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Intel Chemical of the Month January 2025

Nitrogen Trifluoride

Note: This material is compiled from a website of the National Institutes of Health (NIH), National Library of Medicine and from content published by Wikipedia. It has been edited slightly for continuity's sake. Some of the text has been repositioned and some sentences have been linked together. Minor changes to the text are highlighted in italics.

Description and Uses

Nitrogen trifluoride (NF_3) is an inorganic, colorless, non-flammable, toxic gas with a slightly musty odor. It finds increasing use within the manufacturing of flat-panel displays, photovoltaics, LEDs and other microelectronics. ***It is also commonly used in the manufacturing of semiconductors.***

Nitrogen trifluoride is primarily used to remove silicon and silicon-compounds during the manufacturing of semiconductor devices such as LCD displays, some thin-film solar cells, and other microelectronics. In these applications NF_3 is initially broken down within a plasma. The resulting fluorine radicals are the active agents that attack polysilicon, silicon nitride and silicon oxide. NF_3 dissociates more readily within a low-pressure discharge in comparison to perfluorinated compounds (PFCs) and sulfur hexafluoride(SF_6). The greater abundance of negatively charged free radicals thus generated can yield higher silicon removal rates, and provide other process benefits such as less residual contamination and a lower net charge stress on the device being fabricated. As a somewhat more thoroughly consumed etching and cleaning agent, NF_3 has also been promoted as an environmentally preferable substitute for SF_6 or PFCs such as hexafluoroethane.

The utilization efficiency of the chemicals applied in plasma processes varies widely between equipment and applications. A sizable fraction of the reactants are wasted into the exhaust stream and can ultimately be emitted into Earth's atmosphere. Modern abatement systems can substantially decrease atmospheric emissions. NF_3 has not been subject to significant use restrictions. The annual reporting of NF_3 production, consumption, and waste emissions by large manufacturers has been required in many industrialized countries as a response to the observed atmospheric growth and the international Kyoto Protocol.

Greenhouse Gas

Nitrogen trifluoride is also an extremely strong and long-lived greenhouse gas. Its atmospheric burden exceeded 2 parts per trillion during 2019 and has doubled every five years since the late 20th century. It did not exist in significant quantities on Earth prior to its synthesis by man.

NF_3 has a global warming potential (GWP) 17,200 times greater than that of CO_2 when compared over a 100-year period. It has an estimated atmospheric lifetime of 740 years, although other work suggests a slightly shorter lifetime of 550 years (and a corresponding GWP of 16,800).

Although NF_3 has a high GWP, for a long time its radiative forcing in the Earth's atmosphere has been assumed to be small, spuriously presuming that only small quantities are released into the atmosphere. Industrial applications of NF_3 routinely break it down, while in the past previously used regulated compounds such as SF_6 and PFCs were often released. Research has questioned the previous assumptions. High-volume applications such as DRAM computer memory production, the manufacturing of flat panel displays and the large-scale production of thin-film solar cells use NF_3.

Safety

NF_3 in quantities at or above 5000 pounds presents a potential for a catastrophic event as a toxic or reactive highly hazardous chemical.

NF_3 is a pulmonary irritant with a toxicity considerably lower than nitrogen oxides, and overexposure via inhalation causes the conversion of hemoglobin in blood to methemoglobin, which can lead to the condition methemoglobinemia. The National Institute for Occupational Safety and Health (NIOSH) specifies that the concentration that is immediately dangerous to life or health (IDLH value) is 1,000 ppm.

Vapors may cause dizziness or asphyxiation without warning, especially when in closed or confined areas. Contact with gas, liquefied gas or cryogenic liquids may cause burns, severe injury and/or frostbite. Fire may produce irritating and/or toxic gases. This substance does not burn but will support combustion. Some may react explosively with fuels and may ignite combustibles (wood, paper, oil, clothing, etc.) Vapors from liquefied gas are initially heavier than air and spread along the ground. Runoff may create fire or explosion hazards, and containers may explode when heated. Ruptured cylinders may rocket. Explosive reactions occur upon ignition of mixtures of nitrogen trifluoride with good reducing agents such as ammonia, carbon monoxide, hydrogen, hydrogen sulfide or methane.

Fire Fighting

Use extinguishing agents suitable for the type of surrounding fire. *For a small* fire, *use* dry chemical or CO_2 *and for a large fire*, water spray, fog or regular foam. If it can be done safely, move undamaged containers away from the area around the fire. Damaged cylinders should be handled only by specialists.

Fire Involving Tanks: Fight fire from maximum distance or use unmanned master stream devices or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Do not direct water at *the* source of leak or safety devices; icing may occur. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks in direct contact with flames. For massive fire, use unmanned master stream devices or monitor nozzles; if this is impossible, withdraw from area and let fire burn. IMMEDIATE PRECAUTIONARY MEASURE: Isolate spill or leak area for at least 100 meters (330 feet) in all directions.

For a large spill, implement an initial downwind evacuation for at least 500 meters (⅓ mile). If a tank, rail tank car or highway tank is involved in a fire, ISOLATE for 800 meters (½ mile) in all directions; also, consider initial evacuation for 800 meters (½ mile) in all directions.

First Aid

If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and *resting*. Get medical attention as soon as possible.

Call 911 or emergency medical service. Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and avoid contamination.

Move *the* victim to fresh air if it can be done safely. Administer oxygen if breathing is difficult.

If *the* victim is not breathing: DO NOT perform mouth-to-mouth resuscitation; the victim may have ingested or inhaled the substance. If equipped and pulse detected, wash face and mouth, then give artificial respiration using a proper respiratory medical device (bag-valve mask, pocket mask equipped with a one-way valve or other device).

If no pulse *is* detected or no respiratory medical device *is* available, provide continuous compressions. Conduct a pulse check every two minutes or monitor for any signs of spontaneous respirations.

Remove and isolate contaminated clothing and shoes. For minor skin contact, avoid spreading material on unaffected skin. In case of contact with substance, remove immediately by flushing skin or eyes with running water for at least 20 minutes.

For severe burns, immediate medical attention is required. Effects of exposure (inhalation, ingestion, or skin contact) to substance may be delayed.

Clothing frozen to the skin should be thawed before being removed. In case of contact with liquefied gas, only medical personnel should attempt thawing frosted parts.

The substance may have effects on the liver and kidneys. Repeated or prolonged inhalation may cause fluorosis.