered in the urine exceeded that administered as a contaminant by at least 9 times. These findings suggest that the dye was converted to benzidine in the dog.

These same dyes were administered orally to two rats for 10 days. The urinary concentration of benzidine was not sufficient to permit chromatographic quantification but a benzidine metabolite, N-acetyl

benzidine, was present in the urine of the rats following the administration of the dyes. This indicates that the dyes had been bioconverted to benzidine.

Genin administered subcutaneously or orally Direct Black 3 [See Note 3] and Direct Diazo Black C (C.I. Direct Blue 2) to albino rats.(20) Urine samples contained a metabolic product that the author identified as benzidine.

Yoshida and Miyakawa injected 4 benzidine-based dyes into sections of ligated intestines of rats and mice and incubated the preparations *in vitro*.(21) The dyes (C.I. Direct Black 38, C.I. Direct Green 1, C.I. Direct Red 17 and C.I. Direct Red 28) were free of residual benzidine prior to injection. Subsequent analyses indicated that the 4 dyes had been converted to benzidine.

There is evidence that humans metabolize certain benzidine-based dyes to benzidine. Korosteleva et al. obtained samples of blood serum from 101 female textile workers in the dye, printing, warehouse, and color room shops.(22) Analysis revealed benzidine in the blood of workers exposed to the dyes. Genin reported that benzidine was detected in the urine of 8 of 22 workers who dried and ground the benzidine-based dyes Direct Black 3 and C.I. Direct Blue 2. (20)

Boeniger surveyed workers at facilities that manufacture or use benzidine-based dyes including paper, textile, leather, and dye manufacturing facilities.(10) At one plant manufacturing benzidine-based dyes, 2 of 8 workers potentially exposed to these dyes excreted monoacetyl benzidine in their urine. At a second dye manufacturing facility, 4 workers provided urine samples; all 4 samples contained benzidine and 3 contained monoacetyl benzidine. Three of 7 workers at a textile dyeing and finishing facility also had benzidine and monoacetyl benzidine in their urine.

o-TOLIDINE and o-TOLIDINE-BASED DYES

Evidence of Carcinogenicity

The potential of o-tolidine to cause tumors has been recognized for several years.(23) Early experiments demonstrated its ability to induce tumors in Zymbal's gland (the specialized sebaceous gland of the auditory canal).(23) Subsequent experiments have shown that o-tolidine has the potential to induce tumors in a variety of organs and tissues.(24-28)

Perhaps the experiments by Pliss and Zabezhinsky reveal its carcinogenic potential most vividly.(25,26,27) These investigators demonstrated in a series of experiments that injections of o-tolidine in rats caused tumors in Zymbal's gland, mammary gland, skin, lung, thyroid, stomach, small intestine, hematopoietic tissue, uterus,

Note 3: The abstract given in the Russian journal translates the dye as Direct Black 3. It may be Direct Black 38.

and preputial gland. IARC reviewed the literature on o-tolidine and concluded that it was a systemic carcinogen in rats when given subcutaneously. (29)

Two o-tolidine-based dyes, trypan blue and Evans blue, were found to be carcinogenic in rats by two independent investigators. (30,31) During an 8-month study by Marshall, these two dyes were injected subcutaneously (trypan blue) and intraperitoneally (Evans blue) into rats.(30) Two different samples of the trypan blue were used in the study; one was 80% pure and the other was 34% pure. The rest of each sample consisted of inorganic salts and probably o-tolidine. Histiocytic tumors of the liver were found in 9 of 45 animals injected with trypan blue and in 10 of 40 rats receiving Evans blue. Reticular cell sarcomas of the lymph nodes and lymphosarcomas developed in treated animals. None of the tumors occurred at the injection sites; no tumors occurred in the two control groups of 20 animals.

Gillman and Gillman injected trypan blue into male and female rats (strain unspecified).(31) The rats were killed between days 70 and 100 and the lymph nodes were examined microscopically. Lymph nodes from control rats were used as a basis for anatomical comparison. Their study revealed that a wide variety of tumors developed in rats given trypan blue; the most common tumor was the histiocytoma.

IARC concluded that trypan blue is carcinogenic in rats when injected either intraperitoneally or subcutaneously.(11) IARC also stated that Evans blue is carcinogenic in rats when injected intraperitoneally.

Metabolism of o-Tolidine-Based Dyes to o-Tolidine

There is some evidence that dogs and humans may metabolize some o-tolidine based dyes to the parent compound. The evidence is not definitive in all cases because the parent compound, o-tolidine, may sometimes be present in the dyes as a trace level contaminant.(10) Lynn et al. studied the metabolism of four o-tolidine-based dyes, Direct Red 2, Direct Red 39, Direct Blue 25, and Acid Red 114, in female dogs and rats.(19) Dogs administered the latter two dyes excreted o-tolidine in the urine. The authors reported that the amount of o-tolidine recovered in the urine exceeded that which could have been contributed by o-tolidine contamination alone.

In the rat, Direct Blue 25 was metabolized to o-tolidine and excreted at concentrations comparable with those observed in dogs; only trace amounts were excreted following administration of Acid Red 114. Neither the dog nor the rat excreted quantifiable amounts of o-tolidine in the urine following the administration of Direct Red 39 or Direct Red 2.

Boeniger reported finding o-tolidine in the urine of two workers in a dye manufacturing plant.(10) These employees worked with o-tolidine-based dyes and not o-tolidine itself. The o-tolidine in the urine in both of these studies may have resulted from o-tolidine metabolism of the dyes or from o-tolidine contamination in the dyes.

o-DIANISIDINE AND o-DIANISIDINE-BASED DYES

Evidence of Carcinogenicity

Hadidian et al. administered o-dianisidine hydrochloride by gavage to rats for 1 year.(32) Tumors developed in the Zymbal's gland, skin, mammary gland, stomach, intestinal tract, and bladder. Most tumors developed after 8 months. The control animals had a relatively low spontaneous tumor rate except for interstitial cell tumors.

Saffiotti et al. and Sellakumar et al., working together, fed 0.1% or 1.0% o-dianisidine to two groups of 60 Syrian Golden hamsters of both sexes throughout their lifetime.(33,34) After 2 years, one tumor of the urinary bladder was found in a hamster fed at the 0.1% level. Forestomach papillomas developed in 57% of the 60 hamsters fed at the 1.0% level.(34) The spontaneous incidence of forestomach papillomas was 2% in the control group of 60 hamsters.[See Note 4].

Pliss administered o-dianisidine to rats by gavage for 13 months.(26,27) In the surviving animals, 3 of 18 developed tumors. None of the 50 control rats developed spontaneous tumors. IARC concluded that o-dianisidine was carcinogenic in rats after oral administration.(35)

Metabolism of o-Dianisidine-Based Dyes to o-Dianisidine

There is evidence that dogs, rats, and humans may metabolize some o-dianisidine-based dyes to the parent compound. As in the case of the o-tolidine-based dyes, a residual amount of the parent compound may be present in the dye.(19) Lynn et al. studied the metabolism of the o-dianisidine-based dyes, C.I. Direct Blue 1 and C.I. Direct Blue 15, in female mongrel dogs and rats.(19) Following the administration of the dyes, o-dianisidine was recovered in the urine of both species. The amount of o-dianisidine recovered in the urine exceeded that which could have been contributed by o-dianisidine contamination alone, according to the authors.

Genin studied the metabolism of two o-dianisidine based dyes, C.I. Direct Blue 15 and Direct Blue Photostable KU, in rats and found o-dianisidine was excreted in the urine.(20) In the same study, Genin reported that he found o-dianisidine in the urine of 3 of 22 workers who dried and ground two dianisidine-based dyes, C.I. Direct Blue 15 and Direct Blue Photostable KU. Boeniger reported finding o-dianisidine in the urine of a worker in a dye manufacturing plant.(10) This employee worked with o-dianisidine-based dyes and not with o-dianisidine itself. The o-dianisidine in the urine may have resulted from metabolism of the dyes or from contamination in the dyes.

o-Dianisidine is used as the starting material in the manufacture of the o-dianisidine-based dyes listed in Appendix IIB. It has been

Note 4: According to Saffiotti, 57% is the correct percentage of hamsters that developed forestomach papillomas, not 37% as given in the publication cited. Personal Communication, U. Saffiotti, 1979.

reported that some of these dyes may no longer contain the methoxy group characteristic of the o-dianisidine moiety as a major component in the dye due to chemical reactions with metals such as copper. (36) Based on structural considerations, it is unlikely that metalized o-dianisidine dyes would metabolize to o-dianisidine. However, the amount of residual o-dianisidine in these dyes is unknown at this time. The contribution of the metal to subsequent toxicity is also unknown at this time.

RECOMMENDATIONS

From the available evidence OSHA and NIOSH conclude that benzidine based dyes are potential human carcinogens. OSHA and NIOSH recommend that worker exposure to these dyes be reduced to the lowest feasible level. The available literature on dyes based on o-tolidine and o-dianisidine, while less extensive and definitive than that for benzidine-based dyes, suggests that these compounds and/or their contaminants may present a cancer risk to workers and should be handled with caution and exposure minimized. Workers should be informed of the potential of dyes based on benzidine, o-tolidine, and o-dianisidine to affect their health.

Several actions should be taken by employers, employees, and their physicians in order to protect workers from exposure to benzidine-, o-tolidine-, and o-diansidine-based dyes.

I. Employers should:

1. Substitute, wherever possible, other less toxic dyes for benzidine-based dyes. Although the literature is less definitive and less extensive in supporting the carcinogenicity of o-tolidine and o-dianisidine-based dyes, OSHA and NIOSH recommend, as a prudent public health measure, substitution of less toxic dyes wherever possible. Caution should be exercised in selecting replacements. Full consideration should be given to the potential toxic effects of the substitutes.
2. Establish, where substitution is not feasible, appropriate and feasible engineering controls for all these chemicals. Engineering controls may include the use of closed process systems, liquid metering systems, walk-in hoods, and specific local exhaust ventilation. Suitable collectors should be used to prevent ambient air contamination.
3. Ensure that good housekeeping procedures and industrial hygiene practices are used to keep the work environment free of accumulated dyes and to reduce the exposure of all workers to the dyes. These procedures include, in part, the use of dyes in the form of pellets, pastes, and liquids to reduce potential exposure to dusts.

4. Establish restricted areas (with appropriate warning signs) for activities that involve occupational exposure to these dyes. Access to these restricted areas should be limited to employees who have been properly informed of the potential hazards and of proper control measures.

5. Inform all employees working with these dyes, or mixtures containing them, of the possible adverse health effects that may result from exposure to them and of acceptable ways to reduce that exposure.

6. Provide all employees who may be exposed to these dyes with a copy of this Health Hazard Alert.

7. Place all employees with occupational exposure to these dyes under a medical monitoring program that includes a medical history and periodic physical examinations. Each examining physician should be provided with a copy of this Health Hazard Alert.

8. Provide washroom or shower facilities and change rooms for employees to remove residual chemical from themselves after leaving the work area where exposure occurs. Cleaning compounds that contain strong reducing agents, such as sodium hydrosulfite, should not be used for skin decontamination.

9. Monitor employee exposure to these chemicals routinely. Exposure surveys should be made to establish the extent of exposure and the effectiveness of controls. An analytical method for quantifying benzidine-based dyes in the presence of other azo type dyes and diazonium compounds has been recently developed by NIOSH. The details of this method are available from:

Publication Dissemination, Division of
Technical Services
National Institute for Occupational Safety
and Health
4676 Columbia Parkway
Cincinnati, Ohio 45226

The NIOSH Manual of Analytical Methods also may be helpful to those developing programs to monitor employee exposures. (37,38)

10. Provide and require personal protective clothing to be used as an interim measure while engineering controls are being installed. Whenever employees leave the area, their protective clothing should be placed in a suitably marked and closed container for disposal or laundering. Laundry personnel should be made aware of the potential hazard from handling contaminated clothing.

11. Provide respiratory protective devices. Table 2 contains acceptable respirators that may be used to reduce exposure.

II. Employees should:

1. Use the correct safety equipment and protective devices as provided by the employer.
2. Wash exposed areas of the body with soap and water upon leaving the restricted area. Cleaning compounds that contain strong reducing agents should not be used because benzidine or other harmful products could be formed on the skin.
3. Dispose of protective clothing in the manner prescribed by the employer.
4. Report signs or symptoms of health problems to your physician if you suspect that you may be exposed to these chemicals.

III. Physicians should:

1. Obtain occupational and exposure histories.
2. Obtain a medical history with special emphasis on complaints associated with the urinary tract and hepatic systems.
3. Perform a physical examination with emphasis on the renal and hepatic systems.
4. Obtain laboratory studies for liver and renal function and a urinalysis that includes microscopic examination of the sediment.
5. Advise the employee of the results of the medical examination and laboratory analyses.

Table 2

RESPIRATORS FOR USE WITH
BENZIDINE, o-TOLIDINE, and o-DIANISIDINE-BASED DYES

<u>Maximum Use Concentration of Conditions of Use</u>	<u>Recommended Respirator</u>
Routine Use	<ol style="list-style-type: none">1. Half-mask powered air-purifying respirator equipped with high-efficiency filters.* Disposable air filters should be replaced after each 8 hours of use.2. Half-mask positive-pressure supplied air respirator.*3. Full facepiece powered air-purifying respirator equipped with high-efficiency filters. Disposable air filters should be replaced after each 8 hours of use.4. Positive-pressure supplied air respirator with full facepiece, hood or helmet.
Unknown Concentration or Emergency Entry	<ol style="list-style-type: none">1. Full facepiece positive-pressure self-contained breathing apparatus.2. Full facepiece positive-pressure supplied air respirator with auxiliary self-contained air supply.
Fire Fighting	Full facepiece positive-pressure self-contained breathing apparatus.

* Full facepieces should be used whenever eye irritation is experienced.

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APPENDICES

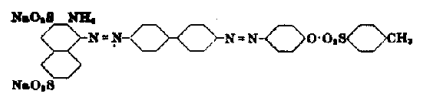
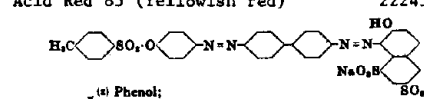
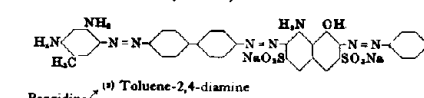
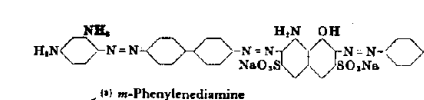
Appendix I is a list of benzidine-based dyes reported to be commercially available in the United States. The list includes Colour Index number of the dyes, domestic production and import quantities, usage by industry, and estimated number of workers exposed.* Appendix II is a list of benzidine-, o-tolidine- and o-dianisidine-based dyes currently available in the United States including Colour Index number, generic names, commercial trade names, and manufacturers and distributors.** These appendices may not be complete. The field of dye chemistry is constantly changing and products are added and removed from the market continually. Further details concerning these dyes can be found in the Colour Index and the American Association of Textile Chemists and Colorist (AATCC) Buyers Guide. Estimates of total dyes usage by industry are: for the textile industry, 66% of all dyes used in the U.S.; for the paper and pulp industry, 17%; for the leather tanners industry, 10%; and for the aqueous ink and plastics industries, about 7%.

* Taken from Appendix III, Special Occupational Hazard Review of Benzidine-Based Dyes. NIOSH Report. DHEW (NIOSH) Publication No. 80-109, 1980.

** Derived from Table I (Corrected), Responses to Questions on Dyes, Submission to Interagency Testing Committee-Subcommittee to Review Dyes and Pigments by Dyes Environmental and Toxicology Organization, Scarsdale, NY, July, 1979.

APPENDIX I

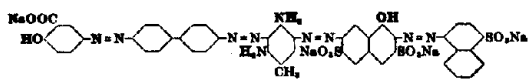
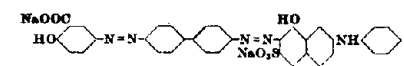
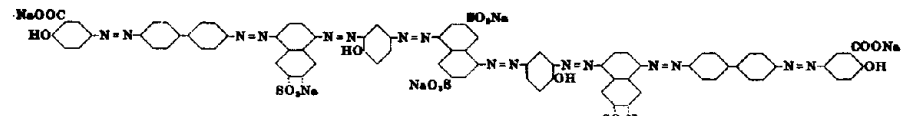
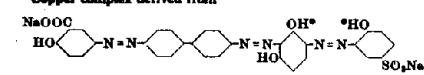
BENZIDINE-BASED DYES REPORTED TO BE COMMERCIALY AVAILABLE IN THE UNITED STATES*

Chemical Structure	Colour Index No.	Chemical Abstracts Service No.	Total Produced lb/y	Total Imported lb/y	Uses	Estimated No. of Workers Exposed**
 <p>3-Amino-2,7-naphthalenedisulfonic acid Benzidine Phenol; then esterify the hydroxy group with p-toluenesulfonyl chloride</p>	22195	2429-80-3	Not reported; less than 3 manufacturers	Not listed	Dyeing of cotton, silk, nylon, and leather; heavy metal salts used as pigments	Unknown
 <p>(s) Phenol; (t) G acid then esterify the phenol hydroxy group with p-toluenesulfonyl chloride There are closely related dyes in which benzidine may be replaced by tolidine and other esterifying agents may be used. See C.I.23635 and C.I.24125</p>	22245	3567-65-5	67,000(1975) 22,245(1978)	2,190(1976) 1,000(1978)	Dyeing of cotton, wool, silk, nylon, and viscose; Viqueureux printing	525
 <p>(s) Toluene-2,4-diamine Benzidine (t) (acid) H acid (alk.) (s) ← Aniline</p> <p>Aqueous solution + HCl conc. — corinth ppt; NaOH conc. — greyish blue ppt.</p>	30245	2429-83-6	26,444(1978)	Not listed	Dyeing of cotton, wool, silk, nylon, leather, and paper	Unknown
 <p>(s) m-Phenylenediamine Benzidine (t) (acid) H acid (alk.) (s) ← Aniline</p>	30235	1937-37-7 RTECS No. JM7170000	3,760,000(1976) 823,000(1978)	70,753(1976) 49,525(1977) 170,442(1978)	Dyeing of leather, plastics, cotton, wool, and silk; aqueous inks, biological stain; wood flour used as a resin filler, wood stain; typewriter ribbons	13,072

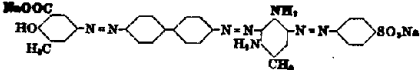
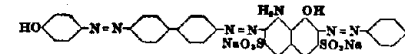
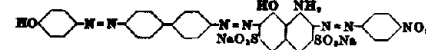
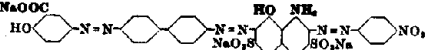
APPENDIX I (CONTINUED)

Chemical Structure	Colour Index No.	Chemical Abstracts Service No.	Total Produced lb/y	Total Imported lb/y	Uses	Estimated No. of Workers Exposed**
<p>Benzidine $\begin{cases} (i) \text{ (alk.) Gamma acid} \\ (ii) \text{ (alk.) H acid} \end{cases}$</p>	22590	2429-73-4	218,435(1978)	38,478(1976) 30,755(1978)	Dyeing of cotton, leather, and paper	1,958
<p>Benzidine \rightleftharpoons (alk.) H acid (2 mol.)</p> <p>Aqueous solution + HCl conc. — navy blue, ppt; + NaOH conc. — dark violet, ppt.</p>	22610	2602-46-2 RTECS No. QJ6400000	327,000(1976) 61,524(1978)	4,409(1978)	Dyeing of leather, cotton, silk, paper; aqueous writing inks, biological stains	832
<p>Benzidine $\begin{cases} (i) \text{ Salicylic acid} \\ (ii) \text{ [m-Phenylenediamine (acid) + Sulfanilic acid]} \end{cases}$</p>	30045	2586-58-5	Not listed	4,409(1978)	Dyeing of leather, paper, silk, nylon, wool and cotton	Unknown
<p>Benzidine $\begin{cases} (i) \text{ Salicylic acid} \\ (ii) \text{ (alk.) Gamma acid} \end{cases}$</p>	22311	2429-82-5	125,000(1975) 27,725(1978)	18,739(1976) 2,205(1977)	Dyeing of leather, paper, silk, nylon, wool, and cotton; heavy metal salts used as pigments	106
<p>Benzidine $\begin{cases} (i) \text{ Salicylic acid} \\ (ii) \text{ Resorcinol (i) + Sulfanilic acid} \end{cases}$</p> <p>This sequence of operations, which is that recorded for Congo Brown G, differs slightly from C.I. 1st Edition 598</p>	30140	NA	8,563(1978)	Not listed	Dyeing of leather, paper, silk, wool, and cotton	Unknown

APPENDIX I (CONTINUED)

Chemical Structure	Colour Index No.	Chemical Abstracts Service No.	Total Produced lb/y	Total Imported lb/y	Uses	Estimated No. of Workers Exposed**
<p>C.I. Direct Brown 31 (Reddish brown) 35660 2429-81-4 37,406(1978) Not listed</p>  <p> Benzidine $\left\{ \begin{array}{l} (1) \text{ Salicylic acid} \\ (2) \text{ (Toluene-2,4-diamine (acid) } \rightarrow \text{O-Phenylsulfonyl 2R acid);} \\ \text{then hydrolyse the benzenesulfonic ester group} \\ (3) \rightarrow \text{Naphthionic acid} \end{array} \right.$ (In some brands 2R acid is used instead of its O-phenylsulfonyl derivative* as in C.I.35650) </p>					Dyeing of leather and paper; heavy metal salts used as pigments; printing on cellulose (concentrated dye only)	Unknown
<p>C.I. Direct Brown 59 (Blackish brown) 22345 NA Not listed "</p>  <p> Benzidine $\left\{ \begin{array}{l} (1) \text{ Salicylic acid} \\ (2) \text{ (alk.) N-Phenyl Gamma acid} \end{array} \right.$ </p>					Dyeing of cotton, wool, and silk; leather; occasional use on chrome and vegetable tannages	"
<p>C.I. Direct Brown 74 (Brown) 36300 NA 32,414(1978) "</p>  <p> [Benzidine $\left\{ \begin{array}{l} (1) \text{ Salicylic acid} \\ (2) \text{ (1,6 (and 1,7)-Cleve's acid)} \end{array} \right.$] (2 mol.) \rightleftharpoons (3) [Phenol (2 mol.) \rightleftharpoons 4,8-Diamino-2,6-naphthalenedisulfonic acid] </p> <p> HNO₃ conc. — dull red solution, turns yellow brown Aqueous solution + HCl conc. — brownish yellow to olive ppt; + NaOH conc. — orange brown </p>					Dyeing of cotton, wool, silk, leather, chrome tannage (occasional)	"
<p>C.I. Direct Brown 95 (Reddish brown) 30145 16071-86-6 346,000(1975) 8,205(1976)</p> <p>RTECS No. 595,000(1976) 15,962(1977)</p> <p>JM78780000 75,953(1978) 5,512(1978)</p> <p>Copper complex derived from</p>  <p> Benzidine $\left\{ \begin{array}{l} (1) \text{ Salicylic acid} \\ (2) \text{ [Copper complex formed at * from 2-Amino-1-phenol-4-sulfonic acid } \rightarrow \text{Resorcinol]} \end{array} \right.$ </p> <p>In Sirius Supra Brown BRLN 20% of the salicylic acid is replaced by 2,3-crotonic acid</p>					Dyeing of cotton, wool, silk paper, plastics, and leather; heavy metal salts used as pigments	714

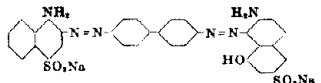
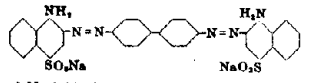
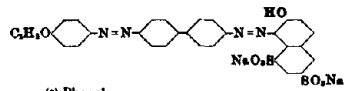
APPENDIX I (CONTINUED)

Chemical Structure	Colour Index No.	Chemical Abstracts Service No.	Total Produced lb/y	Total Imported lb/y	Uses	Estimated No. of Workers Exposed**
C.I. Direct Brown 111 (Reddish brown) Structure Unknown	No C.I. No.	NA	Not listed	Not listed	Dyeing of cotton and leather; chrome tannage (occasional)	Unknown
C.I. Direct Brown 154 (Brown)	30120	6360-54-9	63,816(1978)	"	Dyeing of cotton, wool, silk, leather, and paper; direct printing on cellulosic weave and silk fabrics	322
 <p>Benzidine $\left\{ \begin{array}{l} \text{2,4-Dinitrophenol} \\ \text{2,4-Dinitrophenylamine} \end{array} \right.$ $\left\{ \begin{array}{l} \text{2,1-Cresotic acid} \\ \text{2-Toluenesulfonamide} \end{array} \right.$ </p>						
C.I. Direct Green 1 (Dull green)	30280	3626-28-6	57,000(1974) 12,666(1978)	"	Dyeing of cotton, wool, silk, nylon, leather, and paper; aqueous inks; direct printing on cellulosic, silk, and nylon fabrics	1,850
 <p>Benzidine $\left\{ \begin{array}{l} \text{(a) Phenol} \\ \text{(b) (alk.) H acid (alk.)} \end{array} \right.$ $\left\{ \begin{array}{l} \text{(c) Aniline} \end{array} \right.$ </p>						
C.I. Direct Green 6 (Dull green)	30295	4335-09-5	143,000(1974) 109,076(1978)	4,659(1978)	Dyeing of cotton, wool, silk, and nylon; aqueous inks, pigments, leather, paper, and soap; direct printing on nylon	1,095
 <p>Benzidine $\left\{ \begin{array}{l} \text{(a) Phenol} \\ \text{(b) (alk.) [H-acid (acid)]} \end{array} \right.$ $\left\{ \begin{array}{l} \text{(c) } \beta\text{-Nitroaniline} \end{array} \right.$ </p> <p>Aqueous solution + HCl conc. — dull bluish green ppt; + H₂SO₄ (10%) — blue; + NaOH conc. — dark green to olive</p>						
C.I. Direct Green 8 (Dull green)	30315	5422-17-3	Not reported; less than 3 manufacturers	250(1977)	Dyeing of cotton, wool, silk, nylon, leather, and paper	Unknown
 <p>Benzidine $\left\{ \begin{array}{l} \text{(a) Salicylic acid} \\ \text{(b) (alk.) [H acid (acid)]} \end{array} \right.$ $\left\{ \begin{array}{l} \text{(c) } \beta\text{-Nitroaniline} \end{array} \right.$ </p>						

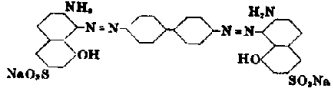
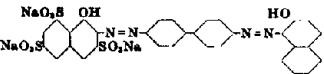
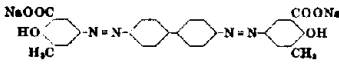
APPENDIX I (CONTINUED)

Chemical Structure	Colour Index No.	Chemical Abstracts Service No.	Total Produced lb/y	Total Imported lb/y	Uses	Estimated No. of Workers Exposed**
<p>C.I. Direct Orange 1 (Yellowish orange)***</p> <p> NaOOC HO </p> <p> HOC-N N COONa </p> <p> SO_3Na </p> <p> Benzidine Salicylic acid 3-Carboxy-1-(β-sulphophenyl)-5-pyrazolone </p>	22370	6459-87-6	Not reported; less than 3 manufacturers	Not listed	Dyeing of cotton, wool, silk, nylon, paper, and leather direct printing on cellulose and nylon	Unknown
<p>C.I. Direct Orange 8 (Reddish orange)</p> <p> NH_2 COONa SO_3Na OH </p> <p> Benzidine (1) Naphthionic acid (1) Salicylic acid </p> <p> <i>In some brands part of the salicylic acid is replaced by 2,3-cresotic acid (C.I.22140) and part of the naphthionic acid by other aminonaphthalene-sulfonic acids (C.I.22165)</i> </p>	22130	2429-79-0	86,000(1976) 27,208(1978)	4,066(1976)	Dyeing of cotton, wool, silk, nylon, and paper	"
<p>C.I. Direct Red 1 (Bluish red)</p> <p> NaOOC HO </p> <p> H_2N HO SO_3Na </p> <p> Benzidine (1) Salicylic acid (1) (acid) Gamma acid </p>	22310	2429-84-7	132,000(1975) 26,370(1978)	4,409(1977)	Dyeing of cotton, wool, silk, nylon, paper, and leather	55,508
<p>C.I. Direct Red 10 (Bordeaux)</p> <p> NH_2 SO_3Na HO NaO_2S </p> <p> Benzidine (1) Naphthionic acid (1) Nevile and Winther's acid </p>	22145	2429-70-1	Not reported; less than 3 manufacturers	100(1975)	Dyeing of cotton, wool, silk, and leather; biological stain	Unknown

APPENDIX I (CONTINUED)

Chemical Structure	Colour Index No.	Chemical Abstracts Service No.	Total Produced lb/y	Total Imported lb/y	Uses	Estimated No. of Workers Exposed**
<p>C.I. Direct Red 13 (Bordeaux) 22155</p> <p>1937-35-5</p> <p>Not reported; less than 3 manufacturers</p> <p>Not listed</p> <p>Dyeing of cotton, wool, nylon, paper, and leather (chrome tannage); printing of cellulose</p> <p>1,640</p>  <p>Benzidine ^{(1) Naphthionic acid} _{(2) (acid) Gamma acid}</p> <p>(In Diamine Bordeaux N (By) part of the Gamma acid was replaced by J acid)</p>						
<p>C.I. Direct Red 28 (Yellowish red) 22120</p> <p>573058-0 RTECS No. QK1400000</p> <p>37,327(1978) 11,000(1974) 33,069(1978)</p> <p>Dyeing of cotton, wool, silk, and paper; biological stain and indicator; (first synthetic direct cellulose dye)</p> <p>523</p> <p>Classical name Congo Red</p>  <p>Benzidine \pm Naphthionic acid (2 mol.)</p> <p>Soluble in water (yellowish red) and ethanol (orange); very slightly soluble in acetone H₂SO₄ conc. — deep blue; on dilution — paler blue, blue ppt. Aqueous solution + HCl conc. — reddish blue ppt.; + Acetic acid — bluish violet, then reddish blue ppt.; + NaOH conc. — yellow</p>						
<p>C.I. Direct Red 37 (Red) 22240</p> <p>3530-19-6</p> <p>63,000(1975) Not listed</p> <p>Dyeing of cotton, wool, silk, leather and paper; direct and discharge printing of cellulose and nylon</p> <p>1,052</p>  <p>Benzidine ^{(1) Phenol;} _{(2) G acid}</p> <p>then ethylate the phenol hydroxy group by heating under pressure with ethyl chloride in aqueous ethanal solution in the presence of sodium carbonate</p>						

APPENDIX I (CONTINUED)

Chemical Structure	Colour Index No.	Chemical Abstracts Service No.	Total Produced lb/y	Total Imported lb/y	Uses	Estimated No. of Workers Exposed**
<p>C.I. Direct Violet 1 (Violet) 22570</p> <p>2586-60-9</p>  <p>Benzidine-4,4'-diylbis(2-naphthol) sodium salt (2 mol.)</p>	22570	2586-60-9	Not reported; Not listed less than 3 manufacturers		Dyeing of cotton, wool, silk, leather, and paper; biological stain	Unknown
<p>C.I. Direct Violet 22 (Bluish violet) 22480</p> <p>6426-67-1</p>  <p>Benzidine-4,4'-diylbis(1-naphthol-3,6,8-trisulfonate) sodium salt</p>	22480	6426-67-1	" manufacturers	"	Dyeing of cotton, wool, silk, nylon, leather	"
<p>C.I. Direct Yellow 20 (Yellow) 22410</p> <p>6426-62-6</p>  <p>Benzidine-4,4'-diylbis(2,3-cresotic acid) sodium salt (2 mol.)</p> <p>Aqueous solution + HCl conc. — brownish yellow, ppt; + NaOH conc. — reddish yellow, ppt.</p>	22410	6426-62-6	Imported only	3,900(1977)	Dyeing of cotton, silk, wool, nylon, leather	"
Resin Fast Black WP	No C.I.#	NA	84,620(1978)	Not listed	Dyeing of textiles, especially those subsequently finished with resins	"

*This table lists the benzidine-based dyes that were reported as being commercially available by DETO [39] and reported as produced or imported by the US International Trade Commission (ITC) [40,41] or those to which potential exposure was found [42]. If less than three manufacturers make a dye, ITC does not publish the production figures.

**A discussion of limitations of the estimation of worker exposure is contained in reference [42].

***This dye may also be synthesized with cresotic acid in place of salicylic acid. The Colour Index designates both dyes as Direct Orange 1.

APPENDIX II A

DYES DERIVED FROM BENZIDINE

<u>Direct Black 4</u> :	Amidine Black RBN (JC)*
30245**	Direct Black RX 125% (FAB)
	Direct Black RW Ex.Conc.(CKC)
<u>Direct Black 38</u> :	Amidine Black GA 200% (JC)
30235	Diazol Black JXA Double (Fran)
	Direct Black E 200% (FAB)
	Direct Black E Ex. Conc. New (CKC)
	Direct Black BHX (CKC)
	Direct Black GAC Conc. 200% (BUC)
	Direct Black GX 200% (FAB)
	Elcomine Direct Black CP Conc. (L&R)
	Elcomine Direct Black GXP 200% (L&R)
	Orcomine Direct Black GX 200% (ORC)
	Synodirect Black GAC (SSS)
<u>Direct Blue 2</u> :	Amidine Diazo Black BHSW Conc. (JC)
22590	Diazo Black BH (FAB)
	Diazo Black BHA (Fran)
	Elcomine Black BH (L&R)
	Elcomine Navy Blue Btt (L&R)
	Orco Diazo Black BH 125% (ORC)
<u>Direct Blue 6</u> :	Amidine Blue 2B Conc. (JC)
22610	Direct Blue 2B 250% (FAB)
	Direct Blue 2B Conc. (CKC)
	Direct Fast Blue 2B Conc. (FAB)
	Elcomine Blue 2B 250% (L&R)
	Synodirect Blue 2B 100% (SSS)
<u>Direct Brown 1A</u> :	Amidine Brown 3GC 250% (JC)
30110	Elcomine Brown D3G Conc. (L&R)
<u>Direct Brown 2</u> :	Amidine Brown M Conc. New (JC)
22311	Direct Brown M (CKC)
	Direct Brown M (FAB)
	Elcomine Brown M Conc. (L&R)

* See page A-21 for full name of manufacturers and/or importers corresponding to code letters in parentheses.

** Colour Index numbers

<u>Direct Brown 6:</u>	Direct Brown 2R (FAB)
30140	

<u>Direct Brown 31:</u>	Direct Brown B 125% (FAB)
35660	Direct Brown BCW (CKC, FAB)
	Elcofast Brown B. Conc. (L&R)
	Solamidine B (JC)

<u>Direct Brown 59:</u>	Amidine Brown DMB (JC)
22349	

<u>Direct Brown 74:</u>	Direct Catechine 3G (FAB)
36300	Elcofast Catechine 3G (L&R)

<u>Direct Brown 95:</u>	Chrome Leather Brown (CKC)
30145	Diazol Light Brown BRN Ultra Conc. (Fran)
	Direct Brown BRL (FAB)
	Elcomine Brown BRLL (L&R)
	Intralite Brown BRLL Conc. (CKC)
	Synodirect Brown BRL 100% (SSS)

<u>Direct Brown 154:</u>	Direct Brown 3GN (FAB)
30120	Direct Brown CMD (CKC)
	Elcomine Brown 3GNP (L&R)

<u>Direct Green 1:</u>	Amidine Dark Green N (JC)
30280	Chrome Leather Dark Green S Conc. (CKC)
	Direct Green WS (FAB)
	Elcomine Green WT (L&R)
	Orcomine Dark Green WS (ORC)

<u>Direct Green 6:</u>	Amidine Green 2BN (JC)
30295	Amidine Green M Special (JC)
	Direct Brilliant Green CBM Ex.Conc.(CKC)
	Direct Green BX (FAB)
	Direct Green MT 150% (FAB)
	Elcomine Green MT 150% (L&R)
	Orcomine Green BX (ORC)

<u>Direct Green 8:</u>	Amidine Green GX (JC)
30315	

<u>Direct Orange 1:</u>	Orcolitefast Orange GLZ (ORC)
22370, 22375 and 22430	

<u>Direct Orange 8:</u>	Direct Fast Orange R (FAB)
22130	Direct Paper Orange R Conc. (FAB)
	Direct Orange R (CKC)
	Elcomine Orange RP Conc. (L&R)
	Paper Orange R (CKC)
	Synodirect Orange Y 100% (SSS)

<u>Direct Red 1:</u>	Amidine Fast Red F New (JC)
22310	Congo Red F (CKC)
	Direct Fast Red F (FAB)
	Elcofast Red FD (L&R)
	Orcomine Red F (ORC)

<u>Direct Red 28:</u>	Congo Red (CKC)
22120	Direct Congo Red 4B (FAB)
	Elcomine Congo Red (L&R)
	Orcomine Congo Red (ORC)
	Synodirect Red 4B 100% (SSS)

<u>Direct Red 37:</u>	Amidine Fast Scarlet BN Conc. (JC)
22240	Direct Fast Scarlet B (FAB)
	Elcomine Scarlet B (L&R)
	Orcomine Scarlet B (ORC)

<u>Direct Violet 1:</u>	Amidine Violet N (JC)
22570	Elcomine Violet 3R Conc. (L&R)

<u>Direct Violet 22:</u>	Elcomine Violet BW 200% (L&R)
22480	

<u>Acid Red 85:</u>	Intrazone Fast Red GRG (CKC)
22245	Milling Red 2J (Fran)
	Milling Scarlet G (FAB)
	Nylon Fast Scarlet PG (FAB)
	Supernylite Scarlet G (CKC)

APPENDIX II B

DYES DERIVED FROM O-DIANISIDINE

Direct Black 91:

30400

Cuprotix Black C-RL (S)
 Cuprophenyl Black RL 200% (CGY)
 Intramet Black GM (CKC)

Direct Black 114:

Cuprophenyl Black BWL (CGY)

Direct Blue 1:

24410

Amanil Sky Blue 6B (AC)
 Amanil Sky Blue FF (AC)
 Atlantic Sky Blue 6B Conc.(ATL)
 Atlantic Sky Blue FF Ex.Conc. (ATL)
 Calcomine Sky Blue 6 BX Conc. (ACY)
 Diazol Blue 6BA Conc. (Fran)
 Diphenyl Brilliant Blue FF Supra (CGY)
 Direct Brilliant Sky Blue 6B Ex. Conc. (CKC)
 Direct Sky Blue 6B (BUC)
 Direct Sky Blue 6B Conc. (FAB)
 Direct Sky Blue 6B Ex. 200% (ATL)
 Direct Sky Blue 6B Ex. Conc. 300% (ATL)
 Direct Sky Blue 6BHF (HSH)
 Direct Sky Blue FF Ex. 200%, 300% (ATL)
 Elcomine Sky Blue 6B Ex. 200% (L&R)
 Pergasol Blue GA Conc. (CGY)
 Phenamine Brilliant Blue 6B Conc. (BAS)
 Pyrazol Sky Blue FF (S)

Direct Blue 8:

24140

Atlantic Azurine G Conc. (ATL)
 Direct Azurine G (ATL)
 Direct Azurine G Conc. (ATL)

Direct Blue 15:

Amanil Sky Blue M Liquid (AC)
 Amidine Sky Blue 5B Ex. (JC)
 Atlantic Sky Blue A Ex. Conc. (ATL)
 Blue M Liquid (ATL)
 Cartasol Blue 2GF (S)
 Direct Sky Blue A Supra Conc. 125% (ATL)
 Intrabond Liquid Sky Blue M (CKC)
 Paper Sky Blue S Liquid 35 (V)
 Pontamine Sky Blue M Liquid (DUP)

Direct Blue 22:

24280

Atlantic Direct Blue RW 100% (ATL)
 Direct Blue RW Conc. 200% (ATL)

<u>Direct Yellow 68:</u>	Cuprophenyl Yellow RL Extra (CGY) Intramet Yellow RL (CKC)
<u>Direct Violet 93:</u>	Cuprophenyl Violet 3RL (CGY)
<u>Azoic Blue Composition 2:</u>	Atlantic Printing Blue D-BC Pdr. (ATL) Atlantic Printing Blue D Pdr. (ATL) Neutrazoic Blue AS Pdr. (ATL) Neutrazoic Blue D (ATL)
<u>Azoic Blue Composition 3:</u>	Atlantic Printing Blue GB1 Pdr. (ATL) Neutrazoic Blue GB Pdr. (ATL) Neutrazoic Blue GN Pdr. (ATL)
<u>Azoic Black Composition 4:</u>	Atlantic Printing Black 3G Pdr. (ATL)
<u>Azoic Diazo Component 48:</u> 37235	Atlantic Stable Blue B Pdr. (ATL) Azoene Fast Blue B Salt (ALL) Fast Blue B-ND Salt (BUC) Fast Blue B Salt (ATL, BUC, PCW, V) Fast Blue B-ND Base (ATL) Stable Blue B Base (ATL)
<u>Azoic Coupling Component 3:</u> 37575	Naphthol AS-BR (ATL) Naphthol AS-BR, AS-BR Soln. (BUC, PCW) Naphthol AS-BR 20% Soln. (BUC)

Dyes Derived from o-Dianisidine Without Colour Index Generic Names

Atlantic Direct Blue 2BNB (ATL)
Atlantic Printing Black 2B Pdr. (ATL)
Atlantic Printing Black FOR Pdr. (ATL)
Neutrazoic Black 2B Pdr. (ATL)
Neutrazoic Black FOR Pdr. (ATL)
Neutrazoic Black GF 167% Pdr. (ATL)
Neutrazoic Black JN Pdr. (ATL)
Padazoic Black GLL Pdr. (ATL)
Padazoic Black RLL Pdr. (ATL)
Padazoic Black 2G 150% Pdr.(ATL)
Padazoic Blue GP Pdr. (ATL)
Padazoic Denim Indigo Blue G Pdr.(ATL)
Padazoic Navy Blue WS EX Pdr. (ATL)
Pontamine Blue WE Liq. (DUP)

Padazoic Brilliant Indigo 3B Pdr. (ATL)
Padazoic Denim Indigo Pdr. (ATL)

Atlantic Printing Brown GGN Pdr. (AIL)
Atlantic Printing Brown BR Pdr. (ATL)
Neutrazoic Brown BR Pdr.(ATL)
Padazoic Farmer Brown Pdr.(ATL)

Metalized o-Dianisidine Based Dyes*

Direct Blue 76*:

24411

Amatfast Blue 16BLL (AC)
Atlantic Resin Fast Blue 16BLL Conc.(ATL)
Atlantic Resin Fast Blue LLGG (AIL)
Diazol Light Blue 7JL U.C. (Fran)
Fastusol Brilliant Blue L2GU (BAS)
Resin Fast Blue 16BLL (FAB)
Superlitesfast Brilliant Blue 16BLL (CKC)

- * Formation involves a metalizing process. The substance does not contain methoxy groups characteristic of the o-dianisidine moiety as major component of the dye. Minor amounts of residual o-dianisidine related substances are unknown at this time.

Direct Blue 80*: Atlantic Resin Fast Blue RLX (ATL)
Atlantic Resin Fast Blue 2RLL (ATL)
Elcofast Blue 2RL (L&R)
Fastusol Blue LRRU (BAS)
Intralite Blue 2RLL (CKC)
Pergasol Blue 4RAL (CGY)
Pyrazol Fast Blue RUL (S)
Resin Fast Blue 7RLL (FAB)
Sirius Supra Blue 2RL (V)
Solophenyl Blue ZRL (CGY)
Superlitefast Blue RL (CKC)
Superlitefast Blue RLE (CKC)

Direct Blue 80(s)*: Intralite Blue NBLL (CKC)
Solophenyl Blue RBL (CGY)

Direct Blue 90*: Pyrazol Fast Blue FGL (S)

Direct Blue 98*: Atlantic Resin Fast Blue LLU (ATL)
23155 Atlantic Resin Fast Blue LLU 200% (AIL)
Atlantic Resin Fast Blue LLUG (ATL)
Diazol Blue 3JLNA (Fran)
Direct Fast Navy BRN (HSH)
Fastusol Blue LR (BAS)
Intralite Brilliant Blue L (CKC)
Pyrazol Fast Blue LUL (S)
Resin Fast Navy WRA (FAB)
Sirius Supra Blue BRL (V)

Direct Blue 100*: Resin Fast Blue 3GLL (FAB)
Superlitefast GL (CKC)

Direct Blue 151*: Diazol Fast Blue MP, MP Conc. (ATL)
24175 Direct Blue R 100%, R. Conc. (ATL)
Elcofast Diazo Blue B Conc. (L&R)

Direct Blue 156*: Cuprophenyl Navy Blue BL (CGY)
Intramet Navy Blue RL (CKC)

Direct Blue 160*:

Cuprodiasol Light Navy RL (Fran)
Cuprofix Navy C-GRL (S)
Cuprophenyl Navy Blue RL (CGY)
Intramet Navy Blue RII Conc. 200% (CKC)

Direct Blue 191 (s)*:

Resin Fast Blue 8GLN (FAB)
Superlitefast Blue 8GLN (CKC)

Direct Blue 218*:

24401

Amafast Blue 3GAV Conc. (AC)
Amafast Bond Blue 10GLP Conc., 10GLP Liq. (AC)
Bond Blue B (ATL)
Carta Blue VP (S)
Elcofast Bond Blue (L&R)
Fastusol Blue 9GLP Liq. (BAS)
Paper Blue 3 GAP (FAB)
Pergasol Blue 8GLP Liq. (CGY)
Pontamine Bond Blue B Liq. (DUP)
Pontamine Fast Blue 7GUN (DUP)
Pyrazol Fast Sky Blue 7GLN (S)
Resin Fast Blue 3 GAV (FAB)
Sirius Supra Blue 5G (V)
Solophenyl Blue 8GL, 8GLP Liq. (CGY)
Superlitefast Blue WB (CKC)
Superlitefast Blue 8GUL (CKC)
Superlitefast Blue 3GLST (CKC)

Direct Blue 218/224(s)*:

Intrabond Liquid Blue 8GLL (CKC)
Intralite Blue 8GLL (CKC)

Direct Blue 224*:

Atlantic Resin Fast Blue 7GUL (ATL)

Direct Brown 200*:

Lumicrease Dark Brown 3LB (S)

Metalized o-Dianisidine Based Dyes Without Colour Index Generic Names*

Atlantic Resin Fast Blue ARL (AIL)
Atlantic Resin Fast Blue BFL (ATL)
Atlantic Resin Fast Blue BLA 150% (AIL)
Atlantic Resin Fast Blue BLC (ATL)
Atlantic Resin Fast Blue BRN (ATL)
Atlantic Resin Fast Blue 8BGI 200%(ATL)
Atlantic Resin Fast Blue 3GLL (ATL)
Atlantic Resin Fast Blue 5GLL (ATL)
Atlantic Resin Fast Blue 8GLN (ATL)
Atlantic Resin Fast Blue LBGL (ATL)
Atlantic Resin Fast Blue 6GKS (ATL)
Atlantic Resin Fast Blue 8GUM (ATL)
Atlantic Resin Fast Blue 9GLR (AIL)
Atlantic Resin Fast Blue UGLL (ATL)
Atlantic Resin Fast Blue FFBL (AIL)
Atlantic Resin Fast Blue GUL (ATL)

Atlantic Resin Fast Grey LVL (ATL)
Superlitefast Grey LVL (CKC)

Superlitefast Rubine WLKS (CKC)

APPENDIX II C

DYES DERIVED FROM o-TOLIDINE

<u>Acid Red 114:</u>	Amacid Milling Red PRS (AC) Atanyl Red RS (ATL) Erionyl Red RS, RS 125% (CGY) Intrazone Red BR (CKC) Levanol Fast Red GG New (V) Milling Red SWB (ATL) Milling Red SWB Conc. (FAB) Nylon Fast Red RM (FAB) Nylosan Red F-RS (S) Orcoacid Milling Red RS 125% (ORC) Polar Red RS Conc. 125% (CGY) Telon Fast Red GG New (V)
23635	
<u>Acid Red 167:</u>	Nylosan Red F-BR (S) Milling Red B (ATL) Polar Red B (CGY)
<u>Acid Black 209:</u>	Sella Fast Black FC (CGY)
<u>Azoic Coupling Component 5:</u>	Naphthol ASG, ASG 20% Soln. (BUC) Naphthol AS-G (ATL, PCW) Naphthol AS-G Soln. (PCW)
3/610	
<u>Azoic Yellow Composition 1:</u>	Atlantic Printing Yellow GN Dbl. Soln. (ATL) Atlantic Printing Yellow GS DBL. Soln., GS Pdr. (ATL) Azogen Yellow GS (ALL) Neutrazoic Yellow GS, GS Pdr. (ATL)
37610 & 37090	
<u>Azoic Yellow Composition 2:</u>	Atlantic Printing Yellow 2G Pdr. (ATL) Azogen Yellow GG Soln. (ALL) Azogen Yellow GN (ALL) Neutrazoic Yellow 2G, 2G Pdr. (ATL)
3/610 & 37120	
<u>Azoic Yellow Composition 3:</u>	Neutrazoic Golden Yellow R, R Pdr. (ATL)
3/610+3/558 & 3/090	
<u>Azoic Orange Composition 3:</u>	Atlantic Printing Orange R, R Pdr. R. Dbl. Soln (ATL)
37558 & 3/010	

Direct Blue 14: Carta Blue 3B (S)
 23850 Chrome Leather Blue 3B (CKC)
 Diphenyl Blue 3B Conc. (CGY)
 Direct Blue 3B Conc. (CKC)
 Paper Blue 1 (CKC)
 Pergasol Blue 3B Conc. (CGY)

Direct Blue 25: Diazol Pure Blue BRA (Fran)
 23790 Diphenyl Brilliant Blue 5B (CGY)
 Direct Brilliant Blue 5BC Conc.(CGY,CKC)
 Direct New Blue 5B, 5B Conc.(ATL)
 Pergasol Brilliant Blue 5B (CGY)
 Pyrazol New Blue (S)

Direct Blue 26: Direct Chrome Blue Black B Ex. Conc.(ATL)
 31930

Direct Orange 6: Amidine Orange GG (JC)
 23365 or 23375 Direct Fast Orange Y 125% (ATL)

Direct Red 2: Amanil Purpurine 4B Conc. (AC)
 23500 Benzopurpurine 4B Ex. Conc.,4B Special (AIL)
 Cotton Red 4BS Conc. (CKC)
 Diphenyl Red 4BS Supra (CGY)
 Direct Purpurine 4B (FAB)
 Elcomine Benzopurpurine (L&R)
 Paper Red 4BS Conc. (CKC)
 Pergasol Red 4BS Conc. (CGY)

Direct Red 39: Amidine Scarlet 3B (JC)
 23630 Atlantic Scarlet 3B (ATL)
 Carta Red 3B (S)
 Direct Fast Red 3B (CKC)
 Elcomine Scarlet 3B (L&R)
 Orcomine Scarlet 3B (ORC)
 Pyrazol Red 3B (S)

Direct Brown 230: Direct Fast Brown BR-NB Conc. (AIL)
 Direct Fast Brown BRLT (ATL)

Direct Yellow 95: Cuprophenyl Yellow 3GL (CGY)

Dyes Derived from o-Tolidine Without Colour Index Generic Names:

Atanyl Red NJ (ATL)
Diphenyl Green BBN (CGY)
Pyrazol Dark Green 3B (S)

Direct Fast Brown BCW-NB (ATL)
Direct Fast Brown BP-NB Conc. (ATL)
Direct Brown GG-NB (ATL)
Direct Brown US-NB (ATL)

Milling Red G-NB (ATL)
Padazoic Yellow G Pdr. (ATL)
Padazoic Golden Yellow RLL Pdr. (ATL)

Padazoic Orange GR Pdr. (ATL)

Penetrating Black AM-NB (CKC)

Sandolan Red N-3B (S)

CODE LETTERS OF MANUFACTURERS, IMPORTERS, AND DISTRIBUTORS

AC American Color and Chemical Corporation
ACY American Cyanamid Company
ALL Alliance Chemical, Inc.
ATL Atlantic Chemical Corporation
BAS B.A.S.F. Wyandotte Corp.
BDU Benzenoid Organics, Inc.
BUC Blackman-Uhler, Chemical Division of Synalloy Corp.
CGY Ciba-Geigy Corporation
CKC Crompton and Knowles Corporation
DUP E.I. DuPont De Nemours and Co., Inc.
FAB Fabricolor Inc.
Fran Francolor—subsidiary of Uguine Kuhlmann Co.
(Importer/Distributor)
HSH Harshaw Chemical Company
ICI ICI United States
JC John Campbell and Company (Importer/Distributor)
L&R L&R International Dyestuffs Corp.
(Importer/Distributor) (Formerly L&R Dyestuffs Corp.)
ORC Organic Chemical Corporation (Importer/Distributor)
PCW Pfister Chemical Ind.
PDC Berncolors—Poughkeepsie, Inc.
S Sandoz Colors and Chemicals
SSS Sidney Springer Company (Importer/Distributor)
V Verona Dyestuff Division, Mobay Chemical Corp.

