Iodine: Inhalation Hazards, Detection and Protection

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INTRODUCTION

Iodine is routinely found at clandestine laboratories producing methamphetamine via the HI/Red Phosphorus method. The iodine is used instead of hydiodic acid. Iodine is also a decomposition product of hydriodic acid. Therefore, personnel entering clandestine laboratories may encounter iodine from off-gassing reaction vessels or storage containers that are opened. This paper will describe the hazards associated with iodine exposure, current detection methods and proper use of respiratory protection.

BACKGROUND

Iodine was discovered by accident in 1811 by Bernard Courtois. When processing seaweed ash instead of wood ash to extract sodium salts, excessive sulfuric acid was added and a violet vapor was observed. Dark, lustrous crystals formed on the cooler parts of the vessel, which corroded it. (1) The name comes from *ioeides*, which is Greek for violet-colored. (2)

The major U.S. sources of iodine are oil field brines. Of the 500 trillion pounds produced in 1984, 22% were used in organic synthesis, 20% in pharmaceuticals, 18% animal feeds, 12% sanitary and industrial disinfectants, 11% stabilizers, 6% inks and colorants, 5% photographic chemicals and 6% miscellaneous. (3)

Tincture of Iodine contains 2% iodine and 2% sodium iodide in 50% alcohol. Strong iodine solution, known as “Lugol’s Solution”, contains 5% iodine and 10% potassium iodide in aqueous solution. (4)

Iodine is an essential nutrient required for development and functioning of the thyroid gland. Goiter (enlarged thyroid gland) is caused by iodine deficiency and may lead to retardation in physical, sexual and mental development in young people. (5)

INHALATION HAZARDS

Iodine vapor is intensely irritating to mucous membranes and adversely affects the upper and lower respiratory system (6) Inhalation of iodine vapor leads to excessive flow of tears, tightness in the chest, sore throat and headache. It will increase pulmonary flow resistance, decrease compliance and decrease the rate of ventilation. (7).

Humans can work undisturbed at 0.1 ppm; with difficulty at 0.15-0.2 ppm and that work is impossible at concentrations of 0.3 ppm (8). The odor threshold has been reported at 0.9 ppm, (9) so irritation may occur before the odor is detected. The Permissible

Exposure Limit (PEL) is 0.1 ppm (as a Ceiling Value). NIOSH, ACGIH, OSHA, Australia, and Germany all have the same exposure value. (10) The Immediately Dangerous to Life and Health (IDLH) value is 2 ppm (11) based on data indicating severe eye irritation at 1.63 ppm after 2 minutes (12) The Inhalation LCLo for rats is 800 mg/m^3 (80 ppm) for 1 hour. (13).

Iodine has a vapor pressure of 0.3 mm at 25^{o}C (14) and 1 mm at 38.7^{o}C (15). Using standard atmospheric pressure, a maximum of 394 ppm of iodine could build up in a container at 25^{o}C, and a maximum of 1315 ppm could build up at 38.7^{o}C. Therefore, opening a container could easily expose personnel to very high levels of iodine for a brief period of time. Given these conditions, a container should be opened in a well-ventilated area while wearing appropriate respiratory protection.

INGESTION HAZARDS

Toxic doses of iodine are achieved only by ingestion. Whereas the Oral LD50 for a rat is 14,000 mg/kg, the LDLo for a human is 28 mg/kg. By inhalation, this would be approximately the same as breathing 126-190 ppm for 30 minutes (16), which would not be possible due to iodine's irritating odor. Iodism, the term for overexposure to iodine, is characterized by headache, excess salivation, runny nose, eye irritation, laryngitis, bronchitis, inflammation of oral mucosa, enlarged submaxillary glands, inflammation of the parotid and skin rashes (17).

Iodine has effect on mothers in middle and late pregnancy by ingestion. Administration of expectorants that contained iodides to pregnant mothers in the past has been associated with development of goiter in the fetus. It can be passed through breast milk (18).

Accidental ingestion can be prevented at a clandestine lab by good decontamination, hand washing and preventing food consumption in the contaminated areas.

DETECTION

Detecting iodine vapor is difficult with real-time instrumentation. No colorimetric tubes or electrochemical sensors specific for iodine detection are commercially available. Iodine does not cause cross sensitivity when using hydrogen chloride tubes at levels up to IDLH levels (unpublished DOJ test results).

Iodine has an ionization potential of 9.31 eV, which means it can be detected by a photoionizing detector (PID). Several manufacturers produce PID's; however, the PID would have to measure at least as low at 100 ppb to measure the PEL. Most PID's do not have that capability. The RAE Systems "ppbRAE" can allegedly measure as low at 1 ppb. Since the ppbRAE is calibrated with isobutylene, a correction factor supplied by the factory (0.1) must be applied. This is useful in a controlled situation where no other confounding chemicals are present. At a typical clandestine lab, the instrument would measure anything that could be ionized (solvents) and would present a reading higher than truly existed for iodine alone.

RESPIRATORY PROTECTION

Due to the highly irritating nature of iodine, respiratory protection must be used whenever the PEL will be exceeded. Since odor detection is unlikely below the PEL, respiratory protection should be used whenever handling iodine at a clandestine lab.

Air purifying respirator (APR) cartridges are certified by NIOSH to protect the worker up to a maximum limit, defined as the maximum use concentration (MUC). NIOSH assigns each respirator a “protection factor” (PF) which when multiplied by the PEL of a contaminant, can give the maximum concentration in which the respirator may be used. A half-face APR is assigned a PF of 10; a full-face APR has a PF of 50. However the cartridge MUC may be below the maximum limit assigned to the respirator.

The Federal Code of Regulations, section 84.190 provides types of contaminants and respective MUC’s that NIOSH will certify: Ammonia (300 ppm), chlorine (10 ppm), Hydrogen Chloride (50 ppm), Methyl amine (100 ppm), Organic vapors (1000 ppm), Sulfur Dioxide (50 ppm) and Vinyl Chloride (10 ppm). Iodine is not listed. Chemically speaking, it would be expected that it would be absorbed similarly to chlorine. CADOJ has confirmed this.

CADOJ submitted Scott brand 642-MPC-P100 cartridges and MSA brand GME-H cartridges to the Miller-Nelson testing laboratory in Monterey, CA. Both types of cartridges are NIOSH certified for the full spectrum of gases with the exception of vinyl chloride. The cartridges were submitted to 2 ppm and 10 ppm atmospheres of iodine vapor for 60 minutes at a flow rate of 16 liters per minute (moderate work rate) with the environmental conditions of $37^{o}C$ and 20% relative humidity. No iodine was detected at either level during the 60-minute period. The detection limit was 0.05 ppm (19) While this testing does not signify NIOSH approval of the cartridge, it can be used to ascertain that personnel will receive certain protection from iodine during sampling activities at a clandestine laboratory, provided the exposures are below the IDLH of 2 ppm. Any exposures above 2 ppm require the use of self-contained breathing apparatus. (20)

CONCLUSIONS

Iodine produces an irritating vapor that readily affects the eyes and upper respiratory system. Iodine related diseases would not expected due to the low tolerance to airborne concentrations. Accidental ingestion can be controlled with good hygienic practices.

Iodine is difficult to detect with real-time monitoring instruments. Evidence sampling should be done in well-ventilated areas using appropriate respiratory protection.

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