CHLORINE

History

Chlorine was discovered by Carl Wilhelm Scheele in 1774 when he observed the reaction between manganese dioxide and hydrochloric acid. He initially called his discovery dephlogisticated hydrochloric acid after he mistakenly thought there was oxygen in the new-found gas. The resulting light green gas that was formed is the reason for its name, which comes from the Greek *chloros* meaning "pale green". It wasn't until 1810 that Sir Humphrey Davy classified chlorine as an element.

Chlorine as a Chemical Weapon

Main Article: Chemical Weapons

Chlorine has had a history of being used as a chemical weapon. It was brought onto the battlefield as chlorine gas, otherwise known as bertholite. Its debut was in World War I in 1915 at Second Battle of Ypres in its use by the Germans. It was also used in other military settings such as in the Iraq war (2006-2007), when insurgents ignited chlorine bombs in the Al Anbar province (#Brulliard, 2007)

Physical Properties

Chlorine gas is a diatomic element that combines with most elements except oxygen, Nitrogen and the noble gas elements. Its chemical symbol is Cl, and it has natural isotopes with mass numbers 35 and 37. Its density at RT. is 1.565. Its melting point is -101°C, and its boiling point is -34.06 °C. At -34°C and at a pressure of 0.66 MPa, chlorine enters a liquid state (Eagleson, 2003). Chlorine exists in nature as a chloride ion that is deposited in the earth (halite, sylvite, carnallite), or typically as a salt in the ocean. Chlorine acts as an oxidizer through its involvement in redox reactions that involve its gain of more electrons so that it becomes more stable. It is used in organic chemistry for its oxidizing capabilities, and for its propensity to perform substitution reactions. With hydrogen-containing organic compounds, chlorine undergoes free-radical substitution reaction, just as other halogen elements.

Uses

Chlorine is typically used in industrial plastic production, metal degreasing and dry cleaning solvents, textiles, agrochemicals and many more industrial and consumer products. It is used in bromine extraction and production ofchlorates. Chlorine is also involved in water purification, disinfecting agents, especially as bleach. Typical household bleach does not contain pure chlorine, but does contain sodium hypochlorite which is created from reacting chlorine and sodium hydroxide. Drinking water and public pools are disinfected by chlorine in hypochlorous acid.

Mechanism of Action

Chlorine has very corrosive properties when it comes in contact with epithelium, especially moist epithelium. Due to its halogen characteristics, chlorine is often reduced (gains an electron) when it interacts with moist tissues. This occurs when hydrogen separates from water in the moist tissues, thereby causing damage to the tissue ashydrochloric or hypochlorous acid is formed. Also, free oxygen radicals are formed, which could potentially be damaging to the tissue as well. This aspect of the mechanism of action is not as well defined, but it is still thought to contribute significantly to chlorine-induced damage.

Effects and Symptoms of Poisoning

Low level exposure of chlorine gas to the skin or eyes results in irritation. Higher exposures result in chemical burns, ulcerations, or frostbite. If ingested, corrosive damage will occur within the gastrointestinal tract. This would more than likely occur if chlorine is consumed in the form of household bleach.

Inhalation, which is most common, has multiple effects on the body. Low-level inhalation causes skin, eye and airway irritation along with a sore throat and a cough. Higher concentrations result in chest tightness, dyspnea, bronchospasms and wheezing. Severe exposure can result in non-cardiogenic pulmonary edema. Other symptoms of chlorine poisoning appear as runny nose and choking. As fluid builds up in the lungs increases after continuous exposure, the person is often at increased risk of pneumonia. 3.5 ppm of chlorine can be detected by its characteristic odor, while 1000 ppm is likely to be fatal after a few deep breaths (#Ophardt, 2003). 2.5 mg/L of chlorine is immediately fatal if the body comes into contact to that amount and 0.15 mg/L is lethal after longer periods of inhalation.

Treatment

There is no official or universal antidote to chlorine poisoning. Liquid chlorine exposure can be treated with immediate cleansing of the skin or eyes with large amounts of water. If the exposure resulted in chemical burns, then the burns should be treated the same way as thermal burns. Inhalation is treated with humidified oxygen, airway management and bronchodilators. This will delay pulmonary edema in the patient, which lessens the effects from exposure.

Prevention

Exposure to toxic levels of chlorine can be prevented by using a protective mask, which will help in avoiding inhaling chlorine gas while working with the chemical. This is most advantageous for those who are constantly encountering chlorine gas, such as in an industrial setting or in routine cleaning situations. Protective clothing and glasses will also prevent liquid chlorine exposure and the corrosive damage that will occur if it encounters the skin or eyes. Most of all, proper handling of the chlorine-containing substances will significantly help prevent toxic exposure.

Cases

Pool Chlorination

Research was conducted to determine if childhood asthma was linked to exposure to indoor public pools that were chlorinated. It was determined that the effects were dose related, and most strongly related to pool attendance that occurred at a young age (6-7 years). Their finding supported the hypothesis implicating pool chlorine in the rise of childhood asthma in industrialized countries (#Bernard et al, 2006).

Another study was conducted to determine if the by-products of pool chlorination were harmful to humans. Scientists interviewed guests that stayed at two different hotels that were exposed to the indoor pool environment. A large proportion of those surveyed were affected, which consisted of ocular symptoms and respiratory symptoms. 71% developed ocular symptoms, while 45% developed respiratory symptoms. It was concluded that the symptoms were consistent with chlorine exposure and proper staff training, pool maintenance, and ventilation could prevent these types of exposures (#Bowen et al, 2007).

Another report discussed the potential relationship between the extent of lung injury in children and chlorine exposure in swimming pools. It was discovered that children who were acutely exposed to chlorine in the pool had substantial lung function impairment associated with an increase in LTB-4. LTB, or lymphotoxin-beta is an inducer of the inflammatory response, and is involved in the development of lymphoid tissue. There was also a noted reduction in FENO or

fixed exhalation flow rate of NO. It was found that while lung function and FENO improved within weeks, the increased levels of LTB-4 lasted for months (#Bonetto et al, 2006).

Chlorinated By-Products (SDBP)

Other groups have examined whether chlorination disinfection by-products (CDBP) increased the risk of pancreatic cancer. CDBPs have been associated with a higher risk of bladder cancer, and the researchers wanted to determine whether there would be also be an increase in pancreatic Cancer. It was found that there was no increase risk of pancreatic cancer after CDBP intake, but other routes of exposure could yield different results. Also, it was noted that the study was done looking at only three of the many CDBPs (#Do et al, 2005).

Regulation

Due to the fact that chlorine is used in many day-to-day cleaning products, and the customers buying them vary greatly, multiple regulatory centers are involved. Regulation for chlorine exposure would typically be conducted by the Environmental Protection Agency (EPA) if chlorine is in the gaseous form or used in sewage treatment. The Occupational Safety and Health Association (OSHA) is involved with regulating its use in industrial settings and in professional cleaning settings. The Centers for Disease Control (CDC) have some regulatory responsibility with regards to illnesses brought on by chlorine exposure. Chlorine in drinking water is generally monitored locally by the body that manages water distribution to ensure that levels of chlorine present within federal safety guidelines.

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