NDMA – a Primer

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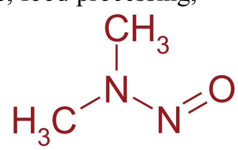
N-nitrosodimethylamine (NDMA) was first identified in drinking water as a contaminant in the late 1990s. Because it is a potential human carcinogen, numerous subsequent studies have examined its occurrence, sources, and toxicity.

NDMA is an N-nitroso organic compound. It is a volatile yellow liquid that is water soluble, relatively polar, of low molecular weight (74.08 grams per mol), reactive, and with a low partition coefficient. These characteristics make NDMA easily transportable by water and very persistent, and also difficult to differentiate from many other contaminants in laboratory analyses.

Industrial and Natural Sources

Currently there are no commercial uses of NDMA in the United States or Canada, but it was used in the past as a fire retardant, in chemical production, for copolymer softening, and in lubricants. Many industrial processes have been identified as sources of NDMA, particularly its use in 1,1-dimethylhydrazine, a liquid rocket fuel used from the 1950s to 1976, including in NASA's Apollo missions.

Although NDMA is no longer deliberately manufactured in North America, it is unintentionally formed during the manufacture of many commercial products and can be found in tobacco, processed food, cosmetics, and detergents, as well as in discharges from industries involved in rubber production, leather tanning, pesticide manufacture, food processing, dye manufacturing, and by foundries.



The molecular structure of NDMA.

Identified biological, chemical, and photochemical processes that result in NDMA formation include the reaction of naturally occurring precursors (typically secondary amines) and nitrosylating agents such as nitrite. NDMA can also form from reaction of dimethylamine with oxides of nitrogen in the air or be produced by soil bacteria, which can generate NDMA from precursor compounds such as nitrate, nitrite, and many amines.

Disinfection of drinking water and wastewater with chlorine/chloramines also has been found to generate NDMA as a byproduct. Water from advanced treatment plants for indirect potable re-use can contain levels of NDMA in excess of typical action limits, a discovery that has led to serious concerns over the practice.

In the Environment

NDMA is found at nanograms per liter (ng/l) concentrations in the environment throughout North America due to the prevalent use of chlorination as a disinfectant and because of the many industrial activities that are potential sources of NDMA. It frequently is found in groundwater surrounding industrial sites and where rocket launching or engine testing has occurred. Many secondary wastewater effluents contain levels of NDMA greater than 100 ng/l, and even advanced wastewater treatment plants have produced effluent with NDMA levels of 80 ng/l. In California, NDMA has been measured in water wells from Los Angeles, Sacramento, and Orange County at levels above the California action limits.

Toxicology studies have shown that NDMA causes carcinomas and tumors of the esophagus, nose, and liver in rodents. The U.S. EPA has listed NDMA as a probable human carcinogen, and it is on California's Safe Drinking Water and Toxic Enforcement Act list of chemicals known to cause cancer or birth defects or other reproductive harm. Chronic exposure is linked to liver disease.

Regulatory Status

The absence of federal standards for NDMA has prompted many jurisdictions to set their own action limits. The province of Ontario, Canada, set an interim maximum acceptable concentration of 9 ng/L for drinking water. California's Department of Health Services set its notification limit (formally an action limit) at 10 ng/L, and has prepared draft groundwater recharge reuse requirements for the compound. The Arizona Department of Environmental Quality now includes NDMA on the monitoring list for National Pollutant Discharge Elimination System permits.

Remediation Approaches

The physical and chemical properties of NDMA limit treatment options. Air stripping, biodegradation, and carbon adsorption are not generally effective. Treatment options involving UV irradiation with or without oxidation do work, and are more cost-effective than other conventional treatment options. More effective approaches focus on removing NDMA precursors or avoiding conditions that promote NDMA formation in the first place.

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