Toluene Diamine

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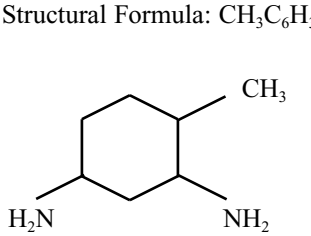
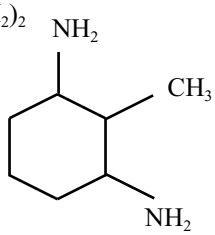
I. IDENTIFICATION

Chemical Name: Toluene diamine
Synonyms: Diaminotoluene; TDA; Tolyenediamine
CAS Number: Mixed Isomers = 25376-45-8; 2,4-toluene diamine = 95-80-7; 2,6-toluene diamine = 823-40-5. *(Note: This OEL guide addresses only the 2,4-isomer or commercial mixtures of the 2,4- and 2,6-isomers.)*
Molecular Formula: $C_7H_{10}N_2$
Structural Formula: $CH_3C_6H_3(NH_2)_2$



2,4-TDA



2,6-TDA

II. CHEMICAL AND PHYSICAL PROPERTIES[1–4]

Physical State and Appearance: Crystalline powder, white when new but rapidly darkening to brown, purple, or black when exposed to air.
Odor Description: No data available
Molecular Weight: 122.19
Conversion Factors: 1 ppm = 5 mg/m^3;
1 mg/m^3 = 0.20 ppm
Melting Point: 99°C (110°F)
Boiling Point: 292°C (558°F)
Vapor Pressure: 3 x 10^{-4} mmHg at 38°C (100°F)
Saturated Vapor Concentration: Approx. 0.5 ppm at 38°C(100°F)
Flash Point: 163°C (325°F), closed cup
Flammability Limits: Not applicable
Autoignition Temperature: No data available
Specific Gravity: 1.04
Solubility in Water: TDA is insoluble in water
Stability: Darkens on exposure to air; otherwise stable
Reactivity and Incompatibilities: No data available

III. USES

Although there are 6 isomers of TDA, only 2,4-, 2,5-, and 2,6-TDA are of any commercial significance. The 2,4- and 2,6- isomers commonly occur together and are by far the most significant in terms of volume. By far the greatest proportion of TDA is used as an intermediate at the site where manufactured to produce toluene diisocyanate, which in turn is used primarily in production of polyurethane compounds. The literature frequently describes commercial grade material as a mixture of the 2,4- and 2,6-isomers in an 80:20 ratio. It also finds some use as an intermediate or component in dyes.[5–7]

IV. ANIMAL TOXICITY DATA

A. Acute Toxicity and Irritancy

1. *Oral Toxicity*[8–12]

Rats: LD_{50} = 125–812 mg/kg

Mice: LD_{50} = 200–400 mg/kg

Rabbits: LD_{50} = 250–500 mg/kg

2. *Eye Irritation*[9,10,12]

Rabbits: Variously reported as mild to severe irritation, depending on concentration.

3. *Skin Absorption*

Rabbits: LD_{50} = >2 gm/kg[8,9]

Rabbits: LD_{50} = 1120 mg/kg[13]

Monkeys: 54% of dermal application, in acetone, absorbed in 24 hr.[14]

In tests with humans, 24% of the dermal application, in acetone, was absorbed in 24 hr.[14]

4. *Skin Irritation*[8,9,12]

Rabbits: Variously reported as mild to moderate, depending on concentration and solvent used.

5. *Skin Sensitization*[15,16]

Guinea pigs: Negative in standard hypersensitization test.

6. *Inhalation Toxicity*

All rats exposed to airborne TDA dust at an estimated concentration of 770 mg/m^3 for 7 hr died within 24 hr of the exposure.[10]

No deaths were reported in a group of rats exposed to TDA dust at 1860 mg/m^3 for 1 hr.[8]

None of 10 rats exposed to TDA dust for 1 hr at an estimated concentration of 200,000 mg/m3 died, although all animals "appeared depressed" during exposure.[9]

7. *Intraperitoneal Toxicity*[13,16]

Rats: LD_{50} = 200–540 mg/kg

Mice: LD_{50} = 200–400 mg/kg

B. Subacute Toxicity (6–28 days)

No published studies were found.

A letter from Mobay Chemical Corporation made available to the AIHA WEEL Committee cites an unpublished study in which two cats were exposed to TDA 'Vapors" at an average of 42 mg/m^3 4 hr/day 5 days/week for 3 weeks. Given the saturated vapor concentration of this compound, this dosage actually would have been a mixture of vapor and aerosol. At the end of the exposure period, methemoglobin levels were 27% and 30%. One animal died 15 days postexposure and was found on necropsy to have damage to liver, lungs, and kidneys.[17]

C. Subchronic Toxicity (29 days–6 months)

As part of an NTP study, rats and mice were fed 2,4-toluene diamine to determine the "maximum tolerated dose" for use in the chronic study to follow. For the rat study, 2,4-TDA was incorporated into the diet at 0, 250, 500,1000,2000, and 3000 ppm over a 7-week period, followed by 1 week of recovery. Each dose group included 5 animals of each sex at each dose. Surviving animals were then killed and subjected to necropsy. Mortality in the 2 highest dose groups was essentially 100% (10 of 10 at 3000 ppm; 9/10 at 1000). Those fed 1000 ppm, were found to have "slight increases in hematopoiesis and cytoplasmic vacuolation of hepatocytes." Mice were fed diets containing 0, 100, 200, 300, 500, 700, or 1000 ppm 2,4-TDA. Again, each dose group included 5 animals of each sex at each dose. All animals survived the exposure, except for 2 of 5 of the highest dose male mice. No clinical or histopathological findings were reported for the male mice at 700 ppm or for the female mice at 1000 ppm. Even in the absence of clinical or histopathological changes, however, significant depression of body weight was observed at 300 ppm and higher in mice and at 500 ppm and higher in male rats and at 1000 ppm and higher in female rats.[6]

As part of another NTP study, rats and mice were fed 2,6-toluene diamine dihydrochloride to determine the "maximum tolerated dose" for use in the chronic study to follow. For the rat study, 2,6-TDA•2HC1 was incorporated into the diet at 0, 100, 300, 1000, 3000 and 10,000 ppm over a 13-week period. Surviving animals were then killed and subjected to necropsy. Two of 10 males and 7 of 10 females in the highest dose group did not survive. The main effect seen was significant depression of body weight. All dose groups of male rats demonstrated depressed weight gain, and females at 1000 ppm and above had significant depression of body weight. Other effects, seen at necropsy, included thyroid enlargement, bone marrow effects, nephrosis and darkening of numerous organs at the highest doses. No significant gross abnormalities (other than depressed body weight) were seen at the lower doses. It is not possible to clearly differentiate what effects were seen in which groups because of discrepancies between data in the text and in the accompanying tables. Mice were fed diets containing 0, 100, 300, 1000, 3000, or 10,000 ppm 2,6-TDA•2HC1. All animals survived the exposure. As with the rats, the main effect seen was significant depression of body weight. Male mice demonstrated depressed weight gain in all groups fed 300 ppm or more, and females at 1000 ppm and above had significant depression of body weight. Clinical or histopathological findings were limited to a squamous papilloma on the forestomach in 1 male at 10,000 ppm, and a few instances of renal hyperpigmentation at the highest doses.[18]

D. Chronic Toxicity/Carcinogenicity

There is several carcinogenicity studies of various TDA isomers reported in the literature; however, reports on other chronic effects are generally lacking.

TDA was tested for carcinogenic potential as early as the 1930s, but these tests did not detect an effect. Umeda published a study in 1955 in which subcutaneous sarcomas resulted from multiple injections of 2,4-TDA in propylene glycol. The regimen was 1 injection per week of 0.5 cc of 0.4% 2,4-TDA over a 28-week period. Although only 9 of 20 rats survived the injections; all 9 survivors developed massive tumors.[19]

A 35-week feeding study published by Ito et al. in 1969 was the first in which 2,4-TDA was shown to cause cancer by this route. Although only 12 rats were used in each of 2 exposed groups — fed either 600 ppm or 1000 ppm by weight in their diet — the results were clear. All 9 of the surviving high-dose animals and 7 of 11 surviving low-dose animals developed hepatocellular carcinomas, while none of the 8 controls did so.[20]

A skin-painting study was performed to evaluate use of 2,4-TDA as a hair dye component. In this study, the skin of Swiss-Webster mice was painted weekly for 1 year, then the animals were observed for an additional year. Various blends of 2,4-TDA were used, including some containing 2,5-toluene diamine sulfate. 2,4-TDA concentrations ranged from 0.2% to 6%. The authors conclude that there was no statistically significant increase in tumors associated with 2,4-TDA.[21]

A standard bioassay for carcinogenicity was performed under the direction of the NTP for the hydrochloride of 2,6-TDA. In the study, rats and mice were fed 2,6-TDA•2HCl at either 250 ppm or 500 ppm by weight in their diets for 103 weeks. Although certain rumors were observed at levels that were enough above or below the typical incidence to be considered worthy of comment in the report's summary, the NTP concluded that none were statistically significant under the conditions of the test.[18]

A standard bioassay was also performed under the direction of the NTP for carcinogenicity of 2,4-TDA. In this study, rats were initially fed diets containing either 100 ppm or 250 ppm by weight 2,4-TDA. However, due to seriously depressed weight gains in the exposed animals, the doses were decreased after the 40th week to 50 ppm and 125 ppm, and then continued to the end of the 103-week exposure. This resulted in average doses of 79 ppm for the low-dose rats and 176 ppm or 171 ppm for the high-dose male and female rats, respectively. Mice were fed diets containing either 100 ppm or 200 ppm throughout the study. There were 50 animals of each sex of each species in each exposed group and 20 animals of each sex of each species in the control group. Decreased body weights were seen in all exposed groups. Both sexes of rats and female mice developed statistically significant increases in both carcinomas and nonmalignant neoplasms of the liver at both doses. The incidence was judged to be dose-related. No control animals developed liver malignancies, and only three of the control rats and none of the control mice were found to have other "areas of cellular alteration." The female rats also had statistically significant increases of carcinomas and adenomas of the mammary glands, and the male rats developed statistically significant increases of fibromas in the subcutaneous tissues in both dose groups. These incidences were also determined to be dose related. Only one female control rat developed a mammary tumor, and male controls did not develop any fibromas in the subcutaneous tissues. Male mice did not experience any statistically significant changes in cancer incidence.[6]

Although the NTP study indicated a dose response for several of these carcinogenic findings, it did not suggest any threshold effect or overall "no observed effect level." Indeed, the low-dose male rats had a liver tumor incidence of 10% of the animals, while the high-dose group was twice as high. Approximately half the low-dose rats, both male and female, were observed to have other "foci or areas of cellular alteration" in the liver, while about 80% of the high-dose rats showed this effect. Also, the low-dose female rats had mammary tumors in more than 70% of the animals (20% had malignant tumors), while 84% of the high-dose females had mammary tumors (18% malignant). In mice, neoplasms were observed in both sexes but were not significantly different from the controls in the males. In addition to the statistically significant increase in liver neoplasm incidence in the female mice, a very high incidence of liver hyperplasia was noted in both sexes of mice (more than 25% of the low-dose and more than half the high-dose animals).[6]

E. Reproductive/Developmental Toxicity

There were no teratologic effects in rabbits dosed orally by intubation at 0, 3, 10, 30, or 100 mg/kg/day of TDA in corn oil on days 6-18 of gestation (15 animals per group). However, the dams in the highest exposure group showed lower weight gains and experienced increased resorption of the litters. A neonatal survival index test performed on the fetuses also indicated fetotoxic effects at the 100 mg/kg level, but not at other doses.[22]

In a similar study, rats were orally dosed by gavage at 0, 10, 30, 100, or 300 mg/kg/day TDA in corn oil on Days 6–15 of gestation. There was no

effect on the number of fetuses; however, there was a statistically significant increase in incomplete vertebrae in the 100 mg/kg and 300 mg/kg groups. There was also an increase in the incidence of abdominal hemorrhages in the 10, 100, and 300 mg/kg fetuses (but not in the 30 mg/kg group). This effect did not show any dose relationship. Weight gains for the dams in the highest exposure group were significantly lower than the controls.[23]

F. Genotoxicity/Mutagenicity

Toluene diamine has been tested for genotoxicity and mutagenicity by many different methods and both the 2,4- and 2,6-isomers generally have been found to be mutagenic. Neither has tested universally positive in all such tests, however.

For example, in the Ames Salmonella typhimurium test, both 2,4- and 2,6-TDA were negative in the absence of S-9 microsomal enzyme activation. In the presence of the microsomal enzymes, both isomers were positive in the TA-98, TA-1537, and TA-1538 tests, and the 2,4-isomer was also active m the TA-100 test.[24,25]

Both were reported by the authors as "marginally active" in the Chinese hamster ovary mammalian cell mutagenicity test.[26]

Both were also reported as having "produced dose responses and absolute increases" in viral transformation of primary hamster embryo cells *in vitro*.[27]

2,4-TDA was reported to cause unscheduled DNA synthesis in primary rat hepatocytes *in vitro*.[28]

In another series of studies, however, 2,4-TDA was found to be negative for mutagenicity in a "dominant lethal assay" (with DBA/2J mice), a "sperm morphology test" (also DBA/2J mice), and a "recessive spot test" (using two strains of mice).[29]

G. Metabolism/Pharmacokinetics

In one study of metabolism in rats, a radio-labeled, intraperitoneally injected dose of 2,4-TDA was followed for 120 hr. In the first 24 hr, 81% was excreted, (73% in urine, 8% in feces). Within 120 hr 98.6% was excreted (76.4% in urine, 22.2% in feces).[30]

Radio-labeled, intraperitoneally injected 2,4-TDA was excreted by mice mainly in the urine (50% in first hr, 52% in first 24 hr). An additional 22% of the material was excreted in the feces within 24 hr. Most of the residual metabolites were in the liver and kidneys, with lesser amounts in several other organs. The specific metabolites were not described.[31]

In yet another study, radio-labeled 2,4-TDA was intraperitoneally injected at 3 mg/kg or given orally at either 3 mg/kg or 60 mg/kg. Again, it was found to be excreted, mainly in the urine (62%–74% in 48 hr). An additional 20%–30% of the material was excreted in the feces within 48 hours. Between 2%–5% remained in the animals after 48 hr, with the higher number associated with the larger dose. The TDA was found to be transformed into its mono- or diacetylated derivatives or else into acid-labile conjugates.[32]

In another test, pretreatment with several doses of TDA prior to administration of the radio-labeled TDA resulted in markedly different distribution of residuals within the animals. The residuals were more widely distributed in the bodies of the pretreated animals.[33]

V. HUMAN USE AND EXPERIENCE

A study for dermal sensitization in humans failed to elicit sensitization in any of 31 subjects.[34]

Dermal contact with TDA has been reported to cause persistent yellow stains.[4]

A NIOSH Health Hazard Evaluation performed at one manufacturing plant reported a decrease in sperm counts for exposed employees that, though not definitely linked to exposure, was "strongly suggestive" of an association in the opinion of the authors.[35] Subsequent studies at several manufacturing facilities using more carefully designed protocols found no association between fertility or sperm count and exposure.[36]

Exposure data reported to the U.S. Environmental Protection Agency under a call for data issued under Section 8 of the Toxic Substances Control Act indicates TDA exposures in manufacturing are generally less than 0.05 ppm.[37]

VI. RATIONALE

Because 2,4-toluene diamine was found to be carcinogenic in the NTP bioassay at very low doses (equivalent to as low as 4 mg/kg/day), and is the predominant compound in occupational settings, this hazard drives the setting of an exposure limit. Extrapolation of this lowest level to the occupational setting would indicate that an average exposure of about 25 mg/m^3 would result in a similar dose to workers. None of the toxicological data is sufficient to indicate whether exposure to TDA by the respiratory route would result in a risk different from the oral route used in the animal testing.

The toxicology tests indicate that 2,4-TDA is mutagenic and carcinogenic. Indeed, the NTP study found a

substantial degree of tumor incidence at the lowest dose used. Data from the NTP bioassay is insufficient to make a reasonable quantitative risk assessment that can be extrapolated to occupational exposure.

Dermal absorption tests indicate that, while TDA is not rapidly absorbed through the skin, it is absorbed through the skin in sufficient quantity to warrant consideration of this route in preventing low-level doses in the workplace. Thus, exposures to TDA by all routes should be maintained at the lowest level practical.

VII. RECOMMENDED OEL

8-hr time-weighted average (TWA): 0.005 ppm (0.025 mg/m^3), skin.

VIII. REFERENCES

1. **Lide, D.R. (ed.):** *CRC Handbook of Chemistry and Physics*, 71st edition. Boca Raton, FL: CRC Press, Inc., 1990.
2. **National Institute for Occupational Safety and Health:** *Current Intelligence Bulletin Number 53, Toluene Diisocyanate (TDI) and Toluene Diamine (TDA): Evidence of Carcinogenicity* (DHEW [NIOSH] Pub. No. 90-101). Washington, D.C.: U.S. Government Printing Office, 1979.
3. **Sax, N.I. and R.J. Lewis, Sr.:** *Dangerous Properties of Industrial Materials*, 7th Ed., Vol. III. New York: Van Nostrand Reinhold Co., 1989.
4. **Olin Corporation:** *Material Safety Data Sheet — Toluene Diamine*, New Haven, Conn.: Olin Corp./Environmental Hygiene and Toxicology Department, September 1976; October 1997. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
5. **Clayton, G.D. and RE. Clayton (eds.):** *Patty's Industrial Hygiene and Toxicology*, 4th edition. New York: John Wiley & Sons, Inc., 1994.
6. **National Cancer Institute:** *NCI Carcinogenesis Technical Report Series No. 162: Bioassay of'2,4-Toluenediamine for Possible Carcinogenicity* (DHEW [NCI] Pub. No. 79-1718). Bethesda, MD: National Cancer Institute, 1979.
7. **International Agency for Research on Cancer:** *I ARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man: Some Aromatic Amines and Related Nitro Compounds — Hair Dyes, Colouring Agents, and Miscellaneous Industrial Chemicals*, Vol. 16. Geneva, Switzerland: International Agency for Research on Cancer, 1978.
8. **Wazeter, F.X., J.G. Keller, and R.G. Buller:** 'Toxicity Tests for Interstate Commerce Commission Labeling Requirements; Olin 53389 Tolylene Diamine, Stripped." July 1963. [Unpublished data.] Olin Corp./Environmental Hygiene and Toxicology Department, 91 Shelton Ave, P,O. Box 30-9643, New Haven, CT 06511. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
9. **Palanker, A.L.:** "Acute Inhalation in Rats, Acute Oral LD_{50} in Rats, Eye Irritation in Rabbits, Dermal Irritation in Rabbits, and Acute Dermal Toxicity in Rabbits." January 1975. [Unpublished data; performed by Biometric Testing Inc.] Olin Corp./ Environmental Hygiene and Toxicology Department, 91 Shelton Ave, P.O. Box 30-9643, New Haven, CT 06511. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call].
10. **Dow Chemical Company:** "Acute Toxicological Properties and Industrial Handling Hazards of Toluene Diamine (TDA; Approximately 80/20 mixture of 2,4- and 2,6- isomers)." May 1975. [Unpublished data.] Dow Chemical/Biomedical Research Division, Midland, Mich. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call]
11. **Knickerbocker, M. and J.G. Babish:** "The Acute Oral LD_{50} of Ortho-Toluene Diamine in Female Rabbits." October 1978. [Unpublished data; performed by Food and Drug Research Laboratories Inc.] New Haven, CT: Olin Corp./ Environmental Hygiene and Toxicology Department].
12. **Allied Chemical Company:** "Toxicity Tests on Meta Phenylene Diamine, Distilled Flakes." May 1961. [Unpublished data; performed by National Aniline Division.] Allied Chemical/Allied Signal Inc./Department of Toxicology, P.O. Box 1139, Mornstown, NJ 07962-1139. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
13. **Nycum, J.S. and C.P. Carpenter:** "Ortho Tolyene Diamine Range Finding Toxicity Studies." April 1961. [Unpublished data; performed by Mellon Institute.] Union Carbide Corp., Danbury, Conn. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call]
14. **Marzulli, F.N., D.M. Anjo, and H.L Maibach:** *In Vivo* Skin Penetration Studies of 2,4-Toluene Diamine, 2,4-Diaminoamsole, 2-Nitro-p-phenylenediamine, p-Dioxane, and N- Nitrosodi-ethanolamine in Cosmetics. *Food Cosmet, Toxicol 79*:743–747 (1981).
15. **Allied Chemical Company:** "Memorandum Project # MA12-77: Guinea Pig Hypersensitization Test." September 18, 1978. [Memo.] Morristown, N.J. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
16. **Eastman Kodak:** "Toxicity and Health Hazard Summary," November 1975. [Unpublished data.] Eastman Kodak. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]

17. **Hackathorn, D.R. (Mobay Chemical Co.):** Letter to J. Jacoby, Ethyl Corporation. November 14, 1984. [Personal communication to the AIHA WEEL Committee in response to information request.]
18. **National Cancer Institute:** *NCI Carcinogenesis Technical Report Series No. 200: Bioassay of 2,6-Toluenediamine D(hydrochloride for Possible Carcinogenicity* (DHEW [NCI] Pub. No. 80-1756). Bethesda, MD: National Cancer Institute, 1980.
19. **Umeda, M.:** Production of Rat Sarcoma by Injections of Propylene Glycol Solutions of m-Toluenediamme. *GANN46*: (1955).
20. **Ito, N., et al.:** The Development of Cancer in Liver of Rats Treated with M-Toluenediamine and the Synergistic and Antagonistic Effects with Other Chemicals. *Cancer Res. 29*:1137–1145 (1969).
21. **Giles, A.L., Jr., C.W. Chung, and C. Kommineni:** Dermal Carcinogenicity Study by Mouse-Skin Painting with 2,4-Toluenediamine Alone or in Representative Hair Dye Formulations. *J. Toxicol Environ. Health 7*:433–440 (1976).
22. **Knickerbocker, M. and T.A Re:** "Teratologic Evaluation of Ortho-Toluene Diamine in Dutch Belted Rabbits." May 1979. [Unpublished data; performed by Food and Drug Research Laboratories Inc.] Olin Corp./Environmental Hygiene and Toxicology Department, 91 SheltonAve, P.O. Box 30-9643, New Haven, CT 06511. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
23. **Knickerbocker, M. and T.A. Re:** "Teratologic Evaluation of Ortho-Toluene Diamine in Sprague-Dawley Rats." April 1979. [Unpublished data; performed by Food and Drug Research Laboratories Inc.] Olin Corp./Environmental Hygiene and Toxicology Department, 91 SheltonAve, P.O. Box 30-9643, New Haven, CT 06511. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
24. **Newell, G.W. and W.A. Skinner:** "*In Vitro* Microbiological Mutagenicity Studies of Olin Corporation Compound Meta-Free-Ortho-Toluene Diamine." March 1978. [Unpublished data; performed by SRI International.] Olin Corp./ Environmental Hygiene and Toxicology Department, 91 SheltonAve, P.O. Box 30-9643, New Haven, CT 06511. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
25. **Greene, E.J., J.A. Sherrod, and M.A. Friedman:** "Bacterial Mutagenicity of Four Toluene Diamine Isomers." May 1979. [Unpublished Allied Chemical Report No. MA-12-77-12.] Allied Chemical/Allied Signal Inc./Department of Toxicology, P.O. Box 1139, Morristown, NJ 07962-1139. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
26. **Greene, E.J. and M.A. Friedman:** "Short-Term Mutagenicity and Cell Transformation Screening of Toluene Diamine: II. Mammalian Cell Mutagenicity of Four Toluene Diamine Isomers." May 1979. [Unpublished Allied Chemical Report No. MA-12-77-13.] Allied Chemical/Allied Signal Inc./Department of Toxicology, P.O. Box 1139, Morristown, NJ 07962-1139. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
27. **Greene, E.J. and M.A. Friedman:** "Enhancement of Viral Transformation of Primary Hamster Embryo Cells By Four TDA Isomers." May 1979. [Unpublished Allied Chemical Report No. MA-12-77-14.] Allied Chemical/Allied Signal Inc./ Department of Toxicology, P.O. Box 1139, Morristown, NJ 07962-1139. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
28. **Bermudez, E., D. Tillery, and B.E. Butterworth:** The Effect of 2,4-Diaminotoluene and Isomers of Dinitrotoluene on Unscheduled DNA Synthesis in Primary Rat Hepatocytes. *Environ. Mutagenesis 7*:391–398 (1979).
29. **Soares, E.R. and L.F. Lock:** Lack of an Indication of Mutagenic Effects of Dinitrotoluenes and Diaminotoluenes in Mice. *Environ. Mutagenesis 2*:111–124(1980).
30. **Grantham, P.H., et. al.:** Metabolism of 2,4-Toluenediamine in the Rat. *Toxicol. Appl. Pharmacol. 33*:179 (1975). [Abstract.]
31. **Unger, P.D., et al.:** "Tissue Distribution and Excretion of 2,4-Toluenediamine ^{14}C in the Mouse." December 1978. [Unpublished Allied Chemical Report No. MA-12-77-10.] Allied Chemical/Allied Signal Inc./Department of Toxicology, P.O. Box 1139, Morristown, NJ 07962-1139. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
32. **Timchalk, C., F.A. Smith, and M.J. Bartels:** Route-Dependent Comparative Metabolism of [^{14}C] Toluene 2,4-Diisocyanate and [^{14}C] Toluene 2,4-Diamine in Fisher 344 Rats. *Toxicol. Appl. Pharmacol. 724*:181–190 (1994).
33. **Unger, P.D., M.A. Friedman, and A.J. Salerno:** "Effect of Subchronic Pretreatment With 2,4- and 2,6-Toluenediamine on the Distribution and Excretion of 2,4-Toluenediamine-^{14}C in the Mouse." April 1979. [Unpublished Allied Chemical Report No. MA-12-77-11.] Allied Chemical/Allied Signal Inc./Department of Toxicology, P.O. Box 1139, Morristown, NJ 07962-1139. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]
34. **Epstein, W.L., and M.K. Taylor:** Experimental Sensitization to Phenylene Diamine and Paratoluenediamine in Man. *Acta. Dermatover. Suppl. 59*:55–57 (1979).

35. **National Institute for Occupational Safety and Health (NIOSH):** Health Hazard Evaluation (Report No. 79-113-728). Brandenburg, Ky.: Olin Chemical Co., August 1980.
36. **Peter, V.V., et al.:** The Epidemiologic Assessment of Male Reproductive Hazard from Occupational Exposure to TDA and DNT. *J. Occup. Med. 24*:985–993 (1992).
37. **Olin Corporation:** "Industrial Hygiene Monitoring Results." June 1983. [Unpublished data.] Olin Corp./Environmental Hygiene and Toxicology Department, 91 Shelton Ave, P.O. Box 30-9643, New Haven, CT 06511. [Submitted to U.S. EPA/OTS in response to TSCA Section 8(d) data call.]

Note: The following databases were searched for this 2010 WEEL™ revision:

MEDLINE (1998–2008)
IPA (1970–2008)
CURRENT CONTENTS (1990–2008)
CAB (Global Health) (1990–2008
CINAHL (1982–2008)
TOXNET (2006–2010)