THE MASSACHUSETTS TOXICS USE REDUCTION INSTITUTE

Massachusetts Chemical Fact Sheet

Dimethylformamide

A potential carcinogen, dimethylformamide (DMF) has come under increasing regulatory scrutiny in the past 10 years. The U.S. Environmental Protection Agency (EPA) added dimethylformamide to its Emergency Planning and Community Right-to-Know list of toxic chemicals in 1995. Manufacturers use dimethylformamide as a solvent in a variety of applications, including the production of electronic components, pharmaceutical products, textile coatings, and urethanes. In Massachusetts, dimethylformamide use declined slightly — by 6% — between 1995 and 1997.

FACTS

Chemical formula:	C_3H_7NO
CAS Number:	68-12-2
Vapor Pressure:	3.7 mm Hg at 20°C
Flash Point:	136°F (57.7°C)
Water Solubility:	Miscible
Description:	Colorless liquid with an unpleasant, fishy odor

Hazards

Acute (Short-Term) Health Effects

- The primary organ affected by acute exposure to dimethylformamide is the liver. Inhalation may also damage the kidneys, cause stomach pain, nausea, and vomiting, or irritate the nose and throat.

- Dermatitis and irritation of the eyes may result from acute contact with dimethylformamide.

- Exposure to concentrations of dimethylformamide at 500 parts per million (ppm) is immediately dangerous to life and health.

Chronic (Long-Term) Health Effects

- Dimethylformamide may be a carcinogen. Human studies have identified increased rates of testicular cancer in humans exposed to dimethylformamide.

The International Agency for Research on Cancer (IARC) classifies dimethylformamide as a Group 2B carcinogen; it is possibly carcinogenic to humans.

- Dimethylformamide may be a teratogen (reproductive hazard). Animal studies have documented teratogenic effects, including decreased fetal weight and increased spontaneous abortions. A human study of individuals exposed to multiple chemicals suggests that dimethylformamide may increase the rate of spontaneous abortions.

- Chronic exposure to dimethylformamide may also result in liver damage or digestive problems.

Exposure Routes

Worker Health

- Facilities using dimethylformamide must minimize worker exposure and take precautions to avoid fires.

- Use dimethylformamide in closed systems. If a closed production system is infeasible, facilities need to enclose operations and use local exhaust ventilation. Where the potential for exposures to dimethylformamide exceed 10 ppm use a Mine Safety and Health Administration/National Institute for Occupational Safety and Health-approved supplied-air respirator with a full facepiece.

- Take precautions to avoid dimethylformamide contact with skin and eyes. Workers need to wear solvent-resistant gloves and clothing. If dimethylformamide contacts skin, immediately wash the exposed area.

- Dimethylformamide is a combustible liquid — it is flammable when exposed to heat or flame. Poisonous gases, including toxic fumes of nitrogen oxide, form during fires.

Public and Ecological Health

While the workplace is the most likely source of exposure to dimethylformamide, it has been found in wastewater and the ambient air.

- Dimethylformamide has been detected in wastewater effluent from sewage treatment and manufacturing plants.

- Dimethylformamide has been detected in the ambient air. For example, it was found at a concentration of 8 parts per billion in Lowell, Massachusetts.

(For section references, see endnote #1.)

Use Nationally and in Massachusetts

The primary suppliers of dimethylformamide are BASF, DuPont, and ICI. Only DuPont manufactures dimethylformamide in the U.S. American manufacturers use dimethylformamide as a solvent and consumed 32 million pounds of dimethylformamide in 1993. The primary end-users of dimethylformamide are manufacturers of pharmaceuticals (12 million pounds), electronic components (10 million pounds), butadiene (3 million pounds), and urethanes (3 million pounds). Miscellaneous uses include a resin clean-up solvent, reaction solvent, and processing solvent in the manufacture of polyimides, optical brightners, semi-permeable membranes, and pesticides.

Massachusetts facilities began reporting dimethylformamide use in 1995, after the U.S. EPA added it to the Emergency Planning and Community Right-to-Know Act (EPCRA) list of toxic chemicals.

- Massachusetts facilities consumed over 4 million pounds of dimethylformamide in 1997 (see Table 1). Chemical distributors accounted for over 50% of total reported dimethylformamide use in Massachusetts.

- Manufacturers of urethane-based textile coatings and laminates accounted for almost one-third of total Massachusetts dimethylformamide use (see Table 2).

Table 1. Dimethylformamide: Use and Output Data for Massachusetts, 1995 and 1997 (pounds)

Use Data -- MA TURA	1995	1997	Change	% Change
Manufactured or Processed	2,573,862	2,568,390	-5,472	-<1%
Otherwise Used	1,953,511	1,706,668	-246,843	-13%
Total TURA Inputs	4,527,373	4,275,058	-252,315	-6%
Output Data -- MA TURA	**1995**	**1997**	**Change**	**% Change**
Generated as Byproduct	1,820,826	1,732,039	-88,787	-5%
Shipped In or As Product	2,469,416	2,351,188	-118,228	-5%
Total TURA Outputs	4,290,242	4,083,227	-207,015	-5%
Releases & Transfers Data -- US EPA, TRI	**1995**	**1997**	**Change**	**% Change**
Environmental Releases	115,743	81,999	-33,744	-29%
Off-site Transfers	184,533	135,200	-49,333	-27%
Total TRI R&T	300,276	217,199	-83,077	-28%

Sources: MA TURA -- Massachusetts Toxics Use Reduction Act data, 1999; and US EPA, TRI -- US Environmental Protection Agency, Toxics Release Inventory data, 1999.

- Dimethylformamide use declined slightly, by 6%, between 1995 and 1997. The majority of dimethylformamide users — including those manufacturing electronics, photoactive/ photographic chemicals, membranes, printing plates, and textiles — cut use slightly between 1995 and 1997.

Table 1 includes two sources of "output" data: MA TURA and U.S. Environmental Protection Agency (EPA), Toxics Release Inventory (TRI) data. The MA TURA database includes all non-product material created by a process line prior to release, on-site treatment, or transfer ("byproduct") and the amount of toxic chemical incorporated into a product ("shipped in or as product"). The U.S. EPA, TRI database includes information on the waste materials generated by a facility after on-site treatment including: releases to air, land, and water ("environmental releases") and transfers off-site for treatment or disposal ("off-site transfers").

- Dimethylformamide outputs — as measured by MA TURA — mirrored the decline in use, declining by 5% between 1995 and 1997.

- TRI environmental releases and off-site transfers declined significantly, by 28% between 1995 and 1997.

- More than one-half of the reduction in on-site releases is due to one company, Polyclad Laminates, which reduced their releases using TUR techniques.

(For section references, see endnote #2.)

Table 2. Massachusetts Dimethylformamide Consumption by Use Categories (1995 and 1997)

Use Category [1]	Facility Name	Use (pounds) 1995	Use (pounds) 1997	Percent Change
Chemical Distribution	Ashland Chemical Company	502,000	1,089,594	117%
	Astro Chemicals Inc	394,790	309,500	-22%
	Monson Companies Inc	302,175	237,775	-21%
	Van Waters & Rogers	1,221,635	578,519	-53%
	subtotal	2,420,600	2,215,388	-8%
Electronic Components	Polyclad Laminates	311,392	297,600	-4%
	subtotal	311,392	297,600	-4%
Photoactive Chemicals	ChemDesign Corp	183,683	149,753	-18%
	Polaroid Corporation	14,161	18,645	32%
	subtotal	197,844	168,398	-15%
Membranes	Innovative Membrane Systems	14,996	0 [2]	-100%
	Ionics Incorporated	0	11,890	n/a[3]
	Koch Membrane Systems Inc	12,697	11,889	-6%
	Millipore Corporation	11,502	0	-100%
	subtotal	39,195	23,779	-39%
Printing	Anitec Printing Plates (2 facilities)	107,278	97,380	-9%
	subtotal	107,278	97,380	-9%
Textiles -- Coating / Laminating Polyurethanes	Bradford Industries	258,037	257,900	-<1%
	Duro Finishing Corp	26,478	33,789	28%
	Highland Industries [4]	269,858	356,386	32%
	Laminating Coating Technologies	249,370	213,191	-15%
	Majilite Mfg Inc	507,995	430,427	-15%
	subtotal	1,311,738	1,291,693	-2%
Urethanes	Stahl USA	112,302	140,177	25%
	subtotal	112,302	140,177	25%
Polymer Manufacture	Surface Coatings Inc	27,024	40,643	50%
	subtotal	27,024	40,643	50%
	Total	4,527,373	4,275,058	-6%

[1] Use Categories were assigned based on the Institute's examination of TURA data and in some cases may not represent the actual use; [2] "0" indicates either that the facility is not using the chemical or has dropped below the reportable threshold; [3] n/a = not applicable; [4] In 1995, Highland Industries reported under the name Mann Industries; Source: Massachusetts Toxics Use Reduction Act data, 1998.

Alternatives

Dimethylformamide is a powerful solvent with the ability to dissolve a variety of organic, inorganic and resin materials. It has been called the universal organic solvent and is especially effective when a low rate of evaporation is required. Owing to its unique qualities, the search for alternatives is not a simple task. Possible alternatives for its use in electronics manufacture, polyurethane coatings and general solvent applications are offered.

- In electronics applications, dimethylformamide (or mixtures containing dimethylformamide) have been used as solvents for epoxy resin catalysts used during the lamination of circuit boards. DMF was a replacement for ethylene glycol monomethyl ether when questions about its toxicity arose. Many companies are now using propylene glycol substitutes, which are thought to be less hazardous. Terpenes and ethyl lactate may also be substitutes for this use.

- DMF is used as a component of the carrier solvent for polyurethane coatings. Possible alternatives for this use include water-based and electron beam-cured coatings. However, based on information from the Massachusetts Office of Technical Assistance, one Massachusetts company that has investigated these alternatives for its particular use has found them to be lacking in quality. Additional application-specific research may be necessary for these alternatives to replace DMF.

- Solvents with different hazard and toxicity characteristics than DMF (e.g., dimethylacetamide or flammable solvents) may be alternatives for general solvent applications. For each use the technical, environmental, safety and cost performance of the alternative must be evaluated and compared to DMF.

- Where alternatives are not available, closed loop recovery may be an appropriate toxics use reduction technique for some DMF applications. In 1991, DuPont of Waynesboro, Virginia installed a wet scrubber and distillation unit to recover DMF used in the manufacture of synthetic fibers. This recovery process reduced their purchase of virgin solvent by 3 million pounds per year, and reduced air emissions by 70%.

(For section references, see endnote #3.)

Regulatory Context

Both the U.S. Occupational Safety and Health Administration (OSHA) and EPA regulate dimethylformamide, a hazard to human and environmental health.

- The OSHA permissible exposure limit (PEL) for an eight-hour workshift for dimethylformamide is 10 parts per million (ppm).

The U.S. EPA regulates dimethylformamide under the authority of three environmental statutes. Under the:

- Clean Air Act, dimethylformamide is a “hazardous air pollutant.”

- Comprehensive Environmental Responsibility, Compensation and Liability Act (popularly known as "Superfund"), DMF is a "hazardous substance."

- Emergency Planning and Community Right-to-Know Act, Toxics Release Inventory (TRI) program, all large quantity users of dimethylformamide must submit data on DMF releases and transfers.

(For section references, see endnote #4.)

This is one in a series of Massachusetts Chemical Fact Sheets prepared for each of the chemicals in significant use on the Toxics Use Reduction Science Advisory Board's "more hazardous chemicals" list. For more information on the Chemical Categorization Project, consult the Institute's Technical Report #47.

Massachusetts Chemical Fact Sheets in the series include the following:

Acrylonitrile
Arsenic and Arsenic compounds
Cadmium and Cadmium compounds
Hexavalent chromium
Cyanide compounds
Dimethylformamide
Ethylene oxide
Formaldehyde
Hydrazine
Lead and Lead compounds
Methylene bisphenyl isocyanate
Nickel and Nickel compounds
Sulfuric acid and fuming sulfuric acid
Tetrachloroethylene
Toluenediisocyanates
Trichloroethylene

Endnotes

1 Environmental Defense Fund (EDF), 1999, "Chemical Profile for N,N-Dimethylformamide (CAS Number: 68-12-2)" (New York: EDF — see webpage: http:/www.scorecard.org/chemical profiles/html/dimethyl_formamide.html); Richard J. Lewis, Sr. (ed.), 1993, *Hazardous Chemicals Desk Reference* (third edition) (New York: Van Nostrand Reinhold); New Jersey Department of Health and Senior Services, 1996, "Hazardous Substance Fact Sheet: Dimethylformamide" (Trenton, New Jersey — see webpage: http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm); and U.S. EPA, Office of Air Quality Planning and Standards, 1998, "N,N-Dimethylformamide" (Washington, D.C.: U.S. EPA — see webpage: http://www.epa.gov/ttn/uatw/hlthef/di-forma.html).

2 The national chemical use data in this section are from Stanford Research Institute (SRI) International, 1994, *Chemical Economics Handbook,* "Dimethylformamide — North America" (Palo Alto, California: SRI). The Massachusetts chemical use data are from the Massachusetts Department of Environmental Protection (MA DEP), 1998, "Massachusetts Toxics Use Reduction Act Chemical Reporting Data" (Boston: MA DEP).

3 SRI, 1997 (see endnote #2 for full citiation); Virginia Waste Reduction Assistance Program, 1991, "Waste Reduction Success Story: Solvent Recovery - Fiber Production (Virginia Department Of Environmental Quality) Volume 1, Number 2.

4 EDF, 1999, "Chemical Profile for N,N-Dimethylformamide"; and the New Jersey Department of Health and Senior Service, 1996, "Hazardous Substance Fact Sheet: Dimethylformamide" (see endnote #1 for full citations).