
Product Safety Assessment

Toluene Diisocyanate

Product Safety Assessment documents are available at: www.dow.com/productsafety/finder/.

Select a Topic:

[Names](#)
[Product Overview](#)
[Manufacture of Product](#)
[Product Description](#)
[Product Uses](#)
[Exposure Potential](#)
[Health Information](#)
[Environmental Information](#)
[Physical Hazard Information](#)
[Regulatory Information](#)
[Additional Information](#)
[References](#)

Names

- CAS No. 26471-62-5 Mixed isomers
- CAS No. 91-08-7 2,6-TDI
- CAS No. 584-84-9 2,4-TDI
- Toluene diisocyanate
- TDI
- 2,4-Toluene diisocyanate
- 2,6-Toluene diisocyanate
- 1,3-Diisocyanatomethyl-benzene
- 2,4-Diisocyanatomethyl-benzene
- VORANATE™ T-80 TDI

[Back to top](#)

Product Overview

- Toluene diisocyanate (TDI) is a reactive chemical. TDI's isocyanate groups ($-N=C=O$) can be reacted with polymers that have alcohol ($-OH$) groups to make polyurethanes.¹ For further details, see [Product Description](#).
- TDI-based products are commonly used in automotive seating, furniture foam applications, mattress cushioning, and specialty foam applications.² For further details, see [Product Uses](#).
- TDI is typically produced in closed systems with stringent process controls, which reduce the potential of workplace exposure. Consumers may be exposed to TDI via "do-it-yourself" applications in the United States (U.S.). For further details, see [Exposure Potential](#).
- All diisocyanates are very reactive chemicals that are potentially hazardous to humans. The inhalation of diisocyanate vapors and aerosol mists represents the primary hazard in the use of diisocyanates; therefore, they must be handled carefully and with procedures designed to minimize exposure.³ Although large quantities of diisocyanates are used without adverse health effects, some cases of bronchial hyper-reactivity have occurred. For further details, see [Exposure Potential and Health Information](#).
- TDI can be a skin and respiratory sensitizer. Even concentrations below exposure guidelines may cause allergic respiratory reactions in individuals already sensitized.⁴ Excessive vapor concentrations of TDI may cause serious adverse effects when inhaled, even death. TDI is listed as a potential carcinogen based on studies by the National Toxicology Program (NTP) and the International Agency for Research on Cancer (IARC). These findings were based on oral ingestion studies in laboratory animals. However, TDI did not cause cancer in laboratory animals exposed to TDI by inhalation. TDI shows little, if any, mutagenic activity and no adverse effects on reproduction.⁵ For further details, see [Health Information](#).

®™ Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow

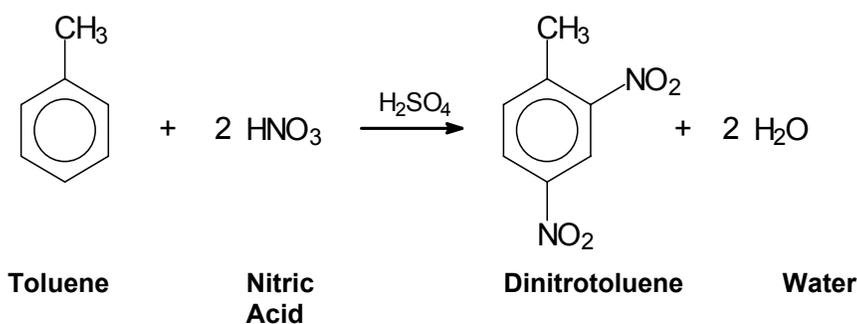
- In the aquatic and terrestrial environment, TDI reacts with water forming insoluble polyureas that are chemically and biologically inert. Studies show that bioconcentration (accumulation in the aquatic food chain) is unlikely. For further details, see [Environmental Information](#).
- FOR EMERGENCY RESPONSE INSIDE THE UNITED STATES: Call CHEMTREC (1-800-424-9300) for first response advice for handling TDI. CHEMTREC will make contact with the manufacturer.⁶
- TDI reacts with water to produce heat and carbon dioxide (CO₂) gas. For further details, see [Physical Hazard Information](#).

[Back to top](#)

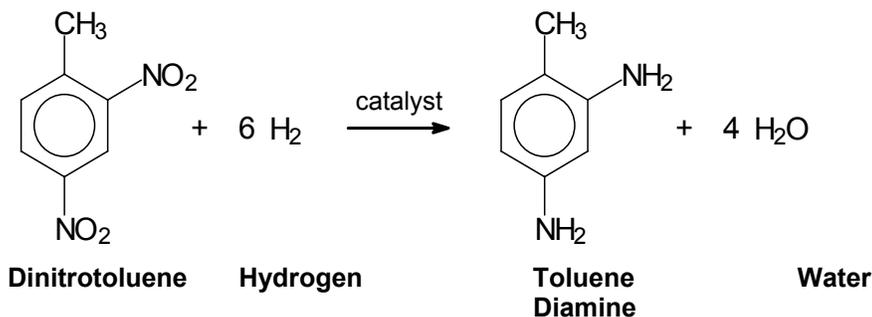
Manufacture of Product

- **Capacity**⁷ – In 2008, worldwide production capacity of TDI was 2,201 thousand metric tons (4.85 billion pounds). Dow's global capacity is reported as 160 thousand metric tons (352 million pounds) of TDI per year from the following locations: Freeport, Texas, in the U.S.; and Camacari, Brazil. However in 2010, Dow discontinued production of TDI in the U.S.
- **Process**⁸ – The current manufacturing technology for most isocyanates is based on the phosgenation of primary amines. The conventional phosgene-based process is outlined below:

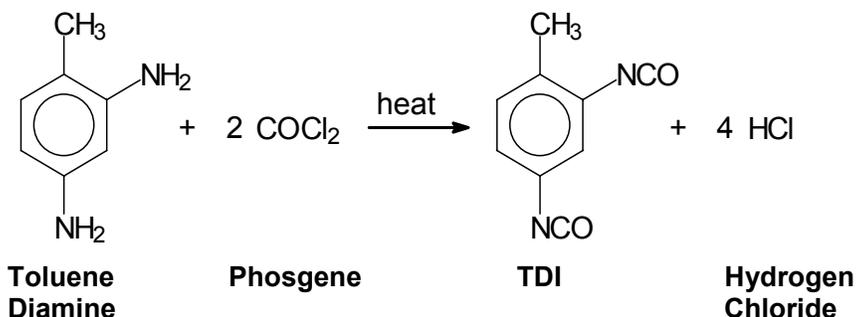
Synthesis of TDI begins with the nitration of toluene using a nitric acid-sulfuric acid mixture. Note: The reaction is shown for the 2,4-isomer only.



The nitration product is reduced catalytically.



The diamine isomer mixture is dissolved in monochlorobenzene or ortho-dichlorobenzene and is reacted with phosgene to produce toluene diisocyanate.



[Back to top](#)

Product Description

Toluene diisocyanate (TDI) is a colorless to pale yellow liquid with a pungent odor. TDI can have different forms or isomers. TDI isomers have the same chemical formula C₉H₆N₂O₂, but the atoms are arranged differently. So, the term "TDI" represents the isomeric compounds along with mixtures of these isomers. The two commonly used isomers of toluene diisocyanate are 2,4-TDI and 2,6-TDI. Mixtures of 80% 2,4-TDI and 20% 2,6-TDI are the most commonly used in industry, although TDI is commercially available in the following forms:

- 100% 2,4-TDI
- 80% 2,4-TDI, 20% 2,6-TDI
- 65% 2,4-TDI, 35% 2,6-TDI

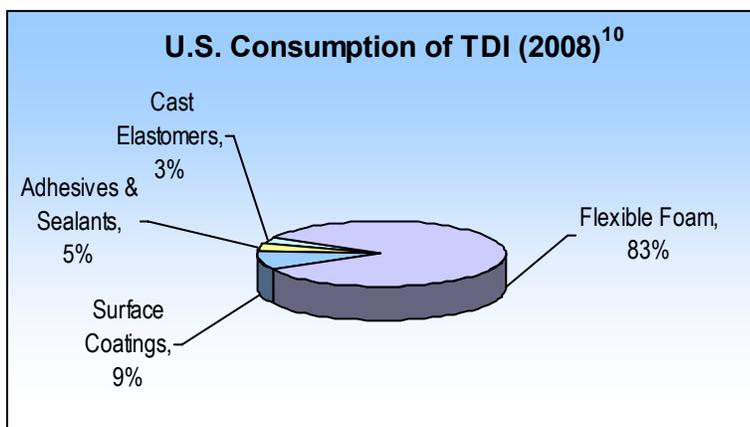
Dow currently sells VORANATE™ T-80, which is an 80/20 mixture of the 2,4- and 2,6-isomers, respectively.

[Back to top](#)

Product Uses⁹

Toluene diisocyanate is commonly used to manufacture:

- **Flexible foam:** Flexible polyurethane foams constitute the largest market for TDI products. The largest end-use markets for TDI-based flexible foams are transportation, carpet underlay and furniture
- **Rigid foam:** Most rigid foam applications use polymeric MDI as the isocyanate component. In the past, only small amounts of TDI were consumed in pour-in-place applications, primarily for appliances, but smaller amounts for construction, packaging and transportation segments. Only minor quantities continue to be used in small-volume rigid foam applications such as surfboards.
- **Adhesives, sealants, surface coatings and elastomers:** TDI is used predominantly for sealants in construction applications. TDI is used principally in urethane alkyds, reactive two-component systems and moisture-curing prepolymer products (mainly for construction coatings). In the past, TDI was used in small amounts in three types of elastomers – reaction-injection molding (RIM), cast and thermoplastic (TPU). Currently, TDI is only used for cast elastomers.



[Back to top](#)

⁹™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow

Exposure Potential

TDI is used in the production of industrial and consumer products. Based on the uses for TDI, the public could be exposed through:

- **Workplace exposure** – Exposure can occur either in a TDI manufacturing facility or in the various industrial or manufacturing facilities that use TDI. TDI is produced, distributed, stored and consumed in closed systems with stringent process controls. Those working with TDI in manufacturing operations could be exposed during maintenance, sampling, testing or other procedures. Each manufacturing facility should have a thorough training program for employees, appropriate work processes and safety equipment in place for employees to limit TDI exposure. Because of the potential hazards posed by TDI vapors, exposure limits have been established regarding allowable TDI vapor concentrations in the work environment. Workers should be examined for pulmonary function with particular emphasis on allergic history including asthma or other diseases. Employment in an isocyanate area may present a health risk to individuals with a history of respiratory problems or allergies.¹⁰ See [Health Information](#).
- **Consumer exposure to products containing TDI** – Dow does not sell TDI for direct consumer use, but TDI is used as a raw material to make polyurethane coating materials. There may be the potential for consumer TDI exposure to some consumer products via “do-it-yourself” applications in the United States, primarily with adhesives and glues. Both inhalation and dermal exposures are possible, although concentrations in these instances are difficult to quantify. The opportunity for exposures to TDI would be relatively short due to its reactivity with moisture. Because of the risk of irritation and sensitization, the use of protective gloves, as recommended on product labels, will limit potential dermal exposures. Due to the risk of allergic respiratory reactions, the use of respiratory protection as suggested in the [Safety Data Sheet \(SDS\)](#) will limit potential inhalation exposure. See [Health Information](#) and the relevant [SDS](#) for more information about protective equipment.
- **Environmental releases**¹¹ – All spills and leaks should be immediately contained to prevent contamination of soil, surface or ground water. The area should be ventilated; open all doors and windows. To avoid inhaling vapors of TDI or the decontamination byproducts, workers should wear approved, positive-pressure self-contained breathing apparatus (SCBA). For small spills, TDI should be absorbed with materials such as: sawdust, vermiculite, dirt, sand or clay absorbents. Shovel the absorbent into an open container and cover, but do not seal. Attempt to neutralize the absorbed mixture with a suitable decontaminant solution and then add more absorbent material. Consult the [VORANATE™ T-80 Toluene Diisocyanates Safe Handling & Storage Guide](#) and relevant [Safety Data Sheet](#) for more information about protective equipment and procedures. See [Environmental](#), [Health](#) and [Physical Hazard Information](#).
- **Large release**¹² – Industrial spills or releases are infrequent and are generally contained. In the event of a large spill, local emergency response services should be contacted immediately, and a state of emergency should be declared for the affected area. Contingency arrangements should be discussed with local emergency response services, such as police and fire units, in advance of actual emergency situations. A written emergency plan for large spill control should be in place with periodic drill practices scheduled before actual emergency situations occur. A positive-pressure, self-contained breathing apparatus (SCBA) with a full-face mask approved by NIOSH is recommended for emergency work. Follow emergency plan guidelines and procedures carefully.
- **FOR EMERGENCY RESPONSE INSIDE THE UNITED STATES:** Call CHEMTREC (1-800-424-9300) for first response advice for handling TDI. CHEMTREC will make contact with the manufacturer.¹³ The material should be neutralized, captured, collected and re-processed, or disposed of according to applicable governmental requirements. Consult the [VORANATE T-80 Toluene Diisocyanates Safe Handling & Storage Guide](#) and relevant [Safety Data Sheet](#) for more information. See [Environmental](#), [Health](#) and [Physical Hazard Information](#).

[®]™ Trademark of The Dow Chemical Company (“Dow”) or an affiliated company of Dow

For more information, request the relevant Safety Data Sheet from the [Dow Customer Information Group](#).

[Back to top](#)

Health Information^{14,15}

Eye Contact: TDI may cause severe eye irritation and moderate corneal injury. Vapor may cause eye irritation experienced as mild discomfort and redness.

Skin Contact: Prolonged contact with TDI may cause severe skin irritation with local redness and discomfort. Skin contact may cause an allergic skin reaction. Animal studies have shown that skin contact with isocyanates may play a role in respiratory sensitization.

Inhalation: Easily attainable vapor concentrations may cause serious adverse effects, even death. Excessive exposure to TDI may cause severe irritation of the upper respiratory tract and lungs, fluid in the lungs, permanent decrease of lung function, neurological disorders, cholinesterase depression and gastrointestinal distress.

Respiratory Sensitization: TDI may cause allergic respiratory response. Re-exposure to extremely low isocyanate concentrations may cause allergic respiratory reactions in individuals already sensitized. Asthma-like symptoms may include coughing, difficult breathing and a feeling of tightness in the chest. Occasionally, breathing difficulties may be life threatening. Effects may be delayed.

Ingestion: TDI has low toxicity if swallowed. Small amounts swallowed incidentally as a result of normal handling operations are not likely to cause injury; however, swallowing larger amounts may cause injury. Swallowing may result in gastrointestinal irritation or ulceration. Good personal hygiene must be followed and hands washed before eating. Food should not be consumed or stored in the work area.

Other: An oral study in which high doses of TDI were reported to cause cancer in animals has been found to contain numerous deficiencies which compromise the validity of the study. TDI did not cause cancer in laboratory animals exposed by inhalation, the most likely route of exposure. TDI did not cause birth defects in laboratory animals. Slight effects were observed in the fetus but only at doses which caused toxic effects to the mother.

For more information, request the relevant Safety Data Sheet from the [Dow Customer Information Group](#).

[Back to top](#)

Environmental Information¹⁶

When an isocyanate group reacts with water, it forms an amine, which itself reacts even faster with another isocyanate group to yield a urea. TDI reacts with water to form stable, insoluble polyureas, which are inert solids. So the reactivity of TDI with water dramatically limits its mobility in the event of a spill.

Because TDI reacts with water to form solids, biodegradation studies for TDI relate to the inert polyureas. These polyureas have not been found to be inherently biodegradable and they have not been found to bioaccumulate. Upon exposure to the environment (with and in water), unreacted TDI is practically unavailable. Nonetheless, TDI has been tested in a number of aquatic species with overall findings showing low to moderate toxicity.

Because released amounts of TDI are low, and exposure is further limited by the reactivity of TDI in water which severely limits its availability and environmental transfer in anticipated conditions, even accidental spills are localized and have only transient impact. Thus, the Organization for Economic Cooperation and Development (OECD) concluded that TDI does not present a significant risk to the environment.

However, TDI should be prevented from entering into soil, ditches, sewers, waterways and/or groundwater because of its reactivity with water. Spilled material should be contained if possible.

For more information, request the relevant Safety Data Sheet from the [Dow Customer Information Group](#).

[Back to top](#)

Physical Hazard Information¹⁷

TDI is stable under recommended storage conditions. However, it can decompose at elevated temperatures. Gas generated during decomposition can cause pressure in closed systems. Pressure build-up can be rapid.

During a fire, smoke may contain TDI in addition to unidentified toxic and/or irritating compounds. Hazardous combustion products may include, but are not limited to: nitrogen oxides, isocyanates, carbon monoxide, carbon dioxide and hydrogen cyanide.

TDI can react violently with moisture, releasing carbon dioxide gas. The resulting pressure buildup can cause closed containers to rupture. Elevated temperatures can accelerate this reaction.

Hazardous polymerization of TDI can occur. Polymerization can be catalyzed by strong bases and water.¹⁸

Spills of TDI should be absorbed with material such as: vermiculite, dirt, sand, or clay. The absorbent mixture should be neutralized with a suitable decontaminant solution. Do not place in sealed containers because pressure could build up as TDI reacts with any moisture that is present. Wash the spill site with large quantities of water. Contact CHEMTREC (1-800-424-9300) for first response advice and cleanup assistance.¹⁹

Additional information on TDI physical hazards, reactivity and stability and accidental release measures such as TDI spill clean up guidance is available Safety Data Sheet that can be requested from the [Dow Customer Information Group](#).

[Back to top](#)

Regulatory Information

Regulations may exist that govern the manufacture, sale, transportation, use and/or disposal of TDI. These regulations may vary by city, state, country or geographic region. Information may be found by consulting the relevant [Safety Data Sheet](#) or [Contact Us](#).

[Back to top](#)

Additional Information

- Safety Data Sheet (request from the Dow Customer Information Group: www.dow.com/assistance/dowcig.htm)
- Contact Us (www.dow.com/polyurethane/contact/index.htm)
- Draft Organization for Economic Cooperation and Development (OECD) Screening Information Data Set (SIDS) Initial Assessment Report for SIAM, June 15, 2004
- Chinn, Henry, *et al.*, Marketing Research Report: "Diisocyanates and Polyisocyanates," *Chemical Economics Handbook*, SRI Consulting, March 2009
- *MDI & TDI: Safety, Health and the Environment*, book written by Dennis Allport, David Gilbert, and Susan Outterside, published by John Wiley & Sons, Copyright 2003
- *Safe Handling of Toluene Diisocyanate (TDI)*, Produced by PRIMEDIA Workplace Learning, Inc., Copyright 1999

- VORANATE™ T-80 TDI Products, The Dow Chemical Company, Form No. 109-01444-303 EC, January 2003, (www.dow.com/PublishedLiterature/dh_0047/0901b80380047009.pdf?filepath=/polyurethane/pdfs/noreg/109-01444.pdf&fromPage=GetDoc)
- VORANATE T-80 Toluene Diisocyanates Safe Handling & Storage Guide, The Dow Chemical Company, Form No. 109-01243X-0704, July 2004 (www.dow.com/PublishedLiterature/dh_0542/0901b80380542017.pdf?filepath=/polyurethane/pdfs/noreg/109-01243.pdf&fromPage=GetDoc)

For more business information about TDI, visit the Dow [Polyurethanes web site](http://www.dow.com/polyurethane/) at www.dow.com/polyurethane/.

[Back to top](#)

References

- ¹ Chinn, Henry, *et al.*, Marketing Research Report: “Diisocyanates and Polyisocyanates,” *Chemical Economics Handbook*, SRI Consulting, March 2009, page 12.
- ² VORANATE™ T-80 TDI Products, The Dow Chemical Company, Form No. 109-01444-303 EC, January 2003, page 1.
- ³ Chinn, Henry, *et al.*, Marketing Research Report: “Diisocyanates and Polyisocyanates,” *Chemical Economics Handbook*, SRI Consulting, March 2009, page 18.
- ⁴ VORANATE T-80 Toluene Diisocyanates Safe Handling & Storage Guide, The Dow Chemical Company, Form No. 109-01243X-0704, page 14.
- ⁵ Chinn, Henry, *et al.*, Marketing Research Report: “Diisocyanates and Polyisocyanates,” *Chemical Economics Handbook*, SRI Consulting, March 2009, pages 18–19.
- ⁶ Video, *Safe Handling of Toluene Diisocyanate (TDI)*, PRIMEDIA Workplace Learning, Inc., 1999.
- ⁷ Chinn, Henry, *et al.*, Marketing Research Report: “Diisocyanates and Polyisocyanates,” *Chemical Economics Handbook*, SRI Consulting, March 2009, pages 6 and 10.
- ⁸ Chinn, Henry, *et al.*, Marketing Research Report: “Diisocyanates and Polyisocyanates,” *Chemical Economics Handbook*, SRI Consulting, March 2009, pages 13–14.
- ⁹ Chinn, Henry, *et al.*, Marketing Research Report: “Diisocyanates and Polyisocyanates,” *Chemical Economics Handbook*, SRI Consulting, March 2009, pages 27–32.
- ¹⁰ VORANATE T-80 Toluene Diisocyanates Safe Handling & Storage Guide, The Dow Chemical Company, Form No. 109-01243X-0704, page 12.
- ¹¹ VORANATE T-80 Toluene Diisocyanates Safe Handling & Storage Guide, The Dow Chemical Company, Form No. 109-01243X-0704, page 10.
- ¹² VORANATE T-80 Toluene Diisocyanates Safe Handling & Storage Guide, The Dow Chemical Company, Form No. 109-01243X-0704, page 10.
- ¹³ Video, *Safe Handling of Toluene Diisocyanate (TDI)*, PRIMEDIA Workplace Learning, Inc., 1999.
- ¹⁴ VORANATE T-80 Type I TDI Material Safety Data Sheet, The Dow Chemical Company, August 17, 2010, Potential Health Affects and Exposure Control Sections.
- ¹⁵ Draft OECD SIDS Initial Assessment Report for SIAM, June 15, 2004, pages 10–17.
- ¹⁶ VORANATE T-80 Toluene Diisocyanates Safe Handling & Storage Guide, The Dow Chemical Company, Form No. 109-01243X-0704, page 11.
- ¹⁷ VORANATE T-80 Type I TDI Material Safety Data Sheet, The Dow Chemical Company, August 17, 2010, Fire Fighting Measures Section.

®™ Trademark of The Dow Chemical Company (“Dow”) or an affiliated company of Dow

¹⁸ VORANATE™ T-80 Type I TDI Material Safety Data Sheet, The Dow Chemical Company, August 17, 2010, Stability and Reactivity Section.

¹⁹ VORANATE T-80 Type I TDI Material Safety Data Sheet, The Dow Chemical Company, August 17, 2010, Accidental Release Measures Section.

[Back to top](#)

NOTICES:

As part of its 2015 Sustainability Goals, Dow has committed to make publicly available safety assessments for its products globally. This product safety assessment is intended to give general information about the chemical (or categories of chemicals) addressed. It is not intended to provide an in-depth discussion of health and safety information. Additional information is available through the relevant Safety Data Sheet, which should be consulted before use of the chemical. This product safety assessment does not replace required communication documents such as the Safety Data Sheet.

The information herein is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will Dow be responsible for damages of any nature whatsoever resulting from the use of or reliance upon the information herein or the product to which that information refers.

Nothing contained herein is to be construed as a recommendation to use any product, process, equipment or formulation in conflict with any patent, and Dow makes no representation or warranty, express or implied, that the use thereof will not infringe any patent.

NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OR THE PRODUCT TO WHICH INFORMATION REFERS.

Dow makes no commitment to update or correct any information that appears on the Internet or on its World-Wide Web server. The information contained in this document is supplemental to the Internet Disclaimer, www.dow.com/homepage/term.asp.

[Back to top](#)

Form No. 233-00286-MM-1110



®™ Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow
