Draft -- 11/6/75

Position Paper on Vinyl Chloride and Birth Defects

Despite a number of alarming articles in the press over the past 15 months, the medical and statistical evidence compiled to date has failed to establish a relationship between vinyl chloride exposure and birth defects in humans. Nevertheless, additional objective and thorough scientific investigation into this area of mutual industry and public concern is desirable.

Background

In January 1974, three cases of an extremely rare but always fatal type of liver cancer, angiosarcoma, were discovered among long term workers exposed to high concentrations of vinyl chloride monomer (VCM), the gaseous chemical used to produce polyvinyl chloride (PVC) resin. The relationship between heavy VCM exposure and angiosarcoma was subsequently confirmed through epidemiological studies of exposed worker populations and by animal research.

In supplemental studies, VCM was shown capable of producing a mutagenic reaction in salmonella bacteria; and an increase in chromosonal breakage was found in a small number of heavily exposed PVC polymerization workers. Because of these isolated findings, concern was raised that VCM might also prove to be teratogenic, i.e. capable of causing malformations or birth defects.

Study of Ohio PVC Plant Towns Undertaken

In order to investigate this supposition, Dr. Peter F. Infante of the Ohio Department of Health examined the birth records of children born between 1970 and 1973 in three towns in eastern Ohio -- Painesville, Avon Lake and Ashtabula -- that

Not only was this discrepancy unexplained, but Dr. Infante then proceeded to lump cases of CNS malformations from one of these two communities -- North Ridgeville -- together with those from the three plant towns in developing his statistics. Dr. Infante explained this unusual procedure by stating that North Ridgeville was "proximate" to one of the plant towns. In reality, the two are nearly 10 miles apart.

In addition, if one examines the data from the four towns separately, rather than in combination as Dr. Infante did, the fact emerges that while one of the plant towns -- Painesville -- did have over half of the observed CNS birth defects, the non-PVC town had 25 percent of the total. Another of the plant towns -- Avon Lake -- which has had a PVC facility in its midst for the longest period of time of all three communities, had no CNS defects at all.

Nearly the same situation applied in the case of CNS cancers among adults. Dr. Infante, once again, added cases from North Ridgeville to the three plant towns. When examined separately, only Painesville and North Ridgeville, which has no PVC facility, showed an excess of adult CNS cancer deaths. The other two PVC plant towns showed no excess.

When the hard data from the three PVC plant towns and North Ridgeville are examined individually, more unexplained differences than similarities in CNS malformation and adult cancer rates emerge. Dr. Infante's unorthodox procedure of "lumping" data from three widely separated communities -- Painesville is located about 30 miles to the west of Ashtabula and Avon Lake lies another 50 miles west of Painesville -- plus a town without a PVC facility, effectively obscured these significant differences.

The second part of the CDC study involved a thorough investigation of the 15 cases of CNS malformation recorded at the Painesville Hospital from 1970-1974. For each malformation case, two normal births were investigated as "controls" for comparison purposes. The results of this research, which was totally absent from Infante's original work, can be summarized as follows:

1. None of the interviewed parents of the children with CNS birth defects ever worked at either of the two PVC polymerization plants in Painesville (one set of parents could not be located, but records show they did not work at the plants at the time of their infant's birth).
2. In the "control" group, two of the fathers of "normal" children were working at one of the PVC plants at the time of their infant's birth.
3. Neither of the parents in either group lived within two miles of either of the two plants.
4. A statistical analysis of the actual distances between the two PVC plants and both residences and workplaces of the parents of "cases" and "controls" showed no difference between either group.

The CDC concluded, on the basis of its own investigations and a thorough analysis of the existing research data, that while the possibility could not be ruled out that VCM might be teratogenic, the evidence to date did "not establish any association between (birth defect) cases and vinyl chloride exposure."

Provocative Statements Still Continue

Despite the research and analysis done by CDC, some individuals continue to make provocative but superficial statements based on inaccurate interpretations of the Infante

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Prodiginine (Prodigiosin-Like) Pigments from *Streptoverticillium rubrireticuli*, an Organism That Causes Pink Staining of Polyvinyl Chloride

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Red pigments were extracted from *Streptoverticillium rubrireticuli* strain 100-19, an organism frequently incriminated in pink staining of polyvinyl chloride. These pigments were identified as undecylprodiginine and butylcycloheptylprodiginine.

Pink discoloration of polyvinyl chloride due to microbial growth has frequently plagued the plastics industry (6, 18). Such discoloration occurs on vinyl-covered furniture, vinyl wall covering, and vinyl doors.

In an attempt to induce artificially the pink discoloration of vinyl plastic, Yeager (17) buried vinyl in soil and observed production of pink spots on the vinyl. Of the many organisms isolated, only one, *Streptoverticillium rubrireticuli* (formerly *Streptomyces rubrireticuli*), produced the pink discoloration of vinyl.

Because of the lack of information in the literature on the nature of the pink pigments produced by *S. rubrireticuli*, a study was initiated to characterize these substances and to determine cultural conditions suitable for their formation. The evidence presented indicates that the pink pigment is actually a mixture of two prodiginine pigments, undecylprodiginine and butylcycloheptylprodiginine.

MATERIALS AND METHODS

Organism. *S. rubrireticuli* strain 100-19, an organism kindly provided by G. Tirpak, Tenneco Chemicals, Inc., was used in this study. It was originally isolated from pink-stained vinyl.

Solid media. Five different media solidified with 15 g of agar per liter (USP no. 1, Meer Corp., New York, N.Y.) were used. These included (i) Bennett's medium (5); (ii) yeast-Czapek medium (5a); (iii) Pablum medium containing 60 g of Pablum mixed cereal per liter (Canadian Pablum, Mead Johnson Co., Toronto, Ont.) in tap water, no pH adjustments; (iv) malt medium containing 10 g of malt extract per liter (Fisher Chemical Co., Pittsburg, Pa.) in tap water; and (v) nutrient glycerol medium containing 60 ml of glycerol, 5 g of Wilson's peptone 851, 5 g of NaCl, and 3 g of meat extract (Difco Laboratories, Detroit, Mich.) per liter of tap water.

Liquid media. The five liquid media used were (i) Bennett's, (ii) yeast-Czapek, (iii) modified yeast-Czapek in which the phosphate salt was replaced by calcium carbonate (10 g/liter), (iv) yeast-dextrose (5), and (v) soybean media (5). The soybean meal in the latter medium differs from that used previously (5) in that it contains 49% solvent-extracted soybean meal from Central Soya (Fort Wayne, Ind.). It contains not less than 49% crude protein; the ingredients are solvent-extracted dehulled soybean meal with added kaolin.

Cultural conditions. Slant cultures on solid media were maintained at 28 C. Growth in liquid media was in 50-ml batches in 250-ml Erlenmeyer flasks shaken on a New Brunswick model V rotary shaker at 180 to 220 rpm. When the organism was grown for extraction and purification of the pigments, a slant culture was inoculated into soybean medium or Bennett's broth, shaken 3 days at 28 C, and then transferred into 10 flasks of soybean medium. After 3 days, the cells were harvested by filtration.

Extraction and purification of the prodiginine pigments. The following steps were taken. (i) The cells were shaken overnight with acetone. Spectrophotometric assay at 530 nm (5), the wavelength at which maximum absorbance occurred, indicated about 4 mg of prodiginine pigments in the acetone extract. (ii) This acetone extract was concentrated and poured into water, and the mixture was extracted twice with chloroform. Before the second extraction the aqueous layer was made strongly acid and the shaken mixture was allowed to stand overnight before the lower, pigment-containing chloroform layer was withdrawn. This procedure was known from previous work with other microorganisms to result in higher yields of chloroform-extractable pigments. (iii) The pigment mixture was further purified and resolved into two fractions by column chromatography on alumina and silica gel (5).

Techniques for characterization of the pigments. Procedures for spectrophotometric analysis, thin-layer chromatography (TLC), and mass spectroscopy were described previously (5). Mass spectra were obtained at 2 kV with an inlet temperature of 240 C.

RESULTS

Pigmentation and cultural conditions. *S. rubrireticuli* grown on five solid media, previously found useful for eliciting prodiginine pigments, showed strong red nondiffusing pigmentation on nutrient-glycerol agar only. Weak red pigmentation was observed in the growth on Bennett's agar, but it was nearly obscured by the intense dark diffusing pigment that was also produced. Only the dark diffusing pigment was observed when this organism was grown on malt, Pablum, or yeast-Czapek agar. During the past 2 years one of us (N.N.G.) has studied 12 *Streptomyces* or *Streptoverticillium* strains that produce prodiginine pigments. *S. rubrireticuli* strain 100-19 is the first such strain that failed to show red pigment on yeast-Czapek agar.

In shaken broth cultures, strain 100-19 grew well in yeast dextrose and soybean media, less well in Bennett's broth, and poorly in the two types of yeast-Czapek broth. Red pigmentation was most noticeable in cells grown in soybean medium. Some pigmentation was apparent in cells from Bennett's and yeast-dextrose media, but it was absent from cells in the two yeast-Czapek media.

More pink pigment was produced at 28 to 31 C than at 22 C. At 38 C pigment production was slight to none. Maximum pigment accumulation occurred during the early stationary phase of growth.

Characterization of the prodiginine pigments. The pigments extracted from cells were purified and resolved into two fractions (A and B) as described in Materials and Methods. The purified pigments were compared with authentic samples of the nine known, fully characterized, naturally occurring prodiginines.

Pigment A exhibited visible absorption maxima at 528 nm in acid-$CHCl_3$ and at 525 nm in acid-ethanol. These maxima as well as the observed TLC behavior (color, fluorescence, and R_f) were identical with those of authentic samples of undecylprodiginine and nonylprodiginine (4). Mass spectroscopy indicated that pigment A was undecylprodiginine (Fig. 1A; Fig. 2). The molecular ion was clearly 393 mass units, and the spectrum closely resembled that of authentic undecylprodiginine (8). Nonylprodiginine has a molecular ion at 365 mass units.

Pigment B was identical with authentic butylcycloheptylprodiginine (Fig. 1B) in visible absorption maxima (542 nm in acid-$CHCl_3$ and 536 nm in acid-ethanol) and TLC behavior (5a). On the TLC plate, spots of pigment B were slightly behind those of authentic metacycloprodigiosin (15) and pinker (less orange). Spots of pigment B were the same color as those of authentic prodigiosin (10, 16) but slightly ahead. The structure was verified by mass spectroscopy (Fig. 2). The mass spectrum was similar to that obtained previously for butylcycloheptylprodiginine (5a) and clearly different from that of metacycloprodigiosin, which does have the same molecular formula but a different structure.

DISCUSSION

Two prodiginine pigments have been identified as products of *S. rubrireticuli*, undecylprodiginine and butylcycloheptylprodiginine. These pigments were recently found by Gerber (5a) to also be produced by *Streptomyces* sp. Y-42, a strain isolated from leaf and grass compost. Several other members of the order *Actinomycetales* have been found to be capable of producing prodiginine pigments (1–5a, 7–9, 11–15).

It is probable that the "pink staining" of polyvinyl chloride caused by *S. rubrireticuli* is due to the prodiginine pigments produced by the organism. Yeager (18) reported that "the presence of the organism in the vinyl system is not necessary to produce the stain. Instead, the discoloration is caused by a migration of the stain from a nearby substrate on which the organism is growing." The prodiginine pigments of *S. rubrireticuli* are soluble in diisodecyl adipate, one of the plasticizers used commercially by some vinyl manufacturers. Exposure of the plasticizer to red mycelia resulted in extraction of the pigment (Stahly, unpublished data). Thus, the plasticizer is the probable vehi-

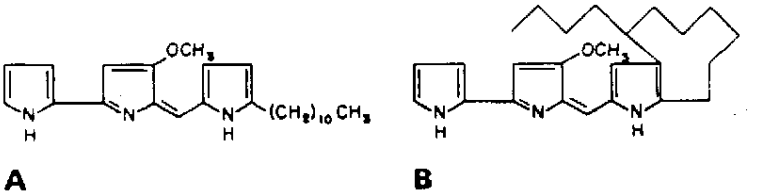

FIG. 1. *Prodiginine pigments of S. rubrireticuli. (A) Undecylprodiginine; (B) butylcycloheptylprodiginine.*

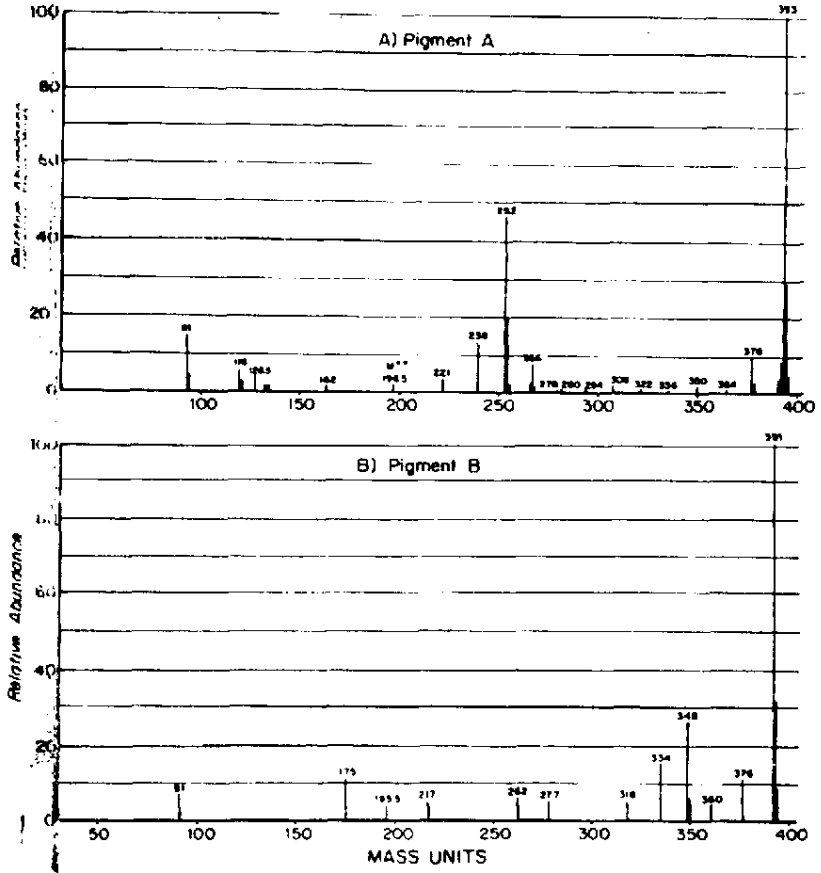

FIG. 2. *Mass spectra of prodiginine pigments of S. rubrireticuli. (A) Pigment A, undecylprodiginine; (B) pigment B, butylcycloheptylprodiginine.*

cle through which the pigment is transported from *S. rubrireticuli* throughout the vinyl system.

The mass spectrum of pigment A with its strong molecular ion at 393 mass units is clearly different from that of nonylprodiginine, the molecular ion of which is 28 mass units less. Both show the 252 mass unit peak caused by β cleavage of the aliphatic side chain. Although both metacycloprodigiosin and butylcycloheptylprodiginine have strong molecular ions at 391 mass units, the next largest peaks are 307 and 320 for the former and 348 and 334 for the latter.

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Solvent search

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HEALTH HAZARD EVALUATION/TOXICITY DETERMINATION REPORT H.H.E. 74-61-232, GATES RUBBER COMPANY, DENVER, COLORADO

Bobby J. Gunter, et al

National Institute for Occupational
Safety and Health
Cincinnati, Ohio

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16. Abstract

Determination: A plant manufacturing extruded hose, principally from the extrusion of polyvinyl chloride, was investigated by NIOSH to evaluate employee exposures to cyclohexanone, TDI, trichloroethylene, Estane® thermoplastic polyurethane, methylene chloride, Nigrosine, Di-2-ethyl hexyl phthalate (DOP oil), dust, and vinyl chloride. It was determined that a potential health hazard may exist from exposure to cyclohexanone, and that several cases of primary irritant dermatitis had occurred following repeated exposure to solvents. Although only one of 38 vinyl chloride samples was found to exceed the Federal Standard action level, it was recommended that airborne concentrations be reduced to levels not detected by the recommended analytical techniques.

17. Key Words and Document Analysis. 17a. Descriptors

Hazardous materials, Toxicity, Toxicology, Criteria, Inspection, Standards, Recommendations, Industrial hygiene, Vinyl Chloride, Isocyanates, Dust, Cyclohexanones, Polyurethanes, Plastics

17b. Identifiers/Open-Ended Terms

Health hazard evaluation, Toxicity determination, Occupational Safety and Health Act of 1970, Toluene diisocyanate, TDI, Nigrosine, Methylene Chloride, Di-2-ethyl hexyl phthalate, Estane, Nuisance dust, DOP oil, Extruded hose, Polyvinyl chloride extrusion, Garden hose manufacture

17c. COSATI Field/Group

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION REPORT 74-61-232
GATES RUBBER COMPANY
DENVER, COLORADO

NOVEMBER 1975

I. TOXICITY DETERMINATION

From the results of environmental and medical evaluations conducted by the National Institute for Occupational Safety and Health (NIOSH) on June 4 and 7, 1974; July 11, 1974; November 11, 1974; December 3, 1974; March 20, 1975; April 10, 1975; and May 5-7, 1975, it has been determined that a potential health hazard may exist from exposures to cyclohexanone in the Extruded Hose Department(Department 60) of the Gates Rubber Company, Denver, Colorado. This determination is based on airborne measurements of cyclohexanone which exceeded recommended hygienic standards for this substance. In addition several workers within this Department were found to have primary irritant contact dermatitis from repeated exposure to solvent containing solutions. All environmental measurements for toluene diisocyanate (TDI), trichlorethylene, and total dust were below NIOSH recommended standards and established OSHA Federal Standards. Only one of 38 vinyl chloride samples was found to exceed the Federal Standard action level of 0.5 ppm. It is NIOSH's policy to reject the concept of a threshold limit for vinyl chloride gas or any other carcinogen. NIOSH recommends that the employer reduce airborne concentrations of vinyl chloride to levels not detectable by the recommended analytical techniques. On three of four occasions when measured all vinyl chloride concentrations were below detection limits.

II. DISTRIBUTION AND AVAILABILITY

Copies of this hazard evaluation determination are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, Fifth and Walnut Streets, Cincinnati, Ohio 45202.
Copies have been sent to:

(a) Gates Rubber Company
(b) United Rubber Workers, Local #154, Denver
(c) U.S. Department of Labor - VIII
(d) NIOSH - Region VIII

For the purpose of informing the approximately 60 "affected employees" this report should be posted in a prominent place accessible to the workers for a period of approximately 30 days.

1.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health received such a request from the President of United Rubber Workers, Local #154, Denver, Colorado, to evaluate the hazards associated with various chemical substances used in the manufacture of extruded hose and dust generated by this manufacturing process.

IV. HEALTH HAZARD EVALUATION

A. Plant Process

The Extruded Hose Department of Gates Rubber Company produces garden hose principally from the extrusion of polyvinylchloride (PVC). Other plastics are used infrequently in this process. Other chemicals used in preparing nylon cords for reinforcing the hose include cyclohexanone, TDI, trichloroethylene, Estane® thermoplastic polyurethane, methylene chloride, di-2-ethylhexyl phthalate (DOP oil), and nigrosine. Various combinations of these chemicals have been in use during the Health Hazard Evaluation study period. During the period of the medical evaluation two principal formulations were in use and designated numerically as compounds 10127 and 10139. While containing common ingredients the former compound also contains methylene chloride and DOP oil while the latter contains nigrosine. Only small quantities of compounds 10127 and 10139 are utilized. Nylon thread is passed through these mixtures, which serve as bonding agents, prior to entering knitting machines that produce a reinforcing matrix surrounding the hose core. Knitting machine operators, who for safety reasons cannot wear protective gloves, are the principal Department personnel exposed to these materials. Other major activities within the Department include plastic blending, extrusion, and hose finishing or coiling. Personnel per shift normally include two stockmen, one blender, four extruder operators, two knitting operators and seven or eight hose finishers.

B. Evaluation Design

The Extruded Hose Department normally works three shifts, with a 40-hour work week per shift. At the time of this evaluation

there were usually 17-18 employees per shift. Environmental evaluations were performed on all three shifts. Environmental samples were analyzed in both NIOSH Salt Lake City and Cincinnati laboratories. Employees from all shifts also participated in the medical evaluation which was principally conducted in the offices of Local Union No. 154, United Rubber, Cork, Linoleum and Plastic Workers of America - AFL-CIO.

C. Evaluation Methods

Vinyl chloride, cyclohexanone, and trichloroethylene were collected on organic vapor sampling tubes and analyzed by gas chromatography. TDI samples were collected in all glass midget impingers and analyzed by the Marcali method. Total dust samples were taken on pre-weighed filters and re-weighed in the laboratory.

Non-directed medical interviews and, when deemed advisable, limited physical examinations were carried out privately by a NIOSH physician. These examinations when indicated included cutaneous, eye, nose, throat, blood pressure, chest, heart, and hearing assessments.

Bulk samples of compounds 10127 and 10139 along with the individual ingredients of each mixture were obtained and concentrations suitable for patch testing prepared. The following concentrations and vehicles were utilized:

Patch Test Materials

1. Estane^{R}, 1% in acetone
2. Nigrosine, 1% in petroleum
3. DOP oil, 1% in petroleum
4. Mixture 10127, 5% in acetone
5. Mixture 10139, 5% in acetone

These concentrations are known to be sufficently low to preclude irritant reactions.

Standard patch test procedures were followed in testing four worker volunteers, each of whom gave histories compatible with repeated episodes of irritant or allergic contact dermatitis. Appropriate acetone and petroleum control patches were also applied. Cyclohexanone and methylene chloride were not tested individually since they have never been reported to cause allergic sensitization and were already present in formulas 10127 and 10139. In addition, a reactive patch test to either or both these formulas plus the reaction pattern to the other materials tested would permit the identification of either of these solvents in the

unlikely event that they were causing sensitization. Patch test sites were carefully examined 48 hours after application and volunteers were urged to report promptly any reactions which might appear subsequently.

D. Evaluation Criteria

Vinyl chloride is considered a carcinogenic agent. It is suspected of being an etiologic agent in the development of angiosarcoma of the liver (a rare form of liver cancer). As stated in NIOSH's Recommended Standard for Occupational Exposure to Vinyl Chloride, "there is probably no threshold for carcinogenesis although it is possible that with very low concentrations, the latency period might be extended beyond the life expectancy." In view of these considerations and NIOSH's inability to define a safe exposure level the concept of a threshold limit for vinyl chloride gas in the atmosphere is rejected. As a result, the NIOSH Recommended Standard for Occupational Exposure to Vinyl Chloride states that exposure to vinyl chloride monomer should not exceed levels that are detectable by the recommended methods of sampling and analysis. These views are not universally held and as will be subsequently presented the OSHA Federal Standard for vinyl chloride has been set at 1.0 ppm.

Cyclohexanone is commonly used as a solvent and chemical intermediate. It is considered to be low in degree of hazard to health under the usual conditions of use. While capable of causing narcosis and even death at very high levels its low volatility at room temperatures renders this possibility negligible. Definite eye, nose, and throat irritation have been reported at levels of 75 ppm. Since cyclohexanone is an excellent lipid solvent it is very likely that repeated contact will result in skin irritation. It has a TLV of 50 ppm.

Trichloroethylene is commonly used as an industrial solvent particularly in degreasing metal parts. It has narcotic effects in high concentrations and was fairly widely used as a surgical anesthetic in the past. Chronic exposure has been reported to cause abnormal fatigue, increased need for sleep, irritability, headache, and decreased tolerance to alcohol. Ventricular fibrillation resulting in death has been related to trichloroethylene exposure in several reports. Adverse kidney and liver effects were noted in the older literature, but are thought to be due to other chlorinated hydrocarbons present as contaminants. Very recently it has been reported that large amounts of trichloroethylene when fed to rats resulted in cancer development in high percentage of animals. The relevance of such

experiments to the usual types of human exposure remains to be determined. To date there are no studies suggesting that trichlorethylene is a human carcinogen.

TDI is the most commonly used isocyanate and is widely used in the manufacture of "polyurethanes" or "polyurethane plastics." In higher concentrations it is a potent pulmonary tract irritant. It is also capable of inducing an allergic pulmonary sensitization which results in an asthma-like syndrome. This sensitization occurs in only a small proportion of exposed individuals, but once developed precludes any further contact with the unreacted substance. The current standard is thought to be sufficently low to prevent the occurrence of sensitization.

Estane^{R} is a trade mark of the B.F. Goodrich Co. for a group of theroplastic polyurethanes. Presumably any toxic properties would be due to any unreacted isocyanate present and might, in general, be expected to resemble those of TDI.

Nigrosine is a widely used black dye. While uncommonly a cause of dermatitis it is a known skin sensitizer. Most cases have been reported from handling "carbon paper."

Methylene chloride is another widely used industrial solvent and is widely used in de-greasing metal parts. Since it is non-flamable its use appears to be growing. In high concentrations it has anesthetic action manifest by headache, giddiness, stupor, irritability, sensations of "drunkenness", and loss of coordination. It is moderately irritating to the skin upon repeated contact.

Di-2-ethylhexyl phthalate (dioctyl phthalate) is one of the most widely used plasticizers and as such as received fairly extensive toxicologic investigation. Based on these studies it may be concluded that the hazard to workers under the usual conditions of use would be extremely low. Patch tests with undiluted material do not cause irritation nor has it been reported to cause sensitization.

Three sources of criteria were considered in assessing the workroom concentrations of air contaminants encountered in evaluation. These are: (1) Recommended and proposed threshold limit values (TLV's) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH) (1974); (2) Occupational health standards as promulgated by the U.S. Department of Labor (Federal Register, June 27, 1974, Title 29, Chapter XVII, Subpart G); and (3) NIOSH recommended criteria for occupational exposures.

In the following tabulation criteria, the most appropriate value in the opinion of the authors is presented with its reference footnoted.

Substance	Permissible Exposures 8-Hour Time-Weighted Exposure Basis	
[1]Vinyl Chloride	1 ppm	(a)
[2]Cyclohexanone	50 ppm	
[3]TDI	C--0.12 mg/M^3	(b)
[4]Trichloroethylene	100 ppm	
[5]Total Dust	10 mg/M^3	(c)

(a) ppm = parts of vapor or gas per million parts of contaminated air

(b) C = ceiling value; this concentration shall not be exceeded for any period

(c) mg/M^3 = approximate milligrams of substance per cubic meter of air

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[1]Reference: current OSHA standard. As previous discussed NIOSH has recommended that exposure to VC should not exceed levels that are detectable by recommended methods of sampling and analysis.

[2]Reference: 1974 ACGIH TLV and current OSHA standard.

[3]Referemce: 1974 ACGIH TLV and current OSHA standard.

[4]REference: 1974 ACGIH TLV and current OSHA standard.

[5]Reference: 1974 ACGIH TLV

Occupational health standards are established at levels designed to protect individuals occupationally exposed to individual toxic substances on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

E. Evaluation Results and Discussion

The environmental measurements are presented in Tables I-IV. Only one vinyl chloride sample exceeded 0.5 ppm out of 38 samples submitted for analysis and all values are within the current Federal Standard (OSHA) for this substance (Table I).

Nuisance dust levels obtained by personal breathing zone collection and general area sampling methods were found to be well under the hygienic standard (Table II). The blender operator was felt to be the only individual potentially exposed to excessive dust based on a careful walk through assessment of the Department.

Cyclohexanone levels were found to exceed the recommended standard for three of the four samples analyzed for this substance (Table III). In view of the restricted usage of this solvent to the knitter operation sampling was limited to those employees working in immediate proximity to that process.

All samples for trichloroethylene (Table III) were reported as being less than 0.05 mg/M^3, the limit of sensitivity for the method employed. TDI sample results (Table IV) were also less than the sensitivity of the current analytic proceedure.

A total of 18 Department 60 employees (4 women and 14 men) participated in the medical portion of the evaluation. The average age was 42 (range 28-60 years). The average duration of employment by Gates was 14 years (range 3-29) and most had spent a majority of this employment (average 10 years) in Department 60. It should be pointed out that these employees were not randomly selected for participation in the study, but rather represent a group who voluntairly came forth on learning that a medical evaluation was planned. It is probably valid to conclude that such a group would contain those employees who are the most likely to have symptoms or complaints which they attribute to their work or who have other health problems and concerns. This sample represents about 30-35% of the total Department work force.

As might be anticipated from the age and size of this group a wide range of symptoms, chronic illnesses, and physical complaints were identified. The most common symptom elicited was headache with five employees mentioning this as a problem. In most instances the headaches were occasional in incidence and not related to any particular department process. One individual did attribute his headaches to the process of purging the tubing extruder.

Four cases of dermatitis were identified and characterized as ezematous in type. The hands were the most common site involved and in several workers the problem had been intermittently present for several years. While the limited distribution to the hands, wrists, and arms suggested primary irritant dermatitis, allergic contact dermatitis could not be excluded on clinical grounds. These four individuals were therefore patch tested as outlined in Section C. The results of these tests were entirely negative confirming the probable irritant nature of the dermatitis. Three of the four employees with dermatitis work as knitter operators in which some exposure to cyclohexanone and methylene chloride, agents easily capable of defatting the skin, is essentially unavoidable since safety considerations preclude the use of gloves.

Other signs, symptoms, and conditions encountered were: asthma-1; allergic rhinitis-2; deafness-1; nose bleeds-1; eye irritation-2; shortness of breath-1; cough-1; arthritis-1; cataract-1; subcutaneous lipomatosis-1; prostatitis-2; cystitis-1; high blood pressure-1; hypercholestrolemia-1; diabetes-1; seizure disorder-1; and post operative status (lipoma excision). The diversity and low frequency of these, not uncommon medical problems, make it quite unlikely that they are related to current occupational exposure.

G. Recommendations

1. Adequate ventilation should be provided during hose extrusion.
2. Exhaust ventialtion should be provided above the hopper where powdered and chipped PVC is hand poured and mixed.
3. Adequate ventilation should be installed in the vicinity of the knitter machines to control cyclohexanone exposure.
4. Knitter machine operators should be supplied with barrier creams formulated to resist organic solvents. Examples of such products are:
   (1) PLY 9 (Milburn Co., 3246 E. Woodbridge, Detroit, Michigan 48207)
   (2) West No. 411 (West Chemical Products, 42-16 West St., Long Island City, New York)
   (3) FEND S-2 (Mine Safety Appliances Co., Pittsburgh, Pa.)
   (4) Kerodex 51 (Ayerst Laboratories, 685 Third Ave., New York, N.Y. 10017)
   (5) MAN-O (MAN-O Products, 3710 Floral Ave., Cincinnati, Ohio 45207)

V. AUTHORSHIP AND ACKNOWLEDGMENT

Report Prepared By:	Bobby J. Gunter, Ph.D. Regional Industrial Hygienist NIOSH - Region VIII Denver, Colorado
	James B. Lucas, M.D. NIOSH Medical Officer Cincinnati, Ohio
Study Participant:	Raymond L. Ruhe NIOSH Industrial Hygienist Cincinnati, Ohio
Originating Office:	Jerome P. Flesch, Chief Hazard Evaluation Services Branch Cincinnati, Ohio

TABLE I

Breathing Zone and General Room Concentrations of
Vinyl Chloride (VC)

Gates Rubber Company
Denver, Colorado

June and July 1974

Date	Job	Sample Vol(cc)	Sample Number	Vinyl Chloride (VC) ppm
June 4, 1974	Blender Operator	377	1	None Detected
"	Tuber Operator	599	2	"
"	Hose Finisher	494	3	"
"	Knitter Operator	794	4	"
"	Blender Operator	479	5	"
"	Tuber Operator	590	6	"
"	Hose Finisher	611	7	"
"	Knitter Operator	874	8	"
"	Blender Operator	426	9	"
"	Tuber Operator	1006	10	"
"	Hose Finisher	1155	11	"
"	Knitter Operator	1520	12	"
June 7, 1974	Knitter Operator	1958	13	< 0.2
"	Insulator	927	14	< 0.2
"	Hose Finisher	1015	15	< 0.2
"	Insulator	1166	16	< 0.2
"	BLANK		17	< 0.2
"	BLANK		18	< 0.2

(continued)

TABLE I
(continued)

Gates Rubber Company
Denver, Colorado

Date	Job	Sample Vol(cc)	Sample Number	Vinyl Chloride (VC) ppm
July 11, 1974	Tuber Operator	4100	1	< 0.2
"	Tuber Helper	390	2	< 0.2
"	Tuber Operator	4000	3	< 0.2
"	Blender Operator	9500	4	0.25
"	Tuber Operator	2300	5	0.25
"	Hose Manager	6500	6	< 0.2
"	Knitter Operator	4400	7	0.21
"	General Blender Area	3200	8	0.25
"	BLANK		13	< 0.2
"	Tuber Operator	7100	18	< 0.2
"	Tuber Helper	10100	17	< 0.2
"	Tuber Operator	7100	20	< 0.2
"	Blender Operator	9500	15	< 0.2
"	Tuber Operator	4000	23	0.29
"	Hose Manager	2000	22	0.46
"	Knitter Operator	9300	19	< 0.2
"	General Blender Area	2300	21	0.52
Nov. 11, 1974	Tuber Operator	8953	1	< 0.2
"	Tuber Operator	4239	2	< 0.2
"	Tuber Operator	9826	3	< 0.2
"	Tuber Operator	4483	4	< 0.2
"	Tuber Operator	3686	5	< 0.2
"	BLANK		6	None Detected
"	BLANK		7	None Detected
"	Tuber Helper	1922	8	< 0.2
	HYGIENIC STANDARD			1.0

The lower limit of detection of vinyl chloride in the NIOSH Salt Lake City laboratory is 0.2 ppm.

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TABLE II

Breathing Zone Concentrations of
Nuisance Dust

Gates Rubber Company
Denver, Colorado

June 7, 1974

Job	Sample Vol(Liters)	Sample Number	Nuisance Dust mg/M^3
Blender Operator	180	E-24	2.2
Blender Operator	456	31	5.2
General Blender Area	456	38	2.1
	HYGIENIC STANDARD		10.0

TABLE III

Breathing Zone Concentrations of
Cyclohexanone and Trichloroethylene

Gates Rubber Company
Denver, Colorado

July 11, 1974

Job	Sample Vol(Liters)	Sample Number	Cyclohexanone mg/M^3	Trichloroethylene mg/M^3
Knitter Operator	10.5	9	86.0	< 0.05
Knitter Operator	9.5	10	68.0	< 0.05
Knitter Operator	20.0	14	68.0	< 0.05
Knitter Operator	39.0	15	8.0	< 0.05
HYGIENIC STANDARDS			50.0	100.0

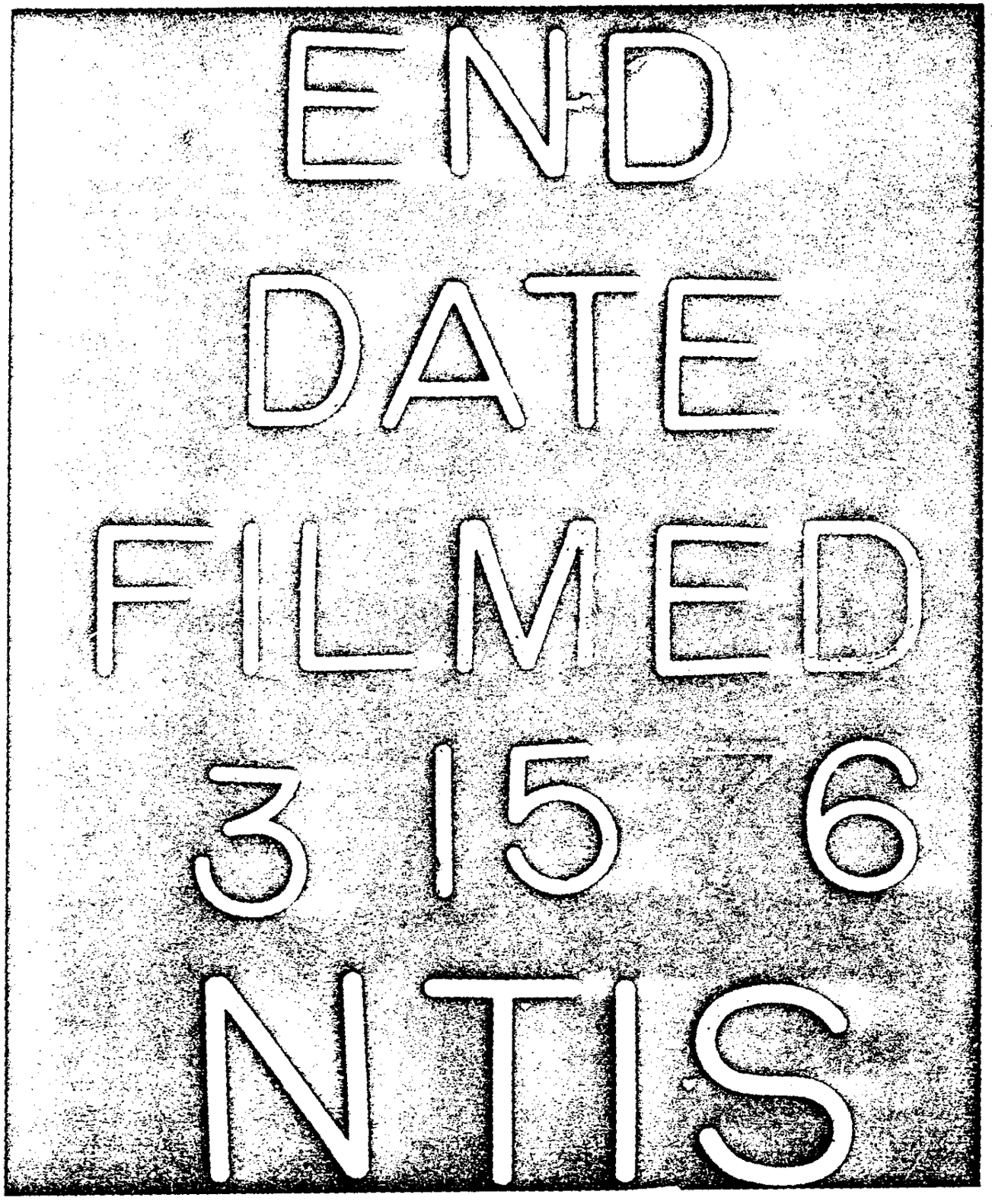
TABLE IV

Breathing Zone and General Room Concentrations of TDI

April 10, 1975

Location	Sample Vol(Liters)	Sample Number	TDI_3 mg/M^3
Knitter Operator	68	1	< 0.02
General Room	61	2	< 0.02
Knitter Operator	66	3	< 0.02
General Room	63	4	< 0.02
BLANK		5	
	HYGIENIC STANDARD		0.12

The lower limit of detection of TDI by current NIOSH analytical methods is 0.02 mg/M^3.



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SEE DISTRIBUTION LIST

BFG TECHNICAL DOCUMENT

FROM: W. C. BACHTEL — DEPT. 0020, BLDG. 5-H (AKRON) — DATE: 11-5-75

SUBJECT:

Toxicity studies have been performed on samples of code 10A both raw and "purified". These studies were performed by Industrial Bio-Test Laboratories using standard test methods.

I have prepared for your information and use a summary of test results, appropriate precautionary statements and discussion.

TOXICOLOGY FILE COPY
Return To. R. K. Hinderer
D/5456 Cleveland

I. Summary of Results

Test	Raw 10A	"Purified" 10A
Acute Oral LD50 (rats)	>15,380 mg/kg relatively harmless	>15,380 mg/kg relatively harmless
Acute Dermal LD_{50} (rabbits)	>3,000 mg/kg practically non toxic	>3,000 mg/kg practically non toxic
Eye Irritation (rabbits)	minimally irritating	extremely irritating
Primary Skin Irritation (rabbits)	minimally irritating	minimally irritating
Inhalation LC_{50} (rats)	> 0.72 mg/L air	> 0.43 mg/L air

II. Applicable Precautionary Statements

A. Eye - Skin

1. Code 10A "Purified"

Danger causes eye burns
Do not get in eyes, avoid contact with skin
Avoid breathing dust
Keep container closed
Use with adequate ventilation
Wash thoroughly after handling
First Aid: In case of contact - immediately flush eyes with plenty of water for 15 minutes. Call a physician. Flush skin with water.

2. Code 10A Raw

WARNING causes irritation
Avoid contact with eyes, skin and clothing
Wash thoroughly after handling
First Aid: In case of contact, immediately flush eye with plenty of water. Call a physician. Flush skin with water.

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B. Inhalation

WARNING harmful if inhaled
Avoid breathing dust
Keep container closed
Use only with adequate ventilation

III. Discussion

A. Acute Oral Toxicity

No deaths were recorded during the 14 day observation period at any of the dose levels of either the raw or purified Code 10A. Solidified test material was found in the stomach of the rats at the 15,380 mg/kg dose level on autopsy. No unexpected reactions or other gross pathological changes were noted with either material. These materials are apparently not readily absorbed through the gastrointestinal tract.

Consequently it can be assumed that the probable acute lethal oral dose for a normal 70 kg man of either material would be in excess of 2 lbs.

B. Acute Dermal Toxicity

All animals survived application of these materials to intact skin at a level of 3000 mg/kg. The materials were applied as an aqueous slurry. No systemic or behavioral reactions were noted. Both materials, however, did cause slight reddening and swelling of the skin. No pathological changes were noted. These results indicate poor dermal absorption. The probable lethal dose via dermal exposure for a normal 70 kg man would be between a pint and a quart of either Code 10A raw or purified.

C. Acute Inhalation Toxicity

A definitive LC_{50} could not be determined for either material. The greatest dust concentration obtainable under the test conditions was 0.72 mg/L air for the purified and 0.43 mg/L air for the raw sample.

There were no untoward reactions during or after exposure, weight gains were normal and no gross pathological changes were noted.

The particle sizes concentrations of the two materials were markedly different. The raw Code 10A contained 46.2% respirable particles while the purified 10A contained 77.1% respirable particles (particles <10 microns).

The data presented in these studies would not indicate that these materials are highly toxic by inhalation. However, since no definitive LC_{50} could be as certained and since a large percentage of the materials are of a particles size that is respirable both 10A raw and purified should be handled as though toxic by inhalation.

D. Eye Irritation

Installation of the normal 100 mg sample of Code 10A raw and purified into

rabbits eyes caused irritation. The purified material was considerably more irritating than the raw material.

The purified material caused corneal density starting within one hour and lasting through the test period with vascularization of the cornea by the seventh day in all rabbits. The irris was severely affected through seven days. By the 14th day no affects was seen in the irris of five of the six animals. The purified material also produced conjunctivitis with swelling redness and discharge throughout the 14 day period in three of the six animals and through seven days in the others.

Code 10A purified is extemely irritating to the eye with a good possibility of permanent eye damage resulting from contact. Clearly, eye protection must be worn by persons who may handle Code 10A purified.

The raw Code 10A caused mild irritation to the rabbit eye consisting of conjunctivitis lasting through 24 hours.one animal showed some corneal clouding at 24 hours. By 48 hours all irritation was absent. Consequently, raw Code 10A would be considered to be minimally irritating to the eye. One would not expect to see permanent eye damage result from contact with this material. Eye protection, should be worn when handling raw Code 10A.

E. Skin Irritation

When both materials were applied to intact and abraded skin only a small amount of reddening was observed at 24 hours. By 72 hours no irritation was noted. Neither of these materials would be considered primary skin irritants. However, one should wash thoroughly after handling them.

IV. Use of Code 10A

If either Code 10A raw or purified is used widely in the polymerization of PVC resins one must consider their potential as an indirect food additive. These materials appear to be innocous by ingestion and skin absorption. If as presently stated the residual level of Code 10A in the resins is in the range of 300 to 800 ppb and extraction into food simulating solvents is less than 50 ppb, I see no need for further chronic testing at this time. If, however, usage levels increase with corresponding increases in extractables (i.e. above 50 ppb in any food simulating solvent) then further studies maybe warranted. At this time we would consider Code 10A as a necessary adjuvant in the polymerization process not reasonably expected to migrate into food.

As far as employee exposure, I feel no further chronic studies are warranted due to the apparent low acute toxicity of these materials. The greatest concern is for the extreme eye irritation caused by the "purified" Code 10A.

W. C. Bachtel

W. C. Bachtel

DISTRIBUTION LIST

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Industrial BIO-TEST Laboratories, Inc.
1810 FRONTAGE ROAD
NORTHBROOK, ILLINOIS 60062

September 9, 1975

Dr. W. C. Bachtel
Toxicologist
The B. F. Goodrich Company
500 South Main Street
Bldg. 5-H - Dept. 0020
Akron, Ohio 44318

Dear Dr. Bachtel:

Re: IBT No. 663-07243 - Acute Dust Inhalation Toxicity Study with TA5DOI-Raw and TA5DOI-Purified in Albino Rats

We are submitting herewith our laboratory reports prepared in connection with the above study.

Very truly yours,

J. C. Calandra
President

JCC/fd

Code 10 A

21493001

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REPORT TO THE B. F. GOODRICH COMPANY

ACUTE DUST INHALATION TOXICITY STUDY IN RATS

Test Material: TA5DOI-Raw
Form Administered: Dust
Acute LC_{50}: > 0.72 mg/l air

Strain: Charles River Rats
Exposure Time: 4 hours
Observation Period: 14 days
IBT No. 663-07243

Generation of Material Exposure:

The dust was suspended by passing a stream of clean dry air (-40°C dewpoint) through a dust shaking mechanism. The resulting air-dust mixture was then introduced into the exposure chamber.

Chamber Conditions Group No.	Size (liters)	Atmospheric Pressure (inches Hg)	Temperature (°C)	Air Flow (l/min)
I	80	30.03	24	15

Results Group No.	Total Number of Animals Male/Femael	Average Analytical Concentration	Mortality Male-Female	Weight Gain Male-Female (grams)
I	5/5	0.72 mg/l air*	0/5 - 0/5	87-34

*Maximum attainable concentration at conditions stated.

Remarks

There were no untoward reactions during exposure or the 14-day observation period which followed. The average 2-week body weight gains were within the normal limits. Necropsy, performed on all rats at the end of the observation period, did not reveal any gross pathologic alterations.

The particle size distribution data is presented on Table I.

Respectfully submitted,

INDUSTRIAL BIO-TEST LABORATORIES, INC.

Prepared by: Larry J. Horath
Larry ~~H.~~ Horath, B.S.
Assistant Toxicologist
Inhalation Toxicology

Approved by: John W. Goode
John W. Goode, Ph.D.
Manager
Decatur Research Laboratories

mk

9/9/75

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Particle Size Distribution

A sample of airborne dust was collected from the test atmosphere for the purpose of conducting a microscopic determination of particle size distribution. Particles were counted with respect to 4 size ranges, viz. 5 microns or smaller, 6 to 10 microns, 11 to 25 microns and larger than 25 microns. Particles less than 10 microns are generally considered to be respirable. The smallest particle which can be detected by the light-field technique employed is approximately 1 micron. The smallest and largest particles observed were also recorded.

TABLE I

TEST MATERIAL: TA5DOI-Raw

Particle Size Distribution Data

Particle Size Range (microns)	Number of Particles Counted	Percent of Total Counted
1-5	36	13.6
6-10	86	32.6
11-25	90	34.1
> 25	52	19.7

The total number of particles counted was 264.

The smallest and largest particles observed were 2 and 65 microns, respectively.

REPORT TO THE B. F. GOODRICH COMPANY

ACUTE DUST INHALATION TOXICITY STUDY IN RATS

Test Material: TA5DOI-Purified
Form Administered: Dust
Acute LC_{50}: > 0.43 mg/l air

Strain: Charles River Rats
Exposure Time: 4 hours
Observation Period: 14 days
IBT No. 663-07243

Generation of Material Exposure:

The dust was suspended by passing clean, dry air (-40°C dewpoint) through a dust shaking mechanism. The resulting air-dust mixture was then introduced into the exposure chamber.

Chamber Conditions Group No.	Size (liters)	Atmospheric Pressure (inches Hg)	Temperature (°C)	Air Flow (l/min)
I	80	30.03	24	15

Results Group No.	Total Number of Animals Male/Female	Average Analytical Concentration	Mortality Male-Female	Weight Gain Male-Female (grams)
I	5/5	0.43 mg/l air*	0/5 - 0/5	86-34

*Maximum attainable concentration at conditions stated.

Remarks

There were no untoward reactions during exposure or the 14-day observation period which followed. The average 2-week body weight gains were within the normal limits. Necropsy, performed on all rats at the end of the observation period, did not reveal any gross pathologic alterations.

The particle size distribution data are presented on Table I.

Respectfully submitted,

INDUSTRIAL BIO-TEST LABORATORIES, INC.

Prepared by: Larry L. Horath
Larry L. Horath, B.S.
Assistant Toxicologist
Inhalation Toxicity

Approved by: John W. Goode
John W. Goode, Ph. D.
Manager
Decatur Research Laboratories

mk

9/9/75

Particle Size Distribution

A sample of airborne dust was collected from the test atmosphere for the purpose of conducting a microscopic determination of particle size distribution. Particles were counted with respect to 4 size ranges, viz. 5 microns or smaller, 6 to 10 microns, 11 to 25 microns and larger than 25 microns. Particles less than 10 microns are generally considered to be respirable. The smallest particle which can be detected by the light-field technique employed is approximately 1 micron. The smallest and largest particles observed were also recorded.

TABLE I

TEST MATERIAL: TA5DOI-Purified

Particle Size Distribution Data

Particle Size Range (microns)	Number of Particles Counted	Percent of Total Counted
1-5	94	42.9
6-10	75	34.2
11-25	35	16.0
> 25	15	6.9

The total number of particles counted was 219.

The smallest and largest particles observed were 1.5 and 50.0 microns, respectively.

Code 10 A
C.2

Industrial **BIO-TEST** *Laboratories, Inc.*
1810 FRONTAGE ROAD
NORTHBROOK, ILLINOIS 60062

REPORT TO

THE B. F. GOODRICH COMPANY

ACUTE TOXICITY STUDIES WITH TA5DOI - PURIFIED

AUGUST 29, 1975

IBT NO. 601-07242

code 10 A

Industrial BIO-TEST Laboratories, Inc.
1810 FRONTAGE ROAD
NORTHBROOK, ILLINOIS 60062

August 29, 1975

Dr. W. C. Bachtel
Toxicologist
The B. F. Goodrich Company
500 South Main Street
Bldg. 5-H - Dept. 0020
Akron, Ohio 44318

Dear Dr. Bachtel:

Re: IBT No. 601-07242 - Acute Toxicity studies with TA5DOI - Raw and TA5DOI - Purified

We are submitting herewith our laboratory reports prepared in connection with the above study.

Very truly yours,

J. C. Calandra

J. C. Calandra
President

JCC/fd

REPORT TO

THE B. F. GOODRICH COMPANY

ACUTE TOXICITY STUDIES WITH
TA5DOI - PURIFIED

AUGUST 29, 1975

IBT NO. 601-07242

I. Introduction

At the request of The B. F. Goodrich Company, the following studies were conducted with a brown powder identified as TA5DOI-Purified:

Acute Oral Toxicity Study - Albino Rats

Acute Dermal Toxicity Study - Albino Rabbits

Eye Irritation Test - Albino Rabbits

Primary Skin Irritation Test - Albino Rabbits

II. Summary

The results of the acute toxicity studies with TA5DOI-Purified are summarized below:

Test	Results
Acute Oral Toxicity Study - Albino Rats	Relatively Harmless LD_{50} > 15,380 mg/kg
Acute Dermal Toxicity Study - Albino Rabbits	Practically Nontoxic LD_{50} > 3,000 mg/kg
Eye Irritation Test - Albino Rabbits	Extremely Irritating (59.3/110.0)
Primary Skin Irritation Test - Albino Rabbits	Minimally Irritating (0.4/8.0)

Respectfully submitted,

INDUSTRIAL BIO-TEST LABORATORIES, INC.

Report prepared by:

Robert J. Quinn, B.S.
Technician
Acute Toxicity

Helfried Paa
Assistant Group Leader
Acute Toxicity

Report approved by:

C. W. Mastri, B.S.
Section Head, Acute Toxicity

Florence K. Kinoshita, Ph.D.
Technical Manager, Toxicology

M. L. Keplinger, Ph.D.
Manager, Toxicology

gb

III. Results

A. Acute Oral Toxicity Study - Albino Rats

1. Mortality and Body Weights

Individual mortality and body weight data are presented in Table I.

2. Reactions and Pathology

Hypoactivity was observed in the rats dosed at 15,380 mg/kg 3 hours following oral administration of TA5DOI-Purified. Diarrhea was observed in the rats of this dose level after 6-22 hours. These symptoms had subsided within a day.

Necropsy examination revealed solidified test material in the stomachs of rats dosed at 15,380 mg/kg level. No other gross pathologic alterations were observed in any of the other animals.

TABLE I

Acute Oral Toxicity Study - Albino Rats

Mortality and Body Weight Data

IBT No.: 601-07242
Test Material: TA5DOI-Purified
Form Administered: As a 40.0 percent (w/v) suspension in 2.0 percent (w/v) aqueous methylcellulose

Classification: Relatively Harmless
Acute Oral LD_{50} > 15,380 mg/kg

Dose Level (mg/kg)	Animal Number and Sex	Individual Body Weights (grams) Test Day Number: 0	14	Number Dead / Number Tested	Percent Dead
1,350	1-M	232	290	0/4	0
	2-M	230	290		
	3-F	240	280		
	4-F	204	244		
4,556	5-M	240	320	0/4	0
	6-M	232	310		
	7-F	190	210		
	8-F	220	240		
15,380	9-M	218	260	0/4	0
	10-M	250	320		
	11-F	188	200		
	12-F	190	210		

B. Acute Dermal Toxicity Study - Albino Rabbits

1. Mortality and Body Weights

Individual mortality and body weight data are presented in Table II.

2. Reactions and Pathology

No pharmacotoxic symptoms were exhibited by any of the rabbits following dermal exposure to TA5DOI-Purified.

The test material was slightly irritating to the skin of the albino rabbit. Pale red erythema and slight edema were observed at 24 hours, while no skin reactions were noted at the test skin sites at 7 and 14 days.

Necropsy examination did not reveal any gross pathologic alterations in any of the rabbits.

TABLE II

Acute Dermal Toxicity Study - Albino Rabbits

Mortality and Body Weight Data

IBT No.: 601-07242
Test Material: TA5DOI-Purified
Form Administered: As an aqueous slurry

Classification: Practically Nontoxic
Acute Dermal LD_{50} > 3,000 mg/kg

Dose Level (mg/kg)	Animal Number and Sex	Individual Body Weights (kg) Test Day Number: 0	7	14	Number Dead / Number Tested	Percent Dead
3,000	1-M*	2.70	2.70	2.66	0/4	0
	2-M	2.70	2.84	2.84		
	3-F*	2.68	3.08	3.18		
	4-F	2.72	2.90	2.90		

* The skin at the site of application was abraded.

C. Eye Irritation Test - Albino Rabbits

The results of the eye irritation test are presented in Table III.