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Chemical Agents in Warfare

Definition and History

Chemical warfare involves the usage of toxic synthetic chemicals, with more horrific destruction than physical means. Chemical warfare agents can be characterized by their properties: high toxicity, imperceptibility to senses, rapidity of action after dissemination, and persistence. This lists them as scheduled chemicals in the Chemical Weapons Convention. Chemical warfare agents can be lethal or cause incapacitating effects on those affected. What makes it all worse, is the fact that they can be dispersed through any means; as a gas, in liquid form, or combined with other particles, making it unnoticeable. All this causes devastating effects on the victims, making them experience sheer pain while they're intoxicated by the substance. However, though all this seems like a new sort of warfare, this originated way back. In the past, chemicals and toxic substances have been used for a long time. Back then, they used to use more natural resources, and gathered toxic substances to bestow its impact on people. However, all this was controlled to a certain level, as there was only so much, they could do with those means. The problem arose when the production of chemicals became industrialized, making it easier than ever to expand its usage and find more creative methods to cause most damage. (National Library of Medicine, 2010)

A notable moment of one of the first usage of chemicals in warfare, dates back to 600 BCE, when the Athenian military tainted a water supply with poisonous plants. Unsuspecting people using the water for their daily needs, soon became victims. Since then, quite a few more notable events took place, but nothing can compare to what happened in the 20th century. The first prevention of chemical weapons dates back to 1675, when France and Germany signed the Strasbourg Agreement. However, that was limited to poisonous bullets back then. Again from 1874-1907, many Western countries tried banning the usage of poison in warfare. This, though, was going to get much worse starting in the First World War. Some famous chemicals used were Chlorine gas (a yellowish colored irritant, but can be lethal with high exposure), Phosphene (slow in effect, but six times more deadly than Chlorine, and is colorless, making it unsusceptible), and lastly, Mustard gas (also slow in effect, but stings the eyes, and causes infection prone blisters in moist and sensitive areas such as the genitals). Near the very end of the 20th century, in 1993, the Chemical Weapons Convention was signed, banning the development, production, stockpiling, and use of chemical weapons, to be in effect in 1997. However, somewhere or the other, this prevention once again is broken in some parts of the world. (Science History Institute, 2015)

Technology of the Chemical Agents Used

Since the rise in popularity of the use of chemical agents in warfare after it was first successfully used in World War 1, technology has advanced, and many types of chemicals and distribution systems have been created. Humans have made everything from chemical agents designed to incapacitate and blister to chemicals meant to be so addictive the victims became mentally unstable.

Choking agents, otherwise known as pulmonary agents, affect the respiratory system by targeting the mucous membranes (Hotzones Solutions Group, Chemical Warfare Agents Complete Guide: Hotzone solutions, 2023). They are typically dispersed as gases and start working as soon as they are inhaled. According to Pike (n.d.), common examples of choking agents are chlorine (Cl), phosgene (PS), diphosgene (DP), and chloropicrin (CG).

Blood agents hinder the body's ability to distribute oxygen and lead to suffocation. Two of the most common examples of blood agents are types of cyanide; hydrogen cyanide and chloro cyanide (Hotzones Solutions Group, Chemical Warfare Agents Complete Guide: Hotzone solutions, 2023). Examples of blood agents include arsine (SA), cyanogen chloride (CK) and hydrogen cyanide (AC) (Pike, n.d.)

Nerve agents disrupt the transmission of nerve impulses throughout the body. They are split up into two groups: G-series ("German series") and V-series (Venomous series). Some G-series chemicals like sarin stay in the affected environment for a short period of time while other chemicals like cyclosarin remain in the area for a longer period. On the other hand, if an area is affected by a V-series chemical (like VX or Venomous Agent X), it is harder to decontaminate compared to G-series chemicals. VX in particular doesn't readily vaporize and is considered a weapon of mass destruction (WMD). Simply being in a contaminated area is enough harm as both types of agents are absorbed through the skin and lungs (Pike, n.d.).

While the chemical agents mentioned earlier are usually distributed as aerosols or gases, blister agents are more versatile. They can be released as liquids, gases, and as dust. Like its name suggests, blister agents cause irritation. Exposure to it can affect the eyes, skin, respiratory tract, and more. However, blister agents are not very lethal unless there was prolonged exposure. Usually, they just put the victim through immense pain and overall bad health. Some common examples of blister agents are sulfur mustard (H,HD), nitrogen mustard (HN), lewisite (L), and phosgene oxime (CX) (Pike, n.d.).

Among the chemicals mentioned, many are forms of cyanide, phosgene, and sarin. Cyanide is a well-known poison and it's no surprise that it has been altered and turned into weaponry. Phosgene truly had its glory days during World War 1 due to its ability to cause build-up in the lungs. Sarin and VX are two very effective examples of nerve gases. Their discrete nature means that it is incredibly difficult to safely discern if the area is safe without equipment. Dispersing chemicals as gases makes it very easy to affect large areas in a short amount of time.

Chemical Properties of the Agents

Sarin

Sarin, also known as isopropyl methylphosphonofluoridate, is an organophosphate ester, and appears as a colorless and odorless liquid under standard temperature and pressure (273.15 K, 1 atm). It is also tasteless, and minimal exposure can cause death within minutes - a drop of 1-10mL on the skin being sufficiently fatal (Haz-Map, 2022). It has a chemical formula of C4H10FO2P, and a molecular mass of 140.09 g/mol. Its melting and boiling points are -57˚C and 147˚C, respectively.

Sarin is typically liquid but evaporates easily and becomes a colorless and odorless gas.

In its liquid state, sarin can rapidly penetrate the skin and in vapor state, can directly contact the eye or be inhaled into the lungs. Its chemical structure can be visualized as below:

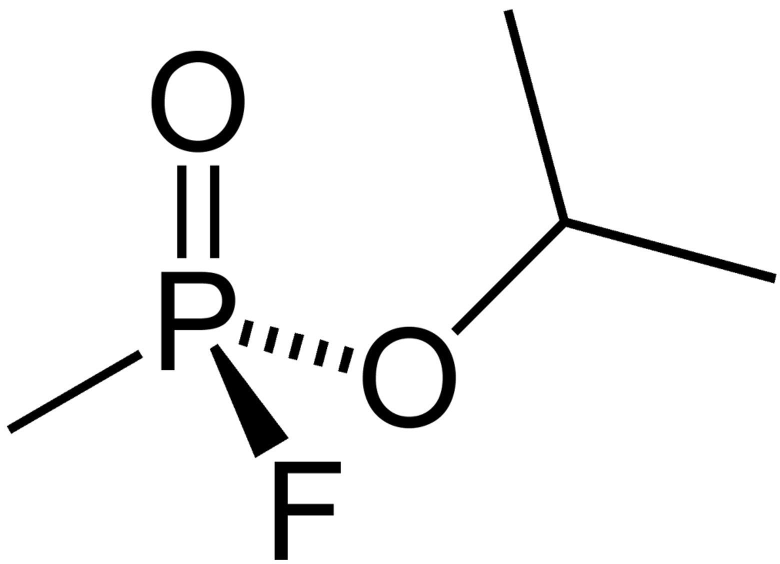


Figure 1 (New World Encyclopedia, 2024)

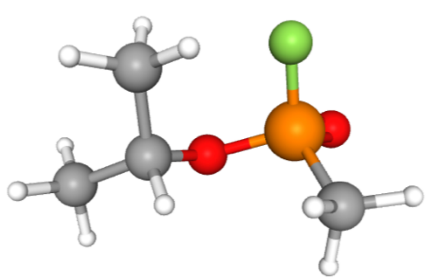


Figure 2 (Pubchem, 2024)

The chemical attacks the nervous system by irreversibly inhibiting the enzyme acetylcholinesterase (AChE), leading to an excessive buildup of acetylcholine in neuromuscular junctions (Abou-Donia et al.). This happens as the organophosphate compound forms a covalent bond with the serine residue of the enzyme, with fluorine being the leaving group. The fluorine reacts with the hydroxyl group on the serine sidechain, forming a phosphoester and releasing hydrogen fluoride. As the resulting phosphoester is biologically inactive, acetylcholine continues to form in the synapse, basically causing paralysis (ChemEurope, n.d.).

It is soluble in water and, like other chemical nerve agents, reacts with bases. Sodium hydroxide (NaOH), for example, can be used in a hydrolysis reaction to convert sarin into a harmless sodium salt.

<u>Hydrogen Cyanide</u>

Hydrogen cyanide, or hydrocyanic acid, is a colorless gas (above 25.6°C) or colorless or pale-blue liquid (below 25.6°C) (CDC, 2011) with a faint bitter, almond-like odor and a bitter, burning taste (ATSDR, 2014). It can damage the body by ingestion, inhalation, skin contact, or eye contact (CDC, 2011). After inhalation, it initially causes hyperventilation, followed by a rapid loss of consciousness at high concentrations. In liquid form, it penetrates the skin. When dispersed as an aerosol, the chemical can be absorbed from the lungs (WHO, 2024).

The chemical formula of hydrocyanic acid is HCN and the molar mass / molecular weight is 27.025 g/mol (BYJU'S, 2024). Its boiling and melting point are 25.6 °C and -13.4 °C respectively. The chemical structure of the compound can be presented as followed:

Figure 3 (WIKIDATA, 2024)

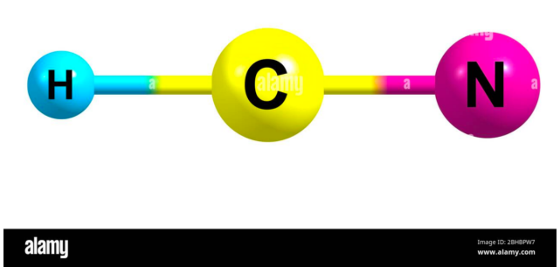


Figure 4 (alamy, n.d.)

Hydrogen cyanide prevents the cell’s oxygen usage or, in other words, inhibits aerobic respiration. Thus, it causes possible harm to the brain, heart, blood vessels, and lungs (CDC, 2019).

The substance is soluble in water (ATSDR, 2014) and, just like sarin, reacts with bases. For example, it enters a reaction with sodium hydroxide and potassium hydroxide to form sodium cyanide and potassium cyanide, respectively, and water (BYJU’S, 2024).

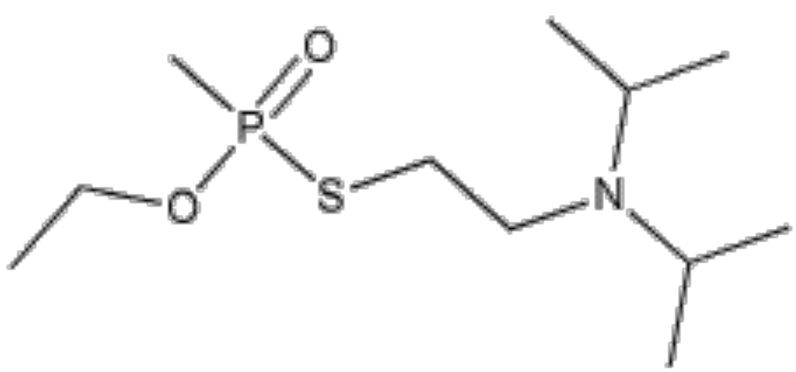
VX

Another member of the organophosphate family, VX gas is a clear, oily and odorless and tasteless liquid. Its chemical name is O-Ethyl-S-[2(diisopropylamino)ethyl] methylphosphonothioate, and is dubbed as the most important agent in the V-series (Keyes, 2019). Through explosion, VX can become an aerosol, or a vapor through heating. Once released, the liquid persists for days and weeks before evaporating. High temperature, wind, humidity and moisture lead to less persistency (US Army Chemical Materials Activity, n.d.).

The Chemical formula of VX is $C11H26NO2PS$. VX is a slightly soluble substance and has a molecular weight of 267.37 g/mol. Its boiling and melting points are set at 298°C and below -51°C, respectively. In a liquid state, VX’s density corresponds to 1.008 g/mL at 20°C. Moreover, it is a combustible compound (CDC, 2021).

Like Sarin, VX renders the enzyme acetylcholinesterase inactive. It also inhibits other cholinesterases like butyrylcholinesterase (BuChE). To expound on the paralysis process mentioned earlier, the actions of acetylcholine (stimulates the secretion of bodily fluids, contraction of skeletal muscles and a key actor in the central nervous system) is terminated when hydrolyzed by AChE, preventing the continual overstimulation of receptors (Moyer et al, 2014).

Exposure to VX can result in death within a few minutes and a drop on the skin could be fatal (CDC, 2021).



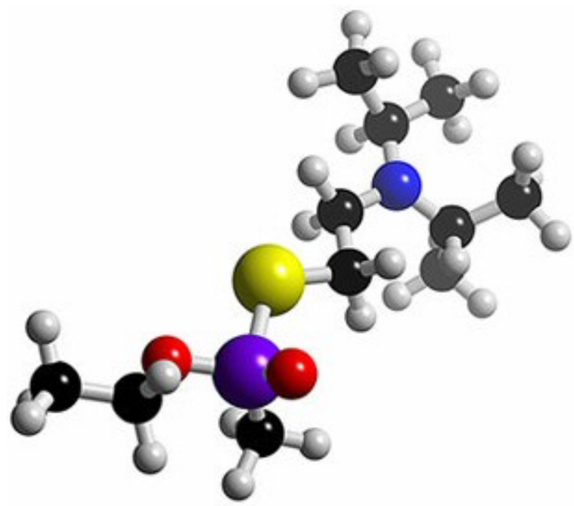


Figure 5 & 6 (University of Bristol, n.d.)

Effects of the Chemicals on Humans and the Environment

Sarin, VX gas and hydrogen cyanide are chemical warfare substances, presenting significant threats to human health and the environment. Let's first look deeper into the effects of these chemical warfare on human health. Sarin is a very harmful gas that can cause humans to stop breathing and eventually kill them if exposed to high amounts. As it's a nerve agent, when exposed in high amounts, it interferes with the operation of an enzyme that stops muscles from contracting (Sarin: Exposure, Decontamination, Treatment | Chemical Emergencies | CDC, 2023). When this enzyme does not work correctly, the muscles will constantly be stimulated and contracted. With continuous contraction of muscles, exposed people may become tired and no longer be able to keep breathing. When exposed in low amounts, antidotes and treatments for sarin removal are available in hospitals but must be provided immediately (Sarin: Exposure, Decontamination, Treatment | Chemical Emergencies | CDC, 2023). VX gas is also a nerve agent and hence works in the same way as sarin, interfering with the operation of enzymes for muscle contraction (VX: Exposure, Decontamination, Treatment | Chemical Emergencies | CDC, 2023). VX gas also has an antidote and a treatment for removal from the body. Hydrogen cyanide interferes with the body's use of oxygen and may cause harm to the brain, heart, blood vessels, and lungs (Hydrogen Cyanide | NIOSH | CDC, 2020). Exposure can be fatal, a hydrogen cyanide concentration of 300 mg/m^3 in air can result in death within about 10 minutes (CEHA, n.d.). Treatments for hydrogen cyanide exposure are available. All these gases are harmful to humans and high exposures may lead to death, the three of them cause similar symptoms to humans such as, headaches, confusion, difficulty breathing, muscle tightness, etc. at low or medium concentrations, and loss of consciousness, seizures, respiratory failure and/or cardiac arrest possibly leading to death, etc. at high concentrations.

These gases also have effects on the environment. Sarin can easily contaminate the surrounding environment as it can be transmitted through both air and water. Creatures in the affected area are exposed to sarin though ingestion, inhalation especially those in low-lying areas where the denser than air, gas accumulates. Although sarin gas degrades rapidly, the liquid form can persist for significantly longer periods, posing a bigger threat (NRT, March 2022). Since animals often can't get treatment for the exposure, they either suffer for a while or die, which causes a disturbance in the ecosystem (CDC, February 7th 2023). The much more harmful chemical VX is also transmittable through the same methods as sarin, which means that the same risks persist (CDC, February 7th 2023). However, VX may also decompose when in contact with metals, which creates a highly flammable hydrogen gas. In general, this chemical forms dangerous and explosive vapors when mixed with air. It also has a significantly higher persistence, as it can stay in a gaseous form for days and in liquids up to months (NRT, July 2022). A lot of factors impact this, however due to its lethality and it being almost impossible to detect without laboratory testing, it is very dangerous when released into nature (CDC, February 7th 2023). Hydrogen cyanide occurs naturally in fruits with pits, such as cherries, apples, and bitter almonds (Wikipedia, February 3rd 2024). Accidentally swallowing a cherry pit poses a lower risk compared to exposure to high doses used in chemical warfare. The gas is highly flammable and will produce a poisonous gas when burning (NJ, January 2011).

In general, the three chemical warfare substances pose a threat to the environment and to humans. For the environment, due to their toxicity to living organisms especially aquatic life. Although air pollution is a concern, the much longer persistence of these chemicals in an aqueous state and environment poses a much greater risk. Everything needs water and water is everywhere, so contaminated water is a huge risk when those gases are used. To human health, they can immediately lead to death if exposed at higher concentrations, but they do have antidotes and treatments available if given as soon as possible.

Countries Holding Chemical Agents for Warfare

Chemical weapons and nuclear weapons are classified as weapons of mass destruction due to their potential to cause extensive harm to large numbers of people and the environment. Despite the international efforts made to eliminate these weapons, some countries have been reported to possess or have used them for warfare purposes (Herre, 2023). The Chemical Weapons Convention (CWC) and the Biological Weapons Convention (BWC) are two significant international treaties aimed at prohibiting the production, stockpiling, and use of chemical and biological weapons. Starting way back in the 1970s, these were used to negotiate and help reduce the usage of chemical agents of many countries. As of now, there are 193 states parties to the CWC and 183 States Parties to the BWC (Chemical and Biological Weapons Status at a Glance | Arms Control Association, n.d.). However, some countries have neither signed nor ratified these conventions. For example, Egypt, North Korea, South Sudan have neither signed nor ratified the CWC. As for BWC, ten states including Chad, Comoros, Israel, Djibouti, Micronesia, Eritrea, Namibia, Kiribati, South Sudan, and Tuvalu. Historically, these chemical weapons have been used in various conflicts. The most famous example is during World War 2, when Japan and Germany used chemical weapons against China and Jews. More recently however is when Iraq used nerve agents and mustard against Iran during the Gulf War (1980-1988), and Syria has been exposed to chemical attacks since 2012 (Polat, Gunata, & Parlakpinar, 2018). Several countries have declared the possession of chemical weapons. For example, Albania, in March 2003 declared their possession of 16 tons of chemical agents. In 1997, China's small offensive chemical weapons program has been dismantled (Chemical and Biological Weapons Status at a Glance | Arms Control Association, n.d.). Both the Unites States and Russia, the two countries with the largest stockpiles of chemical weapons, signed the convention and are still in the process of destroying their arsenals. The process of eliminating chemical weapons is very difficult. It requires slow and careful process, overseen by the Organization for the Prohibition of Chemical Weapons (OPCW)(Mahapatra, 2021b). To conclude what was stated, the progress to eliminate chemical weapons has been significant and the required global effort for many countries, politicians, and citizens to come together is still a much-needed role. However, the threat they pose remains. Continued international cooperation and enforcement of the CWC and BWC are crucial to ensure a world free of chemical agents and chemical warfare and help create peace worldwide.

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Bibliography

Definition and History:

- Ganesan, K., & Raza, S. K., & Vijayaraghavan, R. (Jul-Sep, 2010). Chemical warfare agents. National Library of Medicine. Web. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3148621/
- Everts, S. (May 12, 2015). A Brief History of Chemical War. Science History Institute. Web. https://sciencehistory.org/stories/magazine/a-brief-history-of-chemical-war/

Technology of the Chemical Agents Used:

- Ganesan, K., Raza, S. K., & Vijayaraghavan, R. (2010, July). Chemical Warfare Agents. Journal of pharmacy & bioallied sciences. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3148621/
- Jeffrey L Arnold, M. (2019, January 11). Chemical Warfare types, risks & treatment. eMedicineHealth. https://www.emedicinehealth.com/chemical_warfare/article_em.htm
- Pike, S. (n.d.). What are the most common types of chemical warfare agent (CWA)?. Argon Electronics. https://www.argonelectronics.com/blog/what-are-the-most-common-types-of-chemical-warfare-agent-cwa
- Chemical Warfare Agents Complete Guide: Hotzone solutions. Hotzone Solutions Group. (2023, January 11). https://hotzonesolutions.org/blog/chemical-warfare-agents/

Chemical Properties of the Agents:

Sarin:

- Abou-Donia, M. B., Siracuse, B., Gupta, N., & Sobel Sokol, A. (2016, November). Sarin (GB, O-isopropyl methylphosphonofluoridate) neurotoxicity: Critical Review. Critical reviews in toxicology. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5764759/
- Institute of Medicine (US) Committee on Health Effects Associated with Exposures During the Gulf War. (1970, January 1). Sarin. Gulf War and Health: Volume 1. Depleted Uranium, Sarin, Pyridostigmine Bromide, Vaccines. https://www.ncbi.nlm.nih.gov/books/NBK222849/#:~:text=Sarin%20(GB%3B%20o%2Disopropyl,(making%20it%20highly%20volatile).
- Sarin. chemeurope.com. (n.d.). https://www.chemeurope.com/en/encyclopedia/Sarin.html
- Sarin. (n.d.). New World Encyclopedia. https://www.newworldencyclopedia.org/entry/Sarin

- U.S. National Library of Medicine. (n.d.). Sarin. National Center for Biotechnology Information. PubChem Compound Database. https://pubchem.ncbi.nlm.nih.gov/compound/7871

Images:

- Sarin. Visit the main page. (n.d.). https://www.newworldencyclopedia.org/entry/Sarin
- U.S. National Library of Medicine. (n.d.). Sarin. National Center for Biotechnology Information. PubChem Compound Database. https://pubchem.ncbi.nlm.nih.gov/compound/7871

Hydrogen Cyanide:

- Admin. (2022, December 22). Hydrogen cyanide (HCN)- Lewis acid structure, molecular mass, physical and Chemical Properties, uses with faqs of hydrogen cyanide. BYJUS. https://byjus.com/chemistry/hydrocyanic-acid/
- Centers for Disease Control and Prevention. (2011, May 12). Hydrogen cyanide (AC): Systemic agent. Centers for Disease Control and Prevention. https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750038.html
- Centers for Disease Control and Prevention. (2014, October 21). Hydrogen cyanide (HCN). Centers for Disease Control and Prevention. https://wwwn.cdc.gov/TSP/MMG/MMGDetails.aspx?mmgid=1141&toxid=249#:~:text=It%20is%20soluble%20in%20water,as%20a%2096%25%20aqueous%20solution
- Centers for Disease Control and Prevention. (2019, June 21). Hydrogen cyanide. Centers for Disease Control and Prevention. https://www.cdc.gov/niosh/topics/hydrogen-cyanide/default.html#:~:text=Hydrogen%20cyanide%20(HCN)%20is%20a,Exposure%20can%20be%20fatal
- World Health Organization. (n.d.). Hydrogen cyanide fact sheet. World Health Organization. https://www.emro.who.int/ceha/information-resources/hydrogen-cyanide-fact-sheet.html

Images:

- Hydrogen cyanide. Wikidata. (n.d.). https://www.wikidata.org/wiki/Q26075
- Limited, A. (n.d.). Hydrogen cyanide or formonitrile is a chemical compound with the chemical formula HCN. it is a colorless, extremely poisonous and Flammable Liquid Tha Stock Photo. https://www.alamy.com/hydrogen-cyanide-or-formonitrile-is-a-chemical-compound-with-the-chemical-formula-hcn-it-is-a-colorless-extremely-poisonous-and-flammable-liquid-tha-image354915939.html

VX:

- Centers for Disease Control and Prevention. (2021, October 20). VX: Nerve agent. Centers for Disease Control and Prevention. https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750005.html

- Daniel C Keyes, M. (2021, October 19). CBRNE - nerve agents, V-series - VE, VG, VM, VX. Background, Pathophysiology, Epidemiology. https://emedicine.medscape.com/article/831760-overview?form=fpf
- Nerve agent VX. U.S. Army Chemical Materials Activity. (n.d.). https://www.cma.army.mil/nerve-agent-vx-fact-sheet/
- VX (nerve agent). VX (Nerve Agent) - an overview | ScienceDirect Topics. (n.d.). https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/vx-nerve-agent

Images:

- University of Bristol. (n.d.). VX Nerve Gas. https://www.chm.bris.ac.uk/webprojects2006/Macgee/Web%20Project/nerve_gas.htm

Effects of the Chemicals on Humans and the Environment:

- Wikipedia contributors. (2024, February 22). Hydrogen cyanide. Wikipedia. https://en.wikipedia.org/wiki/Hydrogen_cyanide
- VX: Exposure, decontamination, treatment | Chemical Emergencies | CDC. (n.d.). https://www.cdc.gov/chemicalemergencies/factsheets/vx.html
- New Jersey Department of Health [NJ Health] (Ed.). (1998, June). Hazardous Substance Fact Sheet. Nj Gov. Retrieved February 24, 2024, from https://nj.gov/health/eoh/rtkweb/documents/fs/1013.pdf
- NRT Quick Reference Guide: VX. (2015, June). Nrt Gov. Retrieved February 24, 2024, from https://nrt.org/sites/2/files/NRT%20CBRN%20CHEM%20UPDATE%20VX%20QRG%20FINAL%202022%2007%2026.pdf
- SARIN: Exposure, decontamination, treatment | Chemical Emergencies | CDC. (n.d.). https://www.cdc.gov/chemicalemergencies/factsheets/sarin.html
- NRT Quick Reference Guide: Sarin (GB). (2022, March). Nrt Gov. Retrieved February 24, 2024, from https://nrt.org/sites/2/files/NRT%20CBRN%20CHEM%20UPDATE%20Sarin%20GB%20QRG%20FINAL%202022%2007%2026.pdf
- National Emission Standards for Hazardous Air Pollutants: Cyanide Chemicals Manufacturing Residual Risk and Technology Review. (2021, January 15). Federal Register. https://www.federalregister.gov/documents/2021/01/15/2021-00374/national-emission-standards-for-hazardous-air-pollutants-cyanide-chemicals-manufacturing-residual
- Sarin: Exposure, Decontamination, Treatment | Chemical Emergencies | CDC. (2023, February 7). Www.cdc.gov. https://www.cdc.gov/chemicalemergencies/factsheets/sarin.html#:~:text=Sarin%2C%20like%20all%20nerve%20agents

- VX: Exposure, Decontamination, Treatment | Chemical Emergencies | CDC. (2023, February 7). Www.cdc.gov. https://www.cdc.gov/chemicalemergencies/factsheets/vx.html#:~:text=VX%2C%20like%20all%20nerve%20agents
- Hydrogen Cyanide | NIOSH | CDC. (2020, December 2). Www.cdc.gov. https://www.cdc.gov/niosh/topics/hydrogen-cyanide/default.html#:~:text=Hydrogen%20cyanide%20interferes%20with%20the
- CEHA. (n.d.). Hydrogen cyanide fact sheet. World Health Organization - Regional Office for the Eastern Mediterranean. https://www.emro.who.int/ceha/information-resources/hydrogen-cyanide-fact-sheet.html

<u>Countries Holding Chemical Agents for Warfare:</u>

- Herre, B. (2023, December 28). Biological and chemical weapons. Our World in Data. https://ourworldindata.org/biological-and-chemical-weapons
- Chemical and biological weapons status at a glance | Arms Control Association. (n.d.). https://www.armscontrol.org/factsheets/cbwprolif
- Polat, S., Gunata, M., & Parlakpinar, H. (2018). Chemical warfare agents and treatment strategies. Annals of Medical Research, 25(4), 776-782. https://annalsmedres.org/articles/2018/volume25/issue4/776-782.pdf
- Mahapatra, L. (2021b, January 9). Not just Syria: which other countries have chemical weapons? [Interactive Map]. International Business Times. https://www.ibtimes.com/not-just-syria-which-other-countries-have-chemical-weapons-interactive-map-1404112