Historical Perspective of Chemical Warfare Agents

**Pre-reading activities**

*I. Discuss these questions with your classmates.*

1. Do the countries in war have the right to use chemical weapons? State your reason why yes/no and be prepared to support them.

2. In which situations should the use of chemical weapons be justifiable?

3. Do you know about cases when the ban on CWs was not followed?

*II. Match the words with their explanations.*

## A

1. to take over

2. confluence

3. agent

4. stockpile

5. incapacitate

6. adjacent

7. drift out

8. rumour

a) substance or organism that exerts some force or effect

b) information that may or may not be true

c) to move out of a place slowly

d) to seize or capture

e) near

f) to deprive of strength or ability; disable

g) large supply of material

h) about rivers – merging and flowing together

B

1. conspicuous

2. defoliant

3. impurity

4. induce

5. ambiguity

6. allegedly

7. antidote

a) to bring about, produce or cause

b) doubtfulness, uncertainty

c) easily seen or noticed

d) reportedly, supposedly

e) substance that counteracts or neutralizes poison

f) chemical sprayed onto trees to cause their leaves to fall

g) contamination, pollution

**Historical Perspective of Chemical Warfare Agents**

*The period after WWII and the cold war*

At the end of WWII, many Allied nations seized the chemical weapons. Most of the CW manufacturing plants in Germany were taken over and moved to Russia to new sites, e.g. the military area of Shikhany. This ‘‘takeover’’ prompted other states to begin even more research on CWs. Despite the Allies’ own research into CWs, very important technologies and ‘‘know how’’ were obtained from Nazi Germany for both the USA and the former Soviet Union.

The interest in CW technology was probably one reason for the change of the future border: according to Churchill’s history of WWII the proposed future boundary between Poland and Germany had been primarily agreed to consist in part of the Oder River flowing to the Baltic Sea, and its tributary, the Neisse River. Before their confluence, the Neisse consists of two branches, the East Neisse and the West Neisse. The East Neisse should be the boundary, resulting in slightly more territory for Germany. Stalin held for the West Neisse and progress was delayed. No one knows why Stalin was so insistent in this matter. The reason was probably very simple: the small town of Dyhernfurth (now Brzeg Dolny), a few kilometers north of Breslau (Wroclaw) in the disputed territory and a factory for the production of nerve agents. It was estimated that when Dyhernfurth was captured it contained stockpiles of 12,000 tons of tabun, 600 tons of sarin, and an unknown amount of soman. Presumably, the factory was dismantled, and along with their stockpiles, transported to the Soviet Union. It has been documented that the Soviets were ready to conduct a chemical attack and their research and development of CWs was very intensified.

In the USA, during the 1950s, the chemical corporations concentrated on the weaponization of sarin. At the same time, they became interested in developing CWs that incapacitated rather than killed the targets. Mescaline and its derivatives were studied but without practical output. Five years later, a new project ‘‘Psychochemical Agents’’ (later K-agents) was established. The objective was to develop a nonlethal but potent incapacitant. Nonmilitary drugs like LSD-25 and tetrahydrocannabinol were also examined. None of these agents were found to be of military importance. The first and only incapacitant was BZ, developed in 1962; however, its stocks were destroyed in 1992 as declared by the US delegation to the Conference on Disarmament in Geneva. These agents, intended not to kill but to induce incapacitation, are covered under the class of nonlethal weapons.

In the former Soviet Union, as a whole in 1940–1945 approximately 110,000 tons of first generation toxic chemicals were produced and most of them were yperite and lewisite, and irritating agents. Second generation CWs were composed of nerve agents such as sarin, soman, V agents, and to a lesser degree tabun. The development of new CWs of the third generation comprised traditional and nontraditional CWs, e.g. blister and irritant agents, and nerve gases including new types, e.g. Novichok 5, whose exact chemical structure is unknown though some assessments have been made; it could be a nerve agent having high toxicity. Its effects are difficult to treat using common antidotes.

An example of the unintentional use of CWs has also been observed. In March 1968, thousands of dead sheep were discovered in the Skull Valley area, Arizona, USA. This area was adjacent to the US Army’s Dugway open-air testing site for CWs. Nerve gas had drifted out of the test area during aerial spraying and killed the sheep. One year later, on July 8, 1969, the Army announced that 23 US soldiers and one civilian had been exposed to sarin in Okinawa during the clearing of sarin-filled bombs.

There are a number of examples of localized conflicts where CWs have been intentionally used but cannot be verified: e.g. in 1951–1952 in the Korean War; in 1963 the Egyptians used mustard bombs against Yemeni royalists in the Arabian peninsula; in the Indo-China War (see VietnamWar); in 1970, in Angola antiplant agents were almost certainly used; and in former Yugoslavia, there were rumors of the use of psychotomimetic agents.

*Iraq–Iran and Afghanistan War*

On September 22, 1980, Iraq launched its invasion against Iran. There has been mention of the large-scale use of CWAs in the Iran–Iraq war. In November 1983, Iran informed the United Nations that Iraq was using CWs against Iranian troops. Soon after, the use of CWs was unleashed. In addition, mustard and tabun were used. It is well known that the Iraqi Government used these agents against its own citizens, more conspicuously at Halbja in March 1988. The CWs attack was the largest against a civilian population in modern times. More than 100,000 Iranians were poisoned with CWAs; sulfur mustard was the most frequently used and has induced a number of delayed complications in Iranian veterans (pulmonary, dermal, ocular, immune system depression, reproduction, malignancy, etc). Other localized conflicts involving alleged use of CWs are described indetail in an extensive review.

The Soviet Union probably used mustard (and nerve gas) in Afghanistan. The Afghanistan war was considered the Soviet Union’s ‘‘Vietnam’’. The use of CWs was described by Sidell and Franz (1997). The use of CWs by Soviet forces was also significant and has been confirmed against unprotected subjects. Despite the use of CWs, the withdrawal of Soviet troops from Afghanistan was realized at the beginning of 1989.

*Vietnam War*

After WWII, the main employment of CWs is recorded in 1961–1972 when the US Army used defoliants. The herbicide Agent Orange was used during the Vietnam War and led to the injury of more than one million Vietnamese and Americans. Agent Orange (a mixture of 2,4-dichlorophenoxy

acetic acid and 2,4,5-trichlorophenoxy acetic acid) contained the chemical contaminant dioxin as an impurity which caused many deaths on both sides. There were other herbicide mixtures such as Agent White (2,4-D and picloram) and Agent Blue (cacodylic acid). The first major operation of this type was conducted over the Ca Mau peninsula in September–October 1962. The area sprayed with defoliants during 1965 had been five times larger than in 1965 and in 1967 ten times larger. The scale of the use of defoliants was roughly in proportion to the overall involvement of US troops. In 1970, herbicides and defoliants were used in tens of tons, especially 2,4,5-T. The area sprayed enlarged from 23 km2 in 1962 to 22,336 km2 in 1969. The area exposed to spraying was assessed to be 58,000 km2 and the number of people exposed was assessed to be more than one million including more than 1,000 deaths. In addition to defoliants used to destroy vegetation concealing the North Vietnamese, the USA used tear gas for clearing tunnels and bunkers. The irritants CS, CN, and DM were reported to be used. The total CS procured was approximately 7,000 tons from 1963 to 1969.

*Development of VX Agent*

VX was synthesized in the 1960s on the basis of the results of Tammelin and Aquilonius. The manufacturing of VX began in the USA in 1961. Construction of the USA’s VX agent production plant at Newport, Indiana, was completed in 1961, when the first agent was produced. The production facility only operated for 7 years, and was placed on standby in 1968.

During the same period, Soviet scientists developed the so-called Russian VX (VR, RVX, R 033). The chemical structure of VX was unknown for a long time. Therefore some attempts to resolve this question have been made. Because of these ambiguities and difficulties in synthesis, model V agent [EDMM, O-ethyl S-(2-dimethylaminoethyl) methylphosphonothioate] was initially used in the Eastern Block to study antidotal treatment. Another structural analog of VX known as Chinese VX (CVX) was also developed and studied.

A very important step in the development in CWs has been the production of ‘‘binary munition’’, in which the final stage of synthesis of the agent from precursors is carried out in the munition (bomb, shell, or warhead) immediately before or during delivery to the target. In the 1950s, armed forces had begun looking at binary weapons. Until this time, CWs were unitary, i.e. the toxic agent was filled in the munition and then stored ready to be used. The binary concept – mixing or storing two less toxic chemicals and creating the nerve agent within the weapon – was safer during storage. The production of binary projectiles began on December 16, 1987 at the Pine Bluff Arsenal,

Arkansas, USA.

*Persian Gulf War*

On August 2, 1990, Saddam Hussein sent Iraqi troops into Kuwait – allegedly in support of Kuwaiti revolutionaries who had overthrown the emirate. Iraq was known to have a large stockpile of CWs during its conflict with Iran and confirmed that they would use CWs.

President George Bush ordered US forces to be sent to Saudi Arabia at the request of the Saudi Government (Operation Desert Shield) – this was the buildup phase of the Persian Gulf War. As a consequence, in 1996, almost 60,000 veterans of the Persian Gulf War claimed certain medical problems related to their war activities, some caused by exposure to nerve agents (released after the bombing and destruction of the sarin production facility). Unexplained ‘‘Gulf War Syndrome’’ with low-dose exposure to CWAs was suggested as a possible cause. Extensive research failed to find any single case of the problem. However, some health effects, including alterations to the immune system 3 months after the exposure to low concentrations of sarin, were demonstrated. In the desert, during the fall and winter of 1990–1991, the threat of chemical warfare became very real to allied military personnel. It was demonstrated by the UN Commission that major Iraqi agents were mustard, tabun, sarin, and cyclosarin. Mustard agent was relatively pure but nerve agents were a complex mixture of the agent and degradation products. Over the period from June 1992 to June 1994, the Commission’s Chemical Destruction Group destroyed 30 tons of tabun, 70 tons of sarin, and 600 tons of mustard, stored in bulk and in munitions.

Suddenly, it became clear to the whole world that there were countries that have CWs and biological weapons, and there were other countries that might obtain or produce them.

**Reading activities**

*IV. Read the first part of the article “The period after WWII and the cold war”, and answer the following questions.*

1. What happened with the chemical weapons and the CW manufacturing plant near Breslaw after the WWII? What consequences did it have?

2. How did the town of Dyhernfurth affect the post-war borders?

3. Describe the development of CW in the post-war USA.

4. What was the development of CW like in the former Soviet Union in the war and post-war time?

5. Which were the cases of unintentional use of CW described in the article?

*V. Divide into groups of four. Each member of the group will read one of the following parts of the article:*

Iraq–Iran and Afghanistan War

Vietnam War

Development of VX Agent

Persian Gulf War

*Make notes and give the summary of what you read to your group members.*

*Then together in the groups fill the data in the table.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Location** | **Year** | **Perpetrator** | **Agent/s used** | **Casualty** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

*VI. Explain the meaning of the following sentences in English.*

1. Stalin held for the West Neisse and progress was delayed.

2. In the USA, during the 1950s, the chemical corporations concentrated

 on the weaponization of sarin.

3. The objective was to develop a nonlethal but potent incapacitant.

4. In Angola antiplant agents were almost certainly used.

*VII. In the text find the words of opposite meaning and explain their meaning*

1. deadly/lethal

2. input

3. conventional/traditional

4. poisonous/venomous/toxic

5. intended/intentional

6. to seize

7. protected

8. to discover

9. to harness/leash

**Post-reading activities**

*VII. In the text find the kinds of agents’ series mentioned. Make a table in which you fill in the kinds od series including the representatives of the particular series discussed in the text.*

*VIII. Give a short summary of:*

*a) the history of CWs,*

*b) the use of CWs in the wars or conflicts mentioned in the article.*

*IX. Videos – choose a video and put down a short written summary of it.*

US Army LSD test / UK Army LSD test

<http://www.youtube.com/watch?v=zLCzR34HfVQ>

<http://www.youtube.com/watch?v=n-rWnQphPdQ>

# World War One Chemical Warfare

<https://www.youtube.com/watch?v=tWtETJ0Pt4g>

# Chemical Warfare Agent Decontamination <https://www.youtube.com/watch?v=T6XBMGQwkC0>

# Decontamination Process from Dangerous Chemicals and Biological Substances

# <https://www.youtube.com/watch?v=bNIaKpg0Mq8>

#  Agent Orange. American Chemical and Biological Warfare

 <https://www.youtube.com/watch?v=wgLlkjsg1uo>

#  How Sarin Gas Works

 <https://www.youtube.com/watch?v=F5WZyp0Ewvc>

#  NATO Codes for common chemical warfare agents

 <https://www.youtube.com/watch?v=coGk0T1W7jw>

# Chemical Weapons: Dose & Exposure Terminology

# <https://www.youtube.com/watch?v=-LBEssUhlPs>

#  What are chemical weapons and who has them? - Truthloader

 <https://www.youtube.com/watch?v=j0GYyYX-eAk>

# Glossary

Adjacent

Agent

Allegedly

Ambiguity

Antidote

Confluence

Conspicuous

Cyclosarin

Defoliant

Drift out

Impurity

Incapacitate

Induce

Irritant

Lewisite

Mustard gas

Psychotomimetic agents

Rumour

Sarin

Soman

Stockpile

Tabun

To take over

Appendix

**G-series of nerve agents**

**Tabun** - or **GA** is an extremely toxic chemical substance. It is a clear, colorless, and tasteless liquid with a faint fruity odor. It is classified as a nerve agent because it fatally interferes with normal functioning of the mammalian nervous system. Its production is strictly controlled and stockpiling outlawed by the Chemical Weapons Convention of 1993. Tabun is the first of the so-called *G-series* nerve agents along with GB (sarin), GD (soman) and GF (cyclosarin).Although pure tabun is clear, less-pure tabun may be brown. It is a [volatile](http://en.wikipedia.org/wiki/Volatility_%28chemistry%29) chemical, although less so than either sarin or soman.

**Sarin** - or GB, is an [organophosphorus compound](http://en.wikipedia.org/wiki/Organophosphorus_compound). It is a colorless, odorless liquid, used as a [chemical weapon](http://en.wikipedia.org/wiki/Chemical_weapons) owing to its extreme potency as a [nerve agent](http://en.wikipedia.org/wiki/Nerve_agent). It has been classified as a [weapon of mass destruction](http://en.wikipedia.org/wiki/Weapon_of_mass_destruction) in UN Resolution 687. Production and stockpiling of sarin was outlawed by the Chemical Weapons Convention of 1993, and it is classified as a [Schedule 1 substance](http://en.wikipedia.org/wiki/List_of_Schedule_1_substances_%28CWC%29). Sarin can be lethal even at very low concentrations, with death following within 1 to 10 minutes after direct inhalation due to suffocation from lung muscle paralysis, unless some antidotesare quickly administered to a person. People who absorb a non-lethal dose, but do not receive immediate medical treatment, may suffer permanent neurological damage.

**Cyclosarin** - or GF (cyclohexyl methylphosphonofluoridate) is an extremely [toxic](http://en.wikipedia.org/wiki/Toxicity) substance used as a chemical weapon. It is a member of the *G-series* family of [nerve agents](http://en.wikipedia.org/wiki/Nerve_agent), a group of [chemical weapons](http://en.wikipedia.org/wiki/Chemical_warfare) discovered and synthesized by a German team led by [Dr. Gerhard Schrader](http://en.wikipedia.org/wiki/Gerhard_Schrader). As a [chemical weapon](http://en.wikipedia.org/wiki/Chemical_warfare), it is classified as a [weapon of mass destruction](http://en.wikipedia.org/wiki/Weapon_of_mass_destruction) by the [United Nations](http://en.wikipedia.org/wiki/United_Nations), according to UN Resolution 687, and its production and stockpiling was outlawed by the Chemical Weapons Convention of 1993.

**Soman** - or GD (systematic name: O-Pinacolyl methylphosphonofluoridate), is an extremely toxic chemical substance. It is a [nerve agent](http://en.wikipedia.org/wiki/Nerve_agent), interfering with normal functioning of the mammalian [nervous system](http://en.wikipedia.org/wiki/Nervous_system) by inhibiting the [cholinesterase enzyme](http://en.wikipedia.org/wiki/Cholinesterase_enzyme). As a [chemical weapon](http://en.wikipedia.org/wiki/Chemical_weapon), it is classified as a [weapon of mass destruction](http://en.wikipedia.org/wiki/Weapon_of_mass_destruction) by the [United Nations](http://en.wikipedia.org/wiki/United_Nations) according to UN Resolution 687. Its production is strictly controlled, and stockpiling is outlawed by the Chemical Weapons Convention of 1993 where it is classified as a [Schedule 1 substance](http://en.wikipedia.org/wiki/List_of_Schedule_1_substances_%28CWC%29). It is a volatile, corrosive, and colorless liquid with a faint odor when pure. More commonly, it is a yellow to brown color and has a strong odor described as similar to [camphor](http://en.wikipedia.org/wiki/Camphor). It is both more lethal and more persistent than [sarin](http://en.wikipedia.org/wiki/Sarin) or [tabun](http://en.wikipedia.org/wiki/Tabun_%28nerve_agent%29), but less so than [cyclosarin](http://en.wikipedia.org/wiki/Cyclosarin). GD can be [thickened](http://en.wikipedia.org/wiki/Thickening) for use as a chemical spray using an acryloid copolymer. It can also be deployed as a [binary chemical weapon](http://en.wikipedia.org/wiki/Binary_chemical_weapon); its precursor chemicals are [methylphosphonyl difluoride](http://en.wikipedia.org/wiki/Methylphosphonyl_difluoride) and a mixture of pinacolyl alcohol and an [amine](http://en.wikipedia.org/wiki/Amine).

# K-series of agents

**Psychochemical Agents** - are agents intended to [incapacitate](http://en.wikipedia.org/wiki/Incapacitating_agent) an enemy through [psychopharmacological](http://en.wikipedia.org/wiki/Psychopharmacological) agents. In the 1950s, the CIA investigated LSD as part of its project [MK Ultra](http://en.wikipedia.org/wiki/MK_Ultra) and some in the US Military speculated about its possible use to disable sentries or incapacitate concentrated masses of troops or enemy populations. [Britain](http://en.wikipedia.org/wiki/United_Kingdom) was also investigating the possible weaponization of [LSD](http://en.wikipedia.org/wiki/LSD) (lysergic acid diethylamide) and BZ ([3-quinuclidinyl benzilate](http://en.wikipedia.org/wiki/3-quinuclidinyl_benzilate)) as nonlethal battlefield drug-weapons. Both the US and Britain concluded that the desired effects of drug weapons were unpredictable under battlefield conditions and gave up experimentation.

**Psychotomimetic agents** - This group of agents usually includes substances which, when administered in low doses (<10 mg) cause conditions similar to psychotic disorders or other symptoms emanating from the central nervous system (loss of feeling, paralysis, rigidity, etc.). The effects are transitory and cause inability to make decisions and incapacitation. During the 1950's, studies were made of substances such as glycolic acid esters (glycolates). Particular interest was paid to 3-quinuclidinylbenzilate, BZ. The effects of this group of substances are similar to those caused by atropine. BZ causes poisoning at doses of 0.5-5 mg. Peripheral symptoms such as distended pupils, deteriorated short-distance vision, dry mouth and palpitations occur after about 30 minutes. A serious effect of poisoning with BZ, as also with other atropine-like substances, is an increased body temperature. Deterioration in the level of consciousness, hallucinations and coma occur subsequently. Incapacitating after-effects may remain 1-3 weeks after the poisoning. LSD is probably one of the most active of all known substances having psychotomimetic effects. However, its chemical stability is very low and it is probably of little use as a CW agent. Nonetheless, there are other chemical substances with effects similar to LSD. These substances are chemically similar to amphetamine and are also stable. Theoretically, this type of substance could be used as a CW agent in special circumstances and dispersed as an aerosol.

# V-series of nerve agents

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These agents have low volatility and are typically used for a persistent effect or liquid contact hazard.

VX, [IUPAC](http://en.wikipedia.org/wiki/IUPAC) name *O*-ethyl *S*-[2-(diisopropylamino)ethyl] methylphosphonothioate, is an extremely toxic substance that has no known uses except in [chemical warfare](http://en.wikipedia.org/wiki/Chemical_warfare) as a [nerve agent](http://en.wikipedia.org/wiki/Nerve_agent). It is a tasteless and odorless liquid. As a [chemical weapon](http://en.wikipedia.org/wiki/Chemical_weapons), it is classified as a [weapon of mass destruction](http://en.wikipedia.org/wiki/Weapon_of_mass_destruction) by the [United Nations](http://en.wikipedia.org/wiki/United_Nations) in UN Resolution 687. The production and stockpiling of VX was outlawed by the Chemical Weapons Convention of 1993. The VX [nerve agent](http://en.wikipedia.org/wiki/Nerve_agent) is the best-known of the [V-series of nerve agents](http://en.wikipedia.org/wiki/Nerve_agent#V-series) and is considered an area denial weapon due to its physical properties.

Novichok (newcomer) is a series of [nerve agents](http://en.wikipedia.org/wiki/Nerve_agent) that were developed by the [Soviet Union](http://en.wikipedia.org/wiki/Soviet_Union) in the 1970s and 1980s Allegedly these are the most deadly nerve agents ever made, with some variants possibly five to eight times more potent than [VX](http://en.wikipedia.org/wiki/VX_%28nerve_agent%29), though this has never been proven They belong to "fourth generation chemical weapons" designed as a part of Soviet "Foliant" program. The Novichok family of analogs comprises more than a hundred structural variants. Of all the variants the most promising, from a military standpoint, was A-232 (Novichok-5). As a nerve agent, Novichok belongs to [organophosphate](http://en.wikipedia.org/wiki/Organophosphate) [acetylcholinesterase inhibitors](http://en.wikipedia.org/wiki/Acetylcholinesterase_inhibitor). These chemical compounds inhibit the enzyme [acetylcholinesterase](http://en.wikipedia.org/wiki/Cholinesterase), preventing the normal breakdown of [neurotransmitter](http://en.wikipedia.org/wiki/Neurotransmitter) [acetylcholine](http://en.wikipedia.org/wiki/Acetylcholine). Acetylcholine concentrations then increase at neuromuscular junctions to cause involuntary contraction of all muscles. This then leads to respiratory and cardiac arrest and finally death.

# Defoliants

**Agent Orange** or Herbicide Orange (HO) is one of the [herbicides](http://en.wikipedia.org/wiki/Herbicide) and [defoliants](http://en.wikipedia.org/wiki/Defoliant) used by the [U.S. military](http://en.wikipedia.org/wiki/United_States_armed_forces) as part of its [herbicidal warfare](http://en.wikipedia.org/wiki/Herbicidal_warfare) program, [Operation Ranch Hand](http://en.wikipedia.org/wiki/Operation_Ranch_Hand), during the [Vietnam War](http://en.wikipedia.org/wiki/Vietnam_War) from 1961 to 1971. It was a mixture of equal parts of two herbicides, [2,4,5-T](http://en.wikipedia.org/wiki/2%2C4%2C5-T) and [2,4-D](http://en.wikipedia.org/wiki/2%2C4-D).

**Agent White** is the code name for a [herbicide](http://en.wikipedia.org/wiki/Herbicide) and [defoliant](http://en.wikipedia.org/wiki/Defoliant) used by the [U.S. military](http://en.wikipedia.org/wiki/U.S._military) in its [herbicidal warfare](http://en.wikipedia.org/wiki/Herbicidal_warfare) program during the [Vietnam War](http://en.wikipedia.org/wiki/Vietnam_War). The name comes from the white stripe painted on the barrels to identify the contents. Largely inspired by the British use of [herbicides](http://en.wikipedia.org/wiki/Herbicides) and [defoliants](http://en.wikipedia.org/wiki/Defoliants) during the [Malayan Emergency](http://en.wikipedia.org/wiki/Malayan_Emergency), it was one of the so-called "[rainbow herbicides](http://en.wikipedia.org/wiki/Rainbow_herbicides)" that included the more infamous [Agent Orange](http://en.wikipedia.org/wiki/Agent_Orange).Agent White is a 4:1 mixture of [2,4-D](http://en.wikipedia.org/wiki/2%2C4-D) and [picloram](http://en.wikipedia.org/wiki/Picloram). Unlike the more infamous [Agent Orange](http://en.wikipedia.org/wiki/Agent_Orange), Agent White did not contain [dioxin](http://en.wikipedia.org/wiki/Polychlorinated_dibenzodioxins), which was a contaminant in the defoliants that included [2,4,5-trichlorophenoxyacetic acid](http://en.wikipedia.org/wiki/2%2C4%2C5-trichlorophenoxyacetic_acid) (2,4,5-T). Agent White was often used when Agent Orange was not available, including for several months after the use of Agent Orange was halted in April 1970. Under the brand name **Tordon 101**, [Dow AgroSciences](http://en.wikipedia.org/wiki/Dow_AgroSciences) has commercialized a similar product containing a mixture of 2,4-D and picloram.

**Agent Blue** obtained by the oxidation of [cacodyl](http://en.wikipedia.org/wiki/Cacodyl), and having the properties of an exceedingly stable acid; is one of the "[rainbow herbicides](http://en.wikipedia.org/wiki/Rainbow_herbicides)" that is known for its use by the [United States](http://en.wikipedia.org/wiki/United_States) during the [Vietnam War](http://en.wikipedia.org/wiki/Vietnam_War). Largely inspired by the British use of [herbicides](http://en.wikipedia.org/wiki/Herbicides) and [defoliants](http://en.wikipedia.org/wiki/Defoliants) during the [Malayan Emergency](http://en.wikipedia.org/wiki/Malayan_Emergency), killing [rice](http://en.wikipedia.org/wiki/Rice) was a military strategy from the very start of US military involvement in [Vietnam](http://en.wikipedia.org/wiki/Vietnam). Agent Blue affects plants by causing them to dry out. As rice is highly dependent on water to live, using Agent Blue on these paddies can destroy an entire field and leave it unsuitable for further planting. This is why Agent Blue was also used where food was not a factor, but foliage was. Arsenical herbicides containing [cacodylic acid](http://en.wikipedia.org/wiki/Cacodylic_acid) as an active ingredient are still used today as [weed-killers](http://en.wikipedia.org/wiki/Weed_control). In the US they are used extensively, from [golf](http://en.wikipedia.org/wiki/Golf) courses to backyards. They are also sprayed on [cotton](http://en.wikipedia.org/wiki/Cotton) fields, drying out the [cotton plants](http://en.wikipedia.org/wiki/Cotton_plant) before harvesting. So common -- and so profitable -- is the original commercial form of Agent Blue that it was among 10 toxic [insecticides](http://en.wikipedia.org/wiki/Insecticide), [fungicides](http://en.wikipedia.org/wiki/Fungicide) and herbicides partially deregulated by the US [Environmental Protection Agency](http://en.wikipedia.org/wiki/United_States_Environmental_Protection_Agency) (EPA) in February 2004. Specific limits on toxic residues in meat, milk, poultry, and eggs were removed.

# Irritants

**The irritants CS, CN** - Tear gas (CS) and chloroacetophenone (CN) are by far the most important pulmonary irritants. These types of compounds were assigned these 2-letter codes by The North Atlantic Treaty Organization (NATO). CN was the primary pulmonary irritant after World War I until Corson and Stoughton developed CS in 1928. CS was found to be more potent (10 times more potent as a lachrymator than CN) but less toxic. In approximately 1959, CS replaced CN as the principal military and law enforcement riot control agent. CS gas is the familiar tear gas most often used by police for crowd control (eg, the police in the United Kingdom have used CS as an incapacitant for the past decade). CN is available as Mace, an over-the-counter product used for personal protection. Capsaicin, or pepper spray, has to some extent replaced CN as a personal protective agent, with less dangerous effects.

**Yperite** - the **sulfur mustards**, or **sulphur mustards**, commonly known as **mustard gas**, are a class of related [cytotoxic](http://en.wikipedia.org/wiki/Cytotoxic) and [vesicant](http://en.wikipedia.org/wiki/Blister_agent) [chemical warfare agents](http://en.wikipedia.org/wiki/Chemical_warfare_agent) with the ability to form large [blisters](http://en.wikipedia.org/wiki/Blister) on the exposed skin and in the lungs. Pure sulfur mustards are colorless, viscous liquids at room temperature. When used in impure form, such as warfare agents, they are usually [yellow-brown](http://en.wikipedia.org/wiki/Tawny_%28color%29) in color and have an odor resembling [mustard plants](http://en.wikipedia.org/wiki/Mustard_plant), [garlic](http://en.wikipedia.org/wiki/Garlic), or [horseradish](http://en.wikipedia.org/wiki/Horseradish), hence the name. Mustard gas was originally assigned the name *LOST*, after the scientists Wilhelm Lommel and [Wilhelm Steinkopf](http://en.wikipedia.org/wiki/Wilhelm_Steinkopf), who developed a method for the large-scale production of mustard gas for the [Imperial German Army](http://en.wikipedia.org/wiki/German_Army_%28German_Empire%29) in 1916. Mustard agents are regulated under the 1993 [Chemical Weapons Convention](http://en.wikipedia.org/wiki/Chemical_Weapons_Convention) (CWC). Three classes of chemicals are monitored under this Convention, with sulfur and nitrogen mustard grouped in [Schedule 1](http://en.wikipedia.org/wiki/List_of_Schedule_1_substances_%28CWC%29), as substances with no use other than in [chemical warfare](http://en.wikipedia.org/wiki/Chemical_warfare). Mustard agents could be deployed on the battlefield by means of [artillery shells](http://en.wikipedia.org/wiki/Artillery_shell), [aerial bombs](http://en.wikipedia.org/wiki/Aerial_bomb), [rockets](http://en.wikipedia.org/wiki/Rocket), or by spraying from [warplanes](http://en.wikipedia.org/wiki/Warplane).

**Lewisite** is an [organoarsenic compound](http://en.wikipedia.org/wiki/Organoarsenic_compound). It was once manufactured in the U.S., Japan, and Germany for use as a [chemical weapon](http://en.wikipedia.org/wiki/Chemical_warfare), acting as a [vesicant](http://en.wikipedia.org/wiki/Vesicant) (blister agent) and [lung](http://en.wikipedia.org/wiki/Lung) irritant. Although colorless and odorless, impure samples of lewisite are a yellow or brown liquid with a distinctive odor that has been described as similar to scented [geraniums](http://en.wikipedia.org/wiki/Pelargonium).