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One hundred and one years after a milestone: Modern chemical weapons and World War I

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Abstract While chemical weapons have been used since the beginning of armed struggles, either for their flammable or toxic properties, it was only during World War I when what is known as ''modern'' chemical warfare began. July 28 marks the one hundred and one anniversary of the beginning of what is also known as ''The Great War''. This conflict created enormous consequences for society at the time, marking a before and after in the history of mankind, as well as being the genesis of modern chemical warfare.

PALABRAS CLAVE
Guerra química moderna;
Primera Guerra Mundial;
Armas químicas

Ciento un años después de un hito: las armas químicas y la Primera Guerra Mundial

Resumen Si bien desde los inicios de las contiendas armadas se utilizaron armas químicas, ya sea por sus propiedades inflamables o tóxicas, fue recién durante la Primera Guerra Mundial cuando se dio inicio a lo que se conoce como guerra química ''moderna''. El 28 de julio de 2014 se cumplieron ciento un años del comienzo de la que también es conocida como la ''la Gran Guerra''. Este conflicto generó enormes consecuencias para la sociedad de su época, marcando un antes y un después en la historia de la humanidad, además de ser la génesis de la guerra química moderna.

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Short historical review

The oldest reported case of a chemical substance being used as a weapon due to its toxic properties occurred in the year 256 BC, during the siege of the Persian city Dura Europos (modern Syria), where they used a mixture of tar and sulfur to produce sulfur oxides and thus take control of the city (Patel, 2010).

While previous reports of chemical substances being used in combat are recognized, generally they were used for their flammable, rather than their toxic properties. Such is the case, for example, of flamethrowers used in the year 424 BC during the Peloponnesian War, or the Greek fire developed in the year 668 BC (Partington, 1990).

It was only in the XVI century when the use of toxic properties of some chemical substances for military purposes was documented. During the Franco-Dutch War they began to use explosive and incendiary devices containing belladonna alkaloids, among other toxic compounds. The effects that the chemical weapons had in the battlefields prompted Germany and France to sign the Strasbourg Agreement on August 27, 1675; the first documented international agreement that prohibited the use of ''perfidious and odious'' toxic devices (Smart, 1996).

Two hundred years later, in 1874, given the concern about chemical weapons, the Brussels Convention was signed, on the law and customs of war. This prohibited the use of poison or poison weapons, and the use of projectile weapons or materials that cause unnecessary suffering. Subsequently, on July 29, 1899, the Second Hague Declaration was signed, leading to the first international ban on the use of projectiles whose sole purpose was to spread asphyxiating or deleterious gases. This prohibition was also included in the Fourth Hague Convention on October 18, 1907, which prohibited the use of toxins or toxic weapons.

World War I

The ''Great War'' marked the beginning of a new era of military history, not only because of the use of trenches, machine guns, the production and the use of tanks, the use of artillery of an unprecedented scale or the introduction of military aviation and submarines, but also for the massive and systemic industrial scale use of chemical weapons for the first time in history (Paige, 2009). Chemical weapons certainly affected those who fought in forests and trenches, both physically and mentally, dramatically undermining their confidence and fighting spirit, but also terrorized the civilian population to the point where the gas mask (essential in the battle field) became a symbol that embodies the legacy of violence and mass destruction that was World War I (Grazel, 2014; Jünger, 1998).

While it is believed that Germany was the first to use chemical warfare agents, it was actually France who, in August 1914, launched bromine ethyl acetate (Fig. 1) tear gas grenades. Meanwhile, the Germans, aware of the allies' interests in developing chemical weapons, also did the same by strongly developing their chemical industry (especially the dye industry), achieving an ideal situation for offensive chemical development.

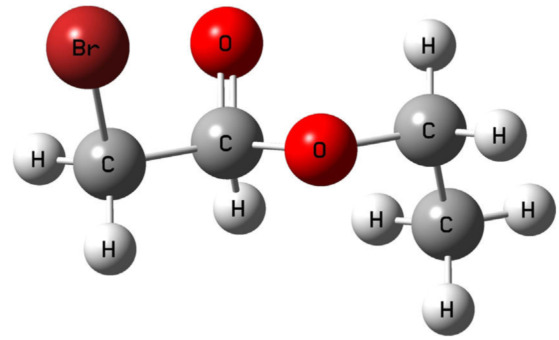

Figure 1 Representation of bromine ethyl acetate.

Thus Fritz Haber, professor at the Kaiser Wilhelm Institute of Physics in Berlin (awarded the Nobel Prize in Chemistry in 1918 for the catalytic synthesis of ammonia from hydrogen and atmospheric nitrogen under high temperature and pressure), directed German operations in the field, where the strategy of creating toxic clouds using commercial cylinders of chlorine gas as a dispersion system was attributed to him. Moreover, it is postulated that Haber selected chlorine gas because it was readily available in the dye industry and it also qualified for military use because it had and an immediate effect, was volatile, and could also become lethal.

It was on the Western Front where we could see the remarkable capacity of chemical weapons to terrorize the enemy and make their troops temporarily lose their minds. The first large-scale attack with chlorine gas occurred on April 22, 1915 in the Second Battle of Ypres, Belgium. There, the Germans, hoping the wind was blowing toward the French side to avoid causing damage to their own troops, released 150 tons of chlorine that spread panic among the enemy ranks. The terrified troops fled from the huge yellow cloud creating an opening of four miles in the French first forward line, which represented a significant advancement for the Germans (Jones, 2014). The operational advantage of toxic attacks was confirmed, to give one example, three years later in 1918 when during the first five hours of the Battle of Kaiserchlacht (the last great successful German offensive and known by the English as The Great Retreat of March), the German infantry general, Erich Ludendorff, combined ''surprise firing with gas'', achieving ''the dislocation and paralysis'' of the British troops. While the 6th and 51st English divisions were ''seen to be pushed toward the rearguard''. The V Corps, ''severely gassed but not directly attacked'', had to ''move back four thousand yards to an intermediate line'' (Gray, 1994).

Just weeks after they recognized the potential of chemical weapons in Ypres, the British and French began to plan a chemical retaliation, which became a triple strategy, as they needed to develop protective devices for their troops, weapons containing toxic gas and dispersion systems that would cross enemy lines. The day after the Germans used chlorine, the allies developed a rudimentary protective mask and in September 1915 they managed to launch their own chemical attack, using chlorine gas in Loos, Belgium (History of Chemical Warfare. Medical Aspects of Chemical Warfare, 2008). Ernst Jünger, the renowned German writer that fought in the Great War, recalls that the ''unpleasant'' and ''frequent'' attacks with gas mines were carried out ''with hundreds of iron pipes placed in the ground, the load was electrically detonated and caused a burst of flames''. When ''the light shone, there were cries for the gas alarm, and those who did not place the mask in front of their mouths before the gas reached them had a hard time'' (Jünger, 1998, p. 134). The Germans, meanwhile, with the assistance of the Engineer Corps, launched gas both with ''artillery'' and ''projectors'' made from ''recalibrated 180 millimeter mortars'' with the capacity to launch between ''three to four gallons of chemical agent a distance of one to two miles'' (Gray, 1994, p. 23).

On the battlefield, soldiers from both sides continuously had to face the combination of different types of agents that, in addition to disorient them, sought to undermine both their confidence and their morale. Chemical weapons produced enormous psychological damage to enemy troops, as they generated uncertainty, and the idea of dying of asphyxiation caused the soldiers to lose their self-control. Although the bursts of machine guns proved far more lethal than chemical agents, the Briton John Hall of the Machine Gun Corps confessed that the gas terrorized him a lot more than facing artillery fire. Jünger's testimony during trench warfare is similar. He remembers how the enemy's artillery attacks ''forced fear into them''. What terrorized him and colleagues was ''not so much'' the ''sudden detonation'' of projectiles but ''the pressure of the gas and the deafening blows'' (Jones, 2014, pp. 355–362; Jünger, 1998, p. 234).

Indeed, one of the main effects of chemical weapons on the enemy was psychological. Lieutenant Colonel S.L. Cummins, consultant pathologist with the British army in France, concluded that all divisions that were continuously exposed to chemical attack showed a significant drop in morale. The medical officer Charles Wilson was even more emphatic in ensuring that most of the men that had been gassed were frankly left in shock. By 1915, after studying its effects, the English had concluded that although they had not been designed to sow terror, the violent sensation of suffocation caused by chlorine and phosgene undermined the will of even the most determined soldiers. In fact, the mere rumor of a chemical attack even had an effect on troops that had not been previously gassed. For example, a group of American soldiers, convinced of having consumed contaminated food, began to feel stomach pain and some even experienced vomiting (Jones, 2014, pp. 363–364). In that context, both for their offensive capacity and the need to defend themselves against chemical attacks, the belligerent powers began a competition to develop better protective masks, more potent chemical products, and delivery systems with better range for dispersing chemical agents during battles.

In December 1915, the Germans introduced phosgene, which was six times more potent than chlorine and when inhaled could be lethal without presenting symptoms of chlorine poisoning, such as coughing. This gas was used both by the Germans and the allies. Jünger recalls, while approaching the Forest with no Name on the Western Front, he walked casually toward ''a weak but uninterrupted firing of grenades'', when he began to feel ''a sweet smell of onions'' coming toward him. From inside the forest he began to hear ''peculiar plaintive drowned cries'', like ''the sound of crickets''. The next morning, he would learn ''that, at that hour, many of our men died poisoned in the forest,

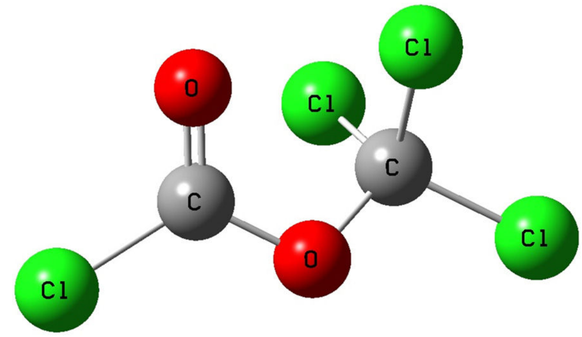

Figure 2 Representation of diphosgene.

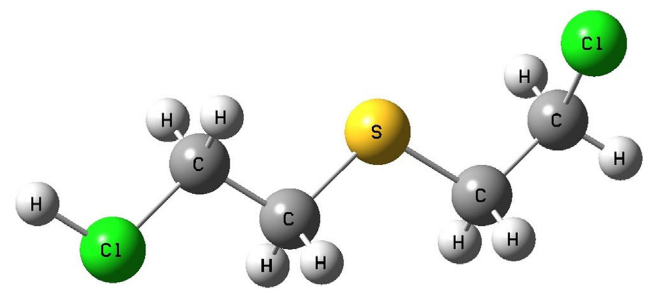

Figure 3 Representation of mustard gas.

where heavy clouds of phosgene clung tenaciously to the bushes''. It is estimated that this gas was responsible for 85% of all deaths caused by chemical weapons during the Great War (Jones, 2014, p. 358; Jünger, 1998, p. 72). In May 1916 the Germans perfected their attacks when they began to use diphosgene (Fig. 2), being in liquid form and at room temperature, favored the load of ammunition. Two months later the French used hydrogen cyanide, and later also used cyanogen chloride, albeit with limited effectiveness, given the low persistence of the compounds (Pita, 2008).

It was during the night of July 12–13, 1917, in the eve of Third Battle of Ypres, when the Germans introduced yperite or mustard gas (Fig. 3) to chemical warfare, by using ''yellow cross'' projectiles (to identify them). Yperite, a blistering agent, produced lesions on the skin (irritation and tissue destruction blisters), not only in the airways, thus the use of masks was not sufficient for protection. Mustard gas was especially damaging because the lesions took several hours to appear after skin contact, and the soldiers were not aware of exposure to the toxic substance until after experiencing its harmful consequences. Because of the novelty of its effects, it was immediately after its introduction when the highest casualties were caused. However, that did not stop the maneuvers of Ludendorff with mustard gas causing 7223 allied casualties on the Western Front on March 9, 1918. As highlighted by Lieutenant Colonel C. Gordon Douglas, the particularity of mustard gas, rather than its lethal power, was its remarkable ability to knockout large contingents (Jones, 2014, pp. 355–361).

In the response to the emergence of yperite, especially to counter the casualties caused, they began to develop the first personal protective equipment, that was combined with the mask and the protective suit. However, these suits were not available until the end of the war, and the effectiveness of their protection was relative, as there were occasions when the gas reached ''almost absolute density, where the mask was useless, for the simple reason that there was no oxygen to breathe'' (Jünger, 1998, pp. 135 and 223). At the same time, importance was given to the decontamination of the skin and materials in the presence of yperite, which, besides attending those intoxicated with oxygen pumps, they began to employ hypochlorite solution as a decontaminant, an element that was available in large quantities, as it was used for cleaning and disinfection of latrines (History of Chemical Warfare. Medical Aspects of Chemical Warfare, 2008).

In addition to all the physical and psychological effects mentioned previously, the ''asphyxiating gases'' that floated over the battlefields also caused lung damage, fatigue and despair (Jünger, 1998, pp. 109–124). The casualty figures and amounts of chemicals used are simply frightening. For example, the use of different types of chemical weapons, including yperite, resulted in 100,000 deaths and more than a million casualties, without considering those who suffered long-term injuries or those who developed cancers after being exposed to mustard gas (History of Chemical Weapons. Threat, Effects and protection, 1992). It should be noted that, according to the Stockholm International Peace Research Institute (SIPRI), during World War I, Germany produced some 62,000 tons of chemical agents, France 34,000, United Kingdom 23,000, United States 5000 and Russia 3500 (Thomas, 1995).

The First World War was a frightening experience for a generation of Europeans. Counting dead, missing and injured the two sides in the debate together suffered over 22 million casualties in combat, not including civilians who were affected by the war. That is why to the horror that marked the first industrial-scale war in the history of mankind, Jünger could only make the following observation: ''Never at any period of time have humans gone into battle as you do, you go mounted in strange machines and steel birds and you advance hidden behind walls of fire and clouds of lethal gas. Earth has spawned terrible animals, provided with strong defenses; but none have been as dangerous as you are, nor have they brought weapons as dangerous as you bear. No cavalry squadron, no Viking ship has ever launched a journey as audacious as yours. The earth opens before your attack; you precede the fire, the poison and some iron giants. Forward, forward, without compassion or fear, the possession of the world is in play!'' (Jünger, 1998, p. 177).

The terrible consequences during the Great War caused chemical weapons made the international community aware of the danger and decided to ban during the Geneva Convention in 1925. After years of negotiations, in 1993 it signed the Convention for the Prohibition of Chemical Weapons. The Convention is the first multilateral treaty whose main objective is the definitive eradication of the threat of chemical weapons. So it not only the prohibition of development, production, stockpiling, transferring and using chemical weapons was determined, but also the deadlines for the destruction of chemical stockpiles that still existed in the world (Organization for the Prohibition of Chemical Weapons, nd). At present we can only hope that in the future all these international efforts have actually served to finally end this struggle of uncertain outcome, so not repeated events like those that occurred 101 years ago in the battle of Ypres, where chlorine was first used in warfare.

Conflict of interest

The authors declare no conflict of interest.

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