

Background Technical Information for

N-Nitrosodimethylamine (NDMA)

Background

CASRN: 62-75-9

Synonyms: N-nitrosodimethylamine (NDMA); dimethylnitrosamine (DMNA); nitrosodimethylamine; N-methyl-N-nitrosomethanamine;

N-Nitrosodimethylamine (NDMA) is an unintended byproduct of industrial and water treatment processes, especially wastewater treatment using chloramines for disinfection. However, NDMA also can be formed during the treatment of drinking water (Mitch et al. 2003). It is a semivolatile organic chemical that is miscible in water and is toxic and carcinogenic. NDMA is listed as a priority pollutant by the EPA, but there are no US federal drinking water standards. NDMA has been listed on the EPA's CCL3 and was tested for occurrence in US drinking waters through the UCMR2 program, indicating that a regulatory decision from the EPA is likely in planning.

Key Issues

The primary health concern related to NDMA exposure is its potential to cause cancer (it is known to be both carcinogenic and genotoxic). NDMA is also considered to have moderate to high acute toxicity based on animal studies (see *Health Effects* section). The main target organ is the liver.

Occurrence

NDMA most frequently detected in water as an unintended disinfection byproduct of wastewater treatment, particularly when chloramines are used for disinfection. It has also been reported to form as a byproduct of anion-exchange treatment of water. NDMA can occur naturally in water, air, and soil as a result of chemical reactions with naturally occurring nitrites or secondary amines. It is also formed inadvertently during certain industrial processes. Although it was formerly used in production of liquid rocket fuel, antioxidants, and softeners for copolymers, currently its only intentional production and use is for research. NDMA is miscible in water, highly mobile in soil, and can leach into groundwater; however, NDMA is relatively biodegradable and often is widely attenuated in biological systems.

According to the World Health Organization (WHO 2014, 2011), NDMA concentrations up to 40 ng/L have been measured in drinking water, though lower concentrations are more common (WHO 2014, 2011). The Hazardous Substances Data Bank (HSDB 2014) indicates that the highest concentration

measured in a study of drinking water in distribution systems in Canada was 108.2 ng/L, but again, most NDMA concentrations measured in that study and others were much lower. NDMA was evaluated in the EPA's UCMR2, and was detected in 27% of all public water systems tested. The highest concentration detected during UCMR2 was 630 ng/L and the average was 8 ng/L (EPA 2015).

Health Effects

NDMA exposure can occur through ingestion of foods containing nitrosamines (e.g., smoked or cured meats and fish, beer, and other products), drinking contaminated water, and inhalation of cigarette smoke (EPA 2012a). The primary route of human exposure is the oral route (EPA 2012a).

NDMA is classified as a B2 carcinogen; in other words, it is reasonably anticipated to be a human carcinogen (EPA 2012a). According to the World Health Organization (WHO 2014), "NDMA is clearly carcinogenic, with a strong likelihood that the mode of action for the induction of tumors involves direct interaction with genetic material." Thus, NDMA is considered to be carcinogenic and genotoxic.

In studies with experimental animals, NDMA is rapidly metabolized, forming toxic and carcinogenic compounds. In animal studies, NDMA exhibits moderate to high acute oral toxicity and high acute inhalation toxicity, with the liver as the target organ. NDMA is also formed endogenously through consumption of nitrite and other nitrogenous substances.

People with liver or renal disease and alcoholics have been identified as potentially more sensitive populations (HSDB 2014).

Guidelines

NDMA is listed as a priority pollutant by the EPA, but there are no US federal drinking water standards, i.e., there is no maximum contaminant level (MCL) or health advisory (HA) (EPA 2012a). The EPA commonly sets the MCLG for carcinogens at "zero" and the MCL for suspected carcinogens at a concentration predicted to cause a lifetime excess (increased) cancer risk between 1 in 10,000 and 1 in 1 million. EPA's IRIS database lists drinking water concentrations at various risk levels: 1 in 10,000 excess cancer risk at 70 ng/L, 1 in 100,000 at 7 ng/L, and 1 in 1,000,000 at 0.7 ng/L. This suggests that if the EPA decided to set an MCL for NDMA, it might fall in the range of 0.7 ng/L to 70 ng/L. However, other factors can be considered in setting an MCL. The EPA has calculated a non-enforceable screening level of 0.42 ng/L for NDMA in tap water and a cleanup level of 0.7 ng/L for NDMA in ground water at a Superfund site in California, both based on a 1 in 1,000,000 lifetime excess cancer risk (EPA 2012a). The EPA Region IX office has set a regional screening level (RSL) (formerly a preliminary remediation goal (PRG)) of 1.3 ng/L for NDMA in contaminated water (Najm 1998).

NDMA is currently on the U.S. Department of Defense (DoD) Emerging Contaminant Watch List (EPA 2012a).

The State of California has placed NDMA on its Proposition 65 list, meaning that it is known by the State to cause cancer. California EPA has set a public health goal (PHG) of 3 ng/L in drinking water based on a 1 in 10^{-6} lifetime excess cancer risk (EPA 2012a).

The World Health Organization's drinking-water guideline for NDMA is 0.0001 mg/L (0.1 µg/L) (WHO 2011).

Detection Methods in Water and Removal via Water Treatment

NDMA can be detected in water through the use of solid phase extraction, gas chromatography, and liquid chromatography. The most common treatment method is photolysis by ultraviolet radiation (UV) in the wavelength range 225-250 nm. Recent studies suggest that aerobic and anaerobic biodegradation may be possible. Wastewater may be treated (biological, microfiltration, and reverse osmosis) to remove NDMA precursors. (EPA 2012a). The EPA utilized method 521 for generating the UCMR2 data in US drinking water (<http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/data.cfm#ucmr2010>).

Action Items

NDMA was on the EPA's Contaminant Candidate List 3 (CCL3) (EPA 2012b). According to the EPA (2012b), "CCL 3 is a list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations, that are known or anticipated to occur in public water systems, and which may require regulation under the Safe Drinking Water Act (SDWA)." As stated previously, national drinking water occurrence for NDMA was performed in UCMR2, so it is likely that a regulatory decision will be forthcoming.

References

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